

**Steroid hormone as an early  
indicator of dioxins-induced  
health effects on humans**

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# **Introduction**

***Agent Orange is known to affect immune system, reproduction, nervous system, and changing steroid hormone levels.***

***Most studies on the adverse health effects induced by herbicide/dioxin have been focused on American veterans, whereas there are few studies concerning the relationship between dioxin and health effects in Vietnamese.***

***Since 2002, we have been continuously researching the dioxin and health in Vietnam.***

***Recently, we have focused the steroid hormone as an early indicator of dioxin-induced health effects.***

# *Purpose*

The aim of this study is to make clear steroid hormone as an early indicator of dioxins-induced health effects on three different Vietnamese subjects such as

*Vietnamese lactating women,*

*their infants and*

*elder men*

in hot-spot and non-sprayed areas.

**I . The relationship between**  
**dioxin in breast milk**  
**and steroid hormone**  
**in Vietnamese lactating women**

# Research Areas

This study was carried out in Phu Cat district, Binh Dinh province and

Kim Bang district, Ha Nam province in Vietnam.

**Phu Cat airbase** is one of three main **dioxin hot spots** in Vietnam and is located in southern Vietnam.

**Kim Bang district** is located in northern Vietnam and did not experience herbicide operations during the war, and was chosen as the control site.



# Subjects(1)

**Breast milk samples** were obtained from lactating females aged between 20 and 30 years from both districts in September 2008. **One hundred and twenty three** lactating females (**60** from Phu Cat district and **63** from Kim Bang district) participated, who had recently given birth to their first or second child.

All lactating females consented to donate **milk samples (10-20 mL)** and were breast-feeding infants aged from 4 to 16 weeks.



# Subjects(2)

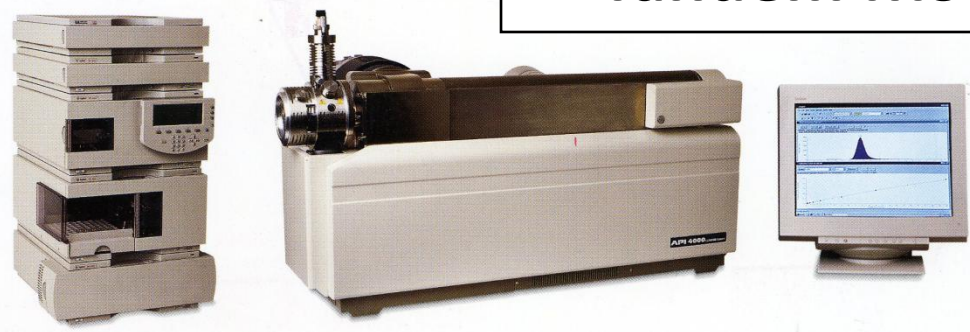
One year later, In August 2009, in the morning (between 8:00 and 10:00 AM) serum and saliva samples were collected to analyze steroid hormone from **one hundred and nine mothers (51** from Phu Cat district and **58** from Kim Bang district) among them in 2008 by using hormone free cotton.



# Principle LC-MS/MS

LC

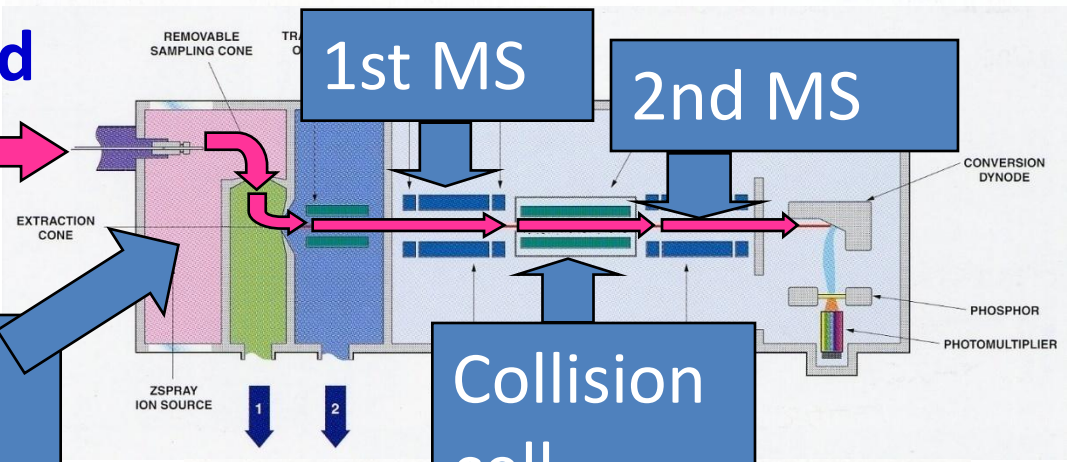
Tandem MS



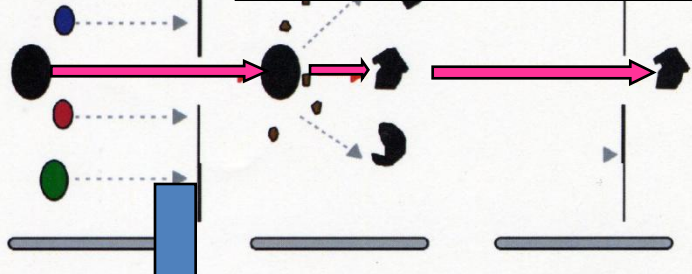
Separated steroid  
By LC

Removal of the  
LC solvent

Selection of molecular  
weight

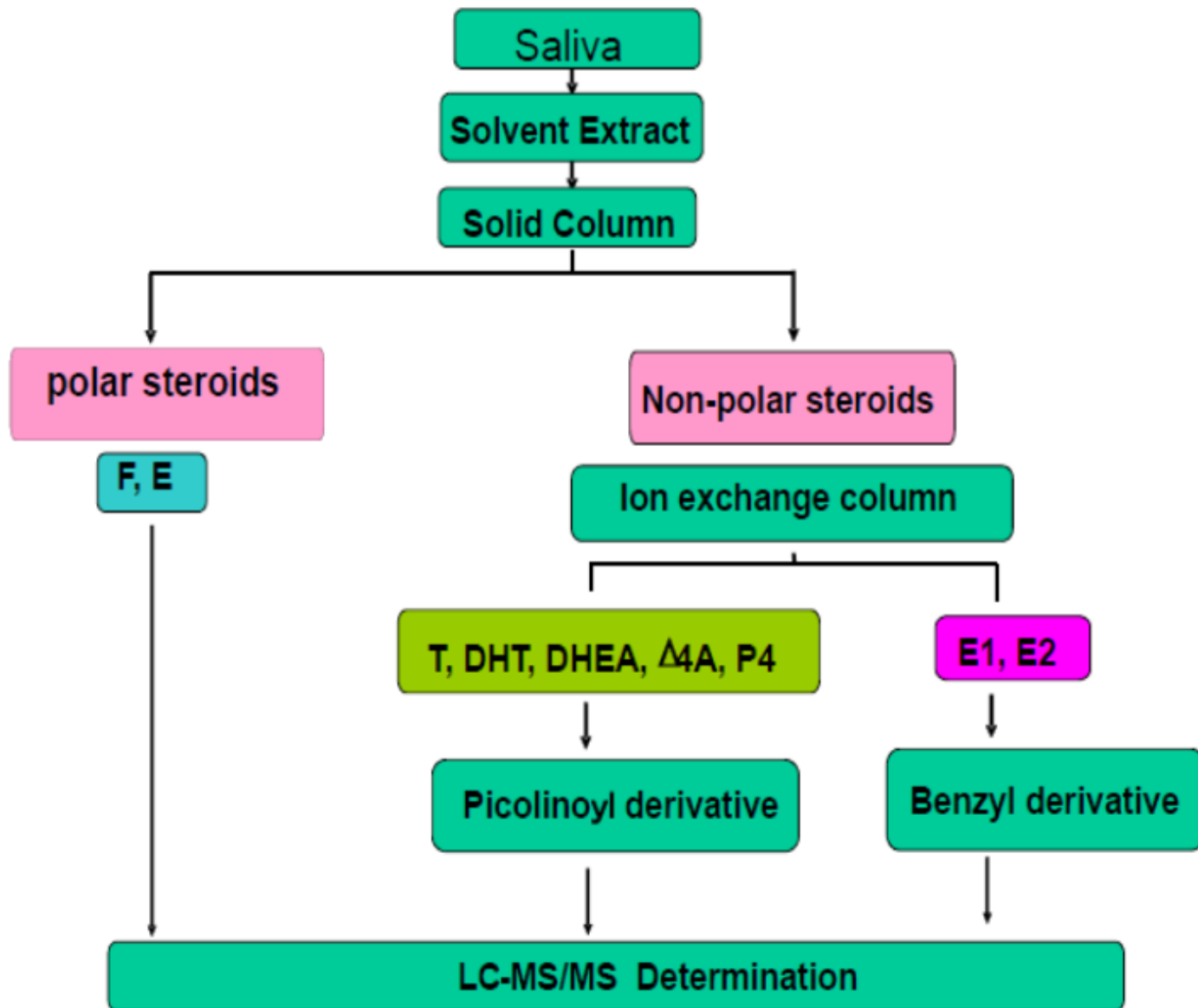


Determination of product ion

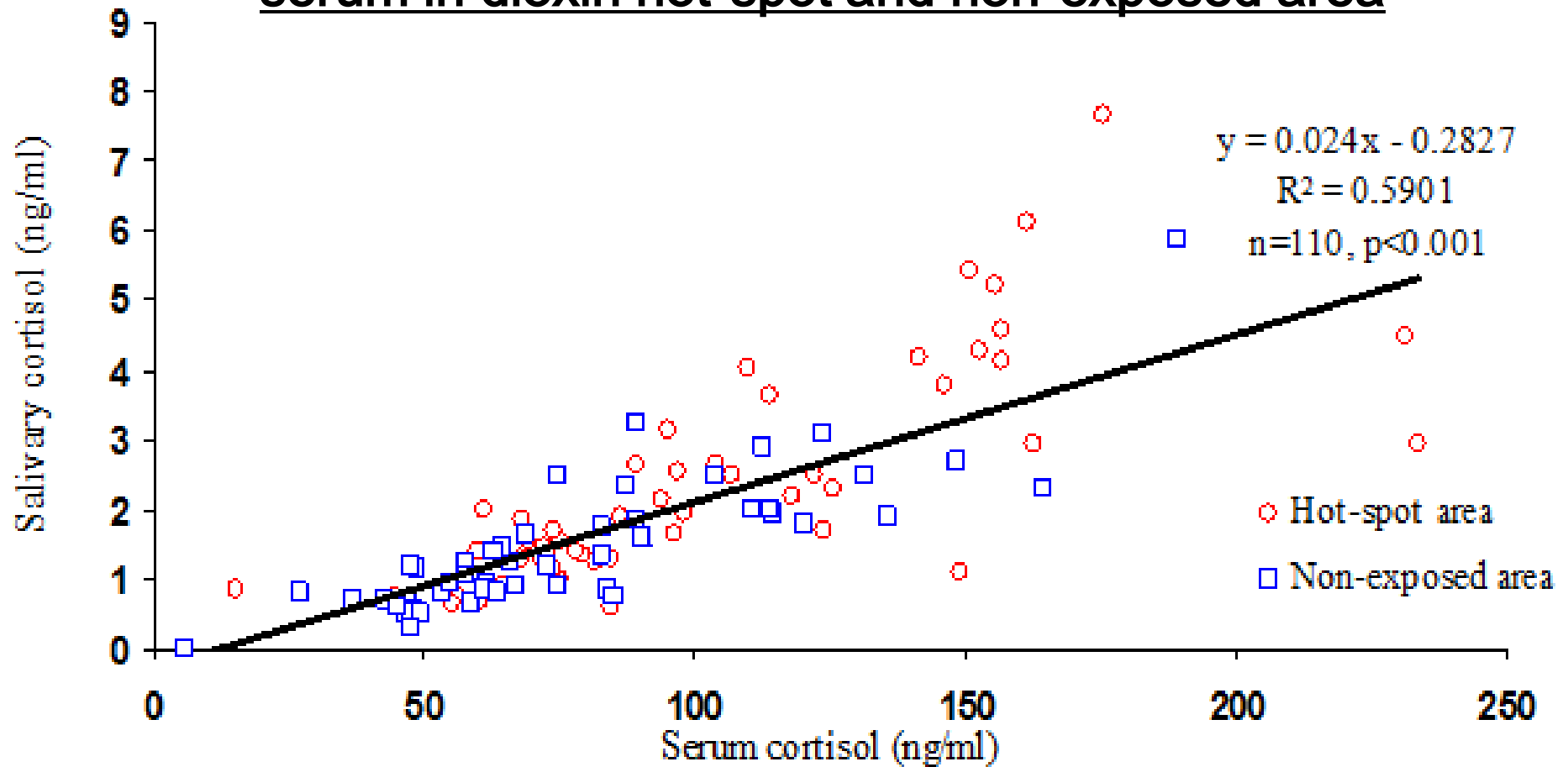


**Specificity**

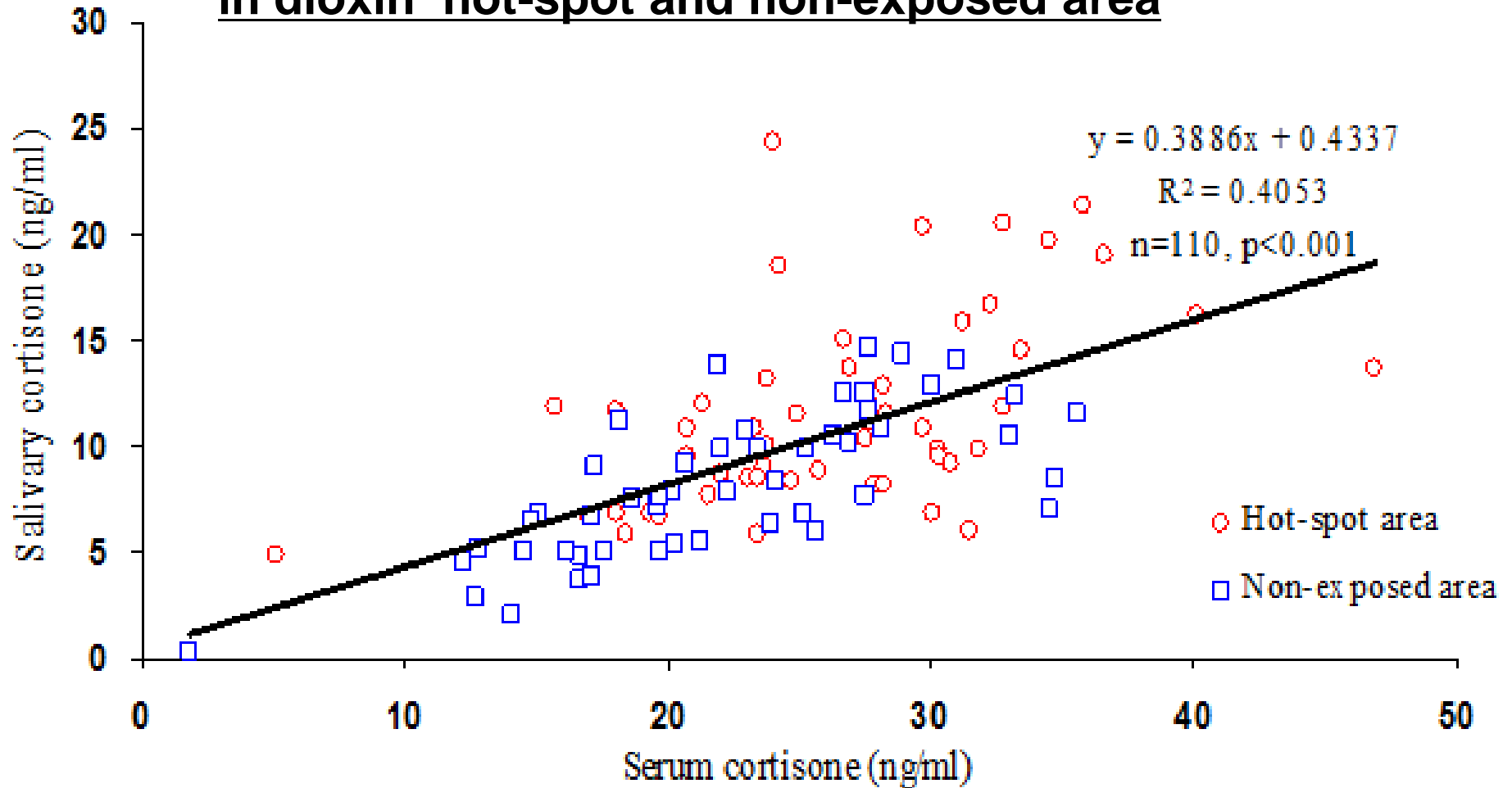
# Analytical Procedure of Steroids in Saliva



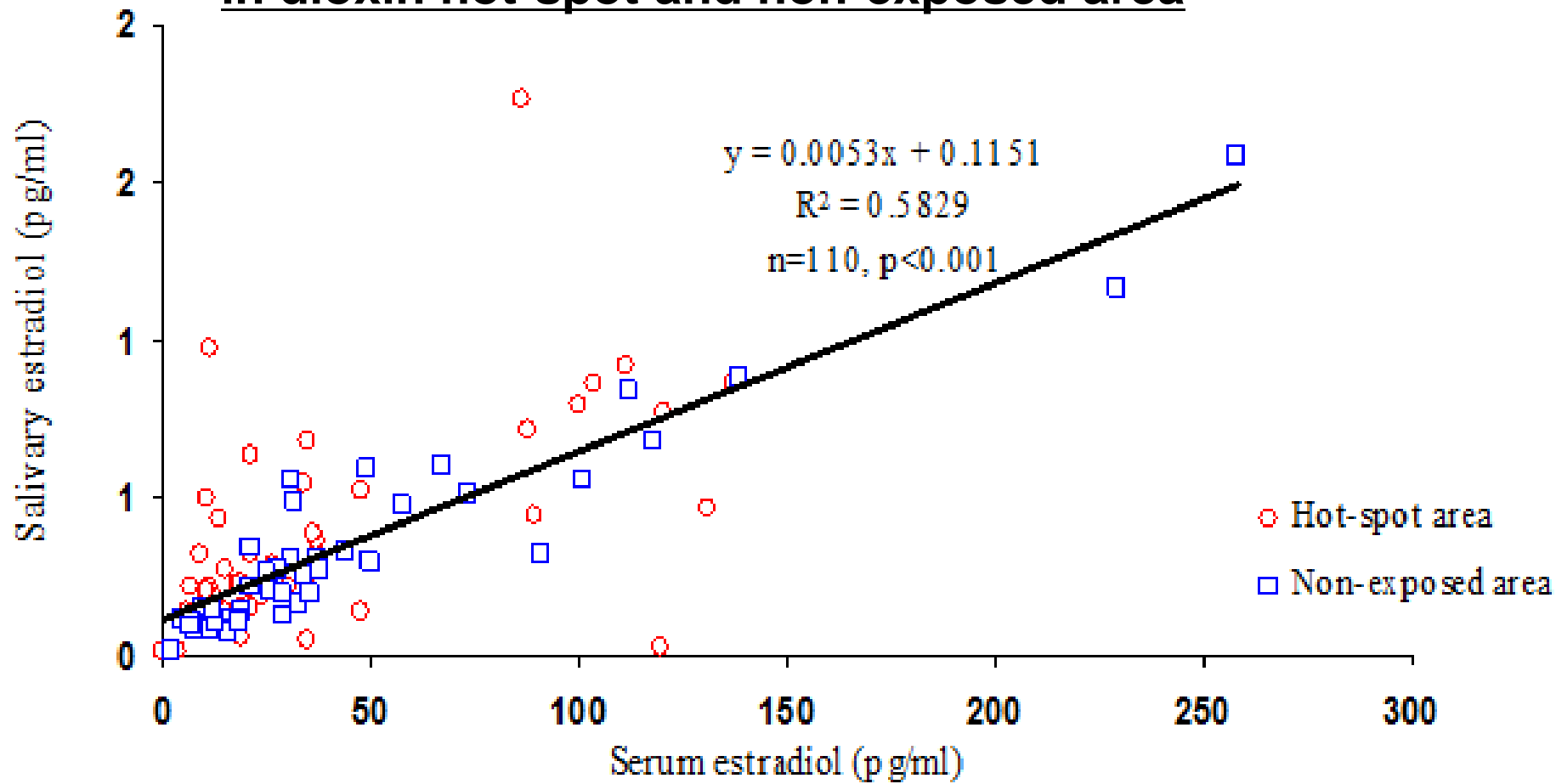
The correlation between **cortisol** in saliva and serum in dioxin hot-spot and non-exposed area



The correlation between **cortisone** in saliva and serum in dioxin hot-spot and non-exposed area



The correlation between estradiol in saliva and serum in dioxin hot-spot and non-exposed area



**Table 1** Characteristics of lactating mothers in the dioxin hot spot and nonexposed area. Data are reported as means  $\pm$  s.d.s for a normal distribution and as medians (interquartile ranges) for a non-normal distribution.

	<b>Dioxin hot spot</b> ( <i>n</i> = 51)	<b>Nonexposed</b> <b>area</b> ( <i>n</i> = 58)	<b><i>P</i> value</b>
Age (years)	27.3 $\pm$ 3.68	26.1 $\pm$ 2.82	0.063 <sup>a</sup>
Weight (kg)	48.5 $\pm$ 6.63	48.8 $\pm$ 5.04	0.786 <sup>a</sup>
Height (cm)	152.3 $\pm$ 5.47	152.7 $\pm$ 5.10	0.721 <sup>a</sup>
BMI (kg/m <sup>2</sup> )	20.9 $\pm$ 2.22	20.9 $\pm$ 1.90	0.866 <sup>a</sup>
Residence period (years)	21.0 (21.0–26.0)	22.5 (18.8–25.0)	0.803 <sup>b</sup>
Family income ( $\times 10^4$ VND/month)	200 (100–300)	200 (110–300)	0.924 <sup>b</sup>

<sup>a</sup>Student's *t*-test.

<sup>b</sup>Wilcoxon's signed-rank test.

**Table 2** Steroid hormone levels in the saliva of lactating mothers in the dioxin hot spot and nonexposed area. Data are reported as medians (interquartile ranges).

	<b>Dioxin hot spot (n=51)</b>	<b>Nonexposed area (n=58)</b>	<b>P value</b>
Cortisol (ng/ml)	1.89 (1.30–3.16)	1.10 (0.70–1.90)	0.0001 <sup>a</sup>
Cortisone (ng/ml)	10.8 (8.41–13.7)	7.74 (5.46–10.6)	0.0001 <sup>a</sup>
DHEA (pg/ml)	154.7 (105.8–232.3)	133.8 (104.1–189.6)	0.223 <sup>a</sup>
A-dione (pg/ml)	56.6 (42.5–75.6)	55.5 (45.8–74.6)	0.923 <sup>a</sup>
Estrone (pg/ml)	1.20 (0.58–2.10)	0.84 (0.62–1.47)	0.146 <sup>a</sup>
Estradiol (pg/ml)	0.22 (0.13–0.46)	0.18 (0.10–0.33)	0.27 <sup>a</sup>

<sup>a</sup>Wilcoxon's signed-rank test.

# Table 3 Dioxin levels in breast milk of lactating mothers in dioxin hot-spot and non-exposed areas

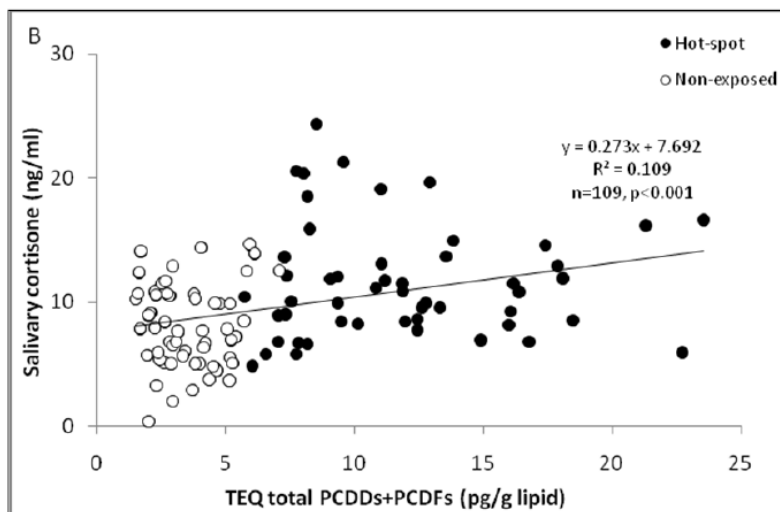
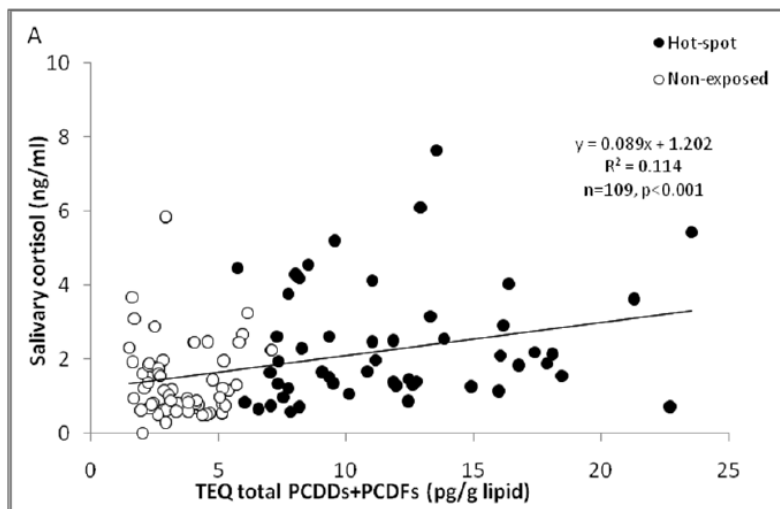
	Hot-spot area (n = 51)	Non-exposed area (n = 58)	p-value
TEQ PCDDs (pg/g)	6.29 ( 4.86 – 8.88)	1.87 (1.28 – 2.91)	0.0001 <sup>b</sup>
TEQ PCDFs (pg/g)	4.44 (3.07 – 6.0)	1.41 (1.10 – 1.78)	0.0001 <sup>b</sup>
Q total PCDDs+PCDFs (pg/g)	11.04 (8.02 – 14.9)	3.15 (2.43 – 4.61)	0.0001 <sup>b</sup>

Notes: Data are shown as median (inter – quartile range)

<sup>b</sup>Wilcoxon Signed Ranks Test

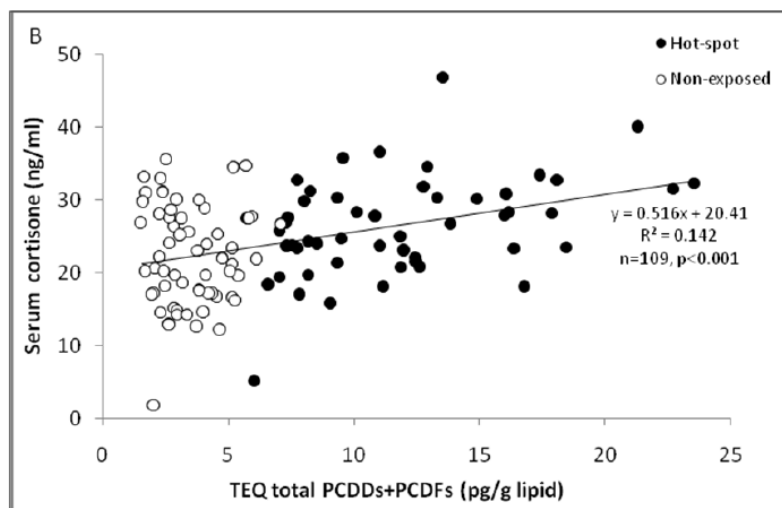
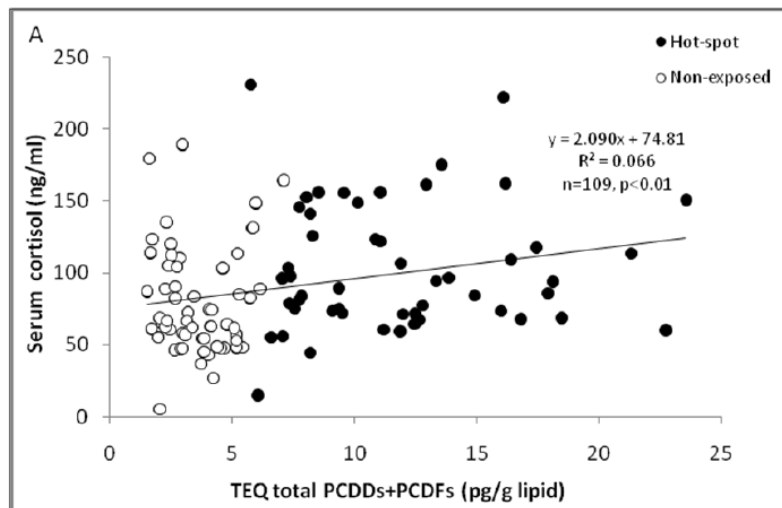
*European Journal of  
Endocrinology  
(2013) 170, 1–10*

**Fig 1. The correlation between cortisol (A), cortisone (B) concentration in **saliva** and dioxin level in breast milk in dioxin hot-spot and non-exposed areas**

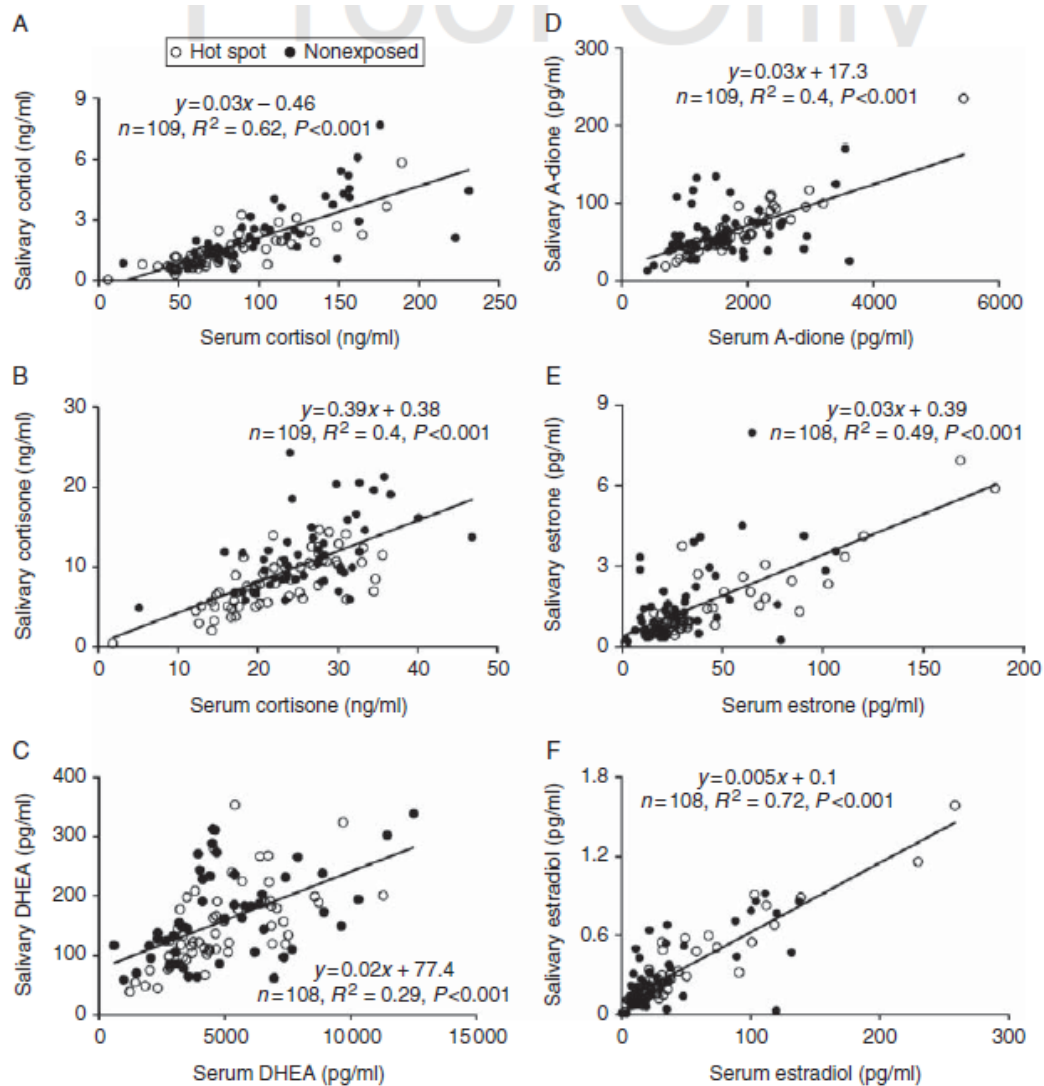


*European Journal of  
Endocrinology  
(2013) 170, 1–10*

**Fig 2. The correlation between cortisol (A), cortisone (B) concentration in **serum** and dioxin level in breast milk in dioxin hot-spot and non-exposed areas**



**Fig. 3. The correlation between serum hormone and salivary hormone in dioxin hot spot and non-exposed areas. A) Cortisol, B) Cortisone, C) DHEA, D) A-dione, E) Estrone, F) Estradiol**



**II . The relationship between  
breast milk dioxin and steroid  
hormone in Vietnamese infants**

# *The purpose of next study*

**It was to determine the adverse health effect of dioxin exposure on steroid hormone of Vietnamese infants**

# Research Areas

This study was carried out in Phu Cat district, Binh Dinh province and Kim Bang district, Ha Nam province in Vietnam.

**Phu Cat airbase** is one of three main **dioxin hot spots** in Vietnam and is located in southern Vietnam.

**Kim Bang district** is located in northern Vietnam and did not experience herbicide operations during the war, and was chosen as the control site.



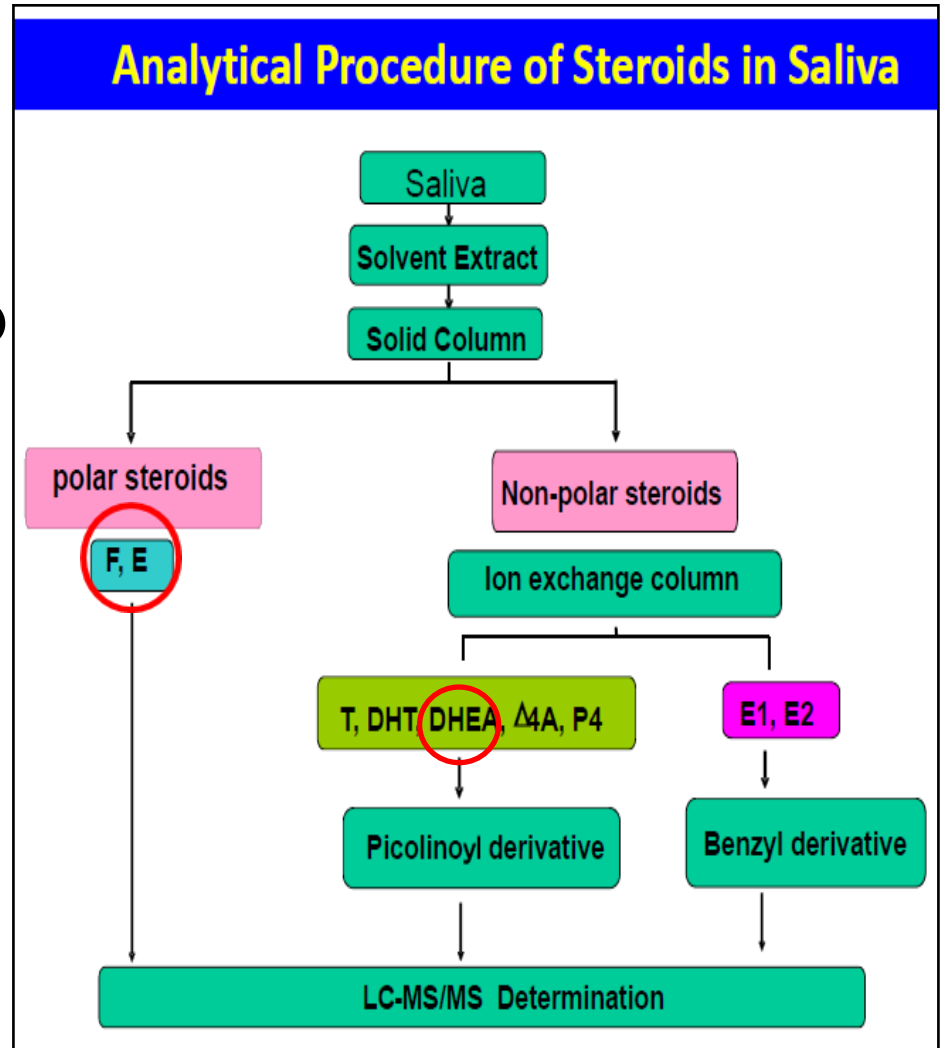
# Subjects

In August **2011**, about **0.25~0.8 ml** of saliva samples of their infants who grew up **about 3 years old** were collected in the morning (between **8:00 and 10:00 AM**) by using hormone free cotton. **One hundred and eleven infants** (52 from Phu Cat district and 59 from Kim Bang district) participated.



# Methods

**Cortisone, cortisol and dehydroepiandrosterone (DHEA)** were analyzed as salivary steroid hormone of infants.



**Table 1 Comparison of salivary steroid hormone of 3 year male infants between hot spot and non-exposed area**

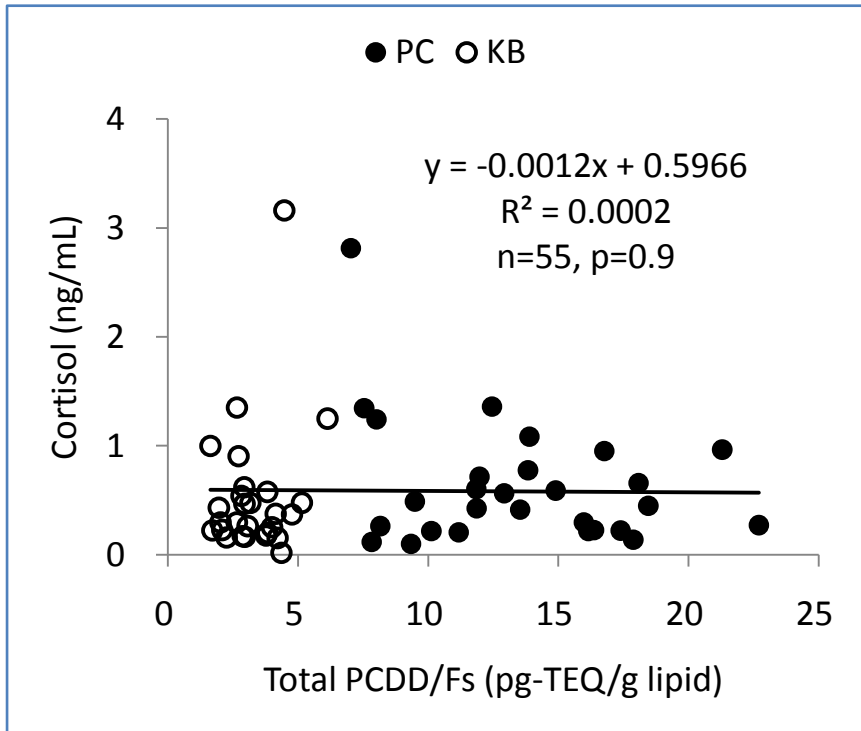
Indicators	Hot spot		Non-exposed		p Value
	n	Median (inter-quartile range)	n	Median (inter-quartile range)	
Cortisol (ng/mL)	29	0.49 (0.22-0.86)	27	0.37 (0.2-0.58)	0.25
Cortisone (ng/mL)	29	3.32 (1.83-5.17)	27	2.88 (2.02-4.36)	0.48
<b>DHEA (pg/mL)</b>	<b>29</b>	<b>39 (30-60)</b>	<b>27</b>	<b>69 (34-102)</b>	<b>0.02 *</b>

**Table 2 Comparison of salivary steroid hormone of 3 year female infants between hot spot and non-exposed area**

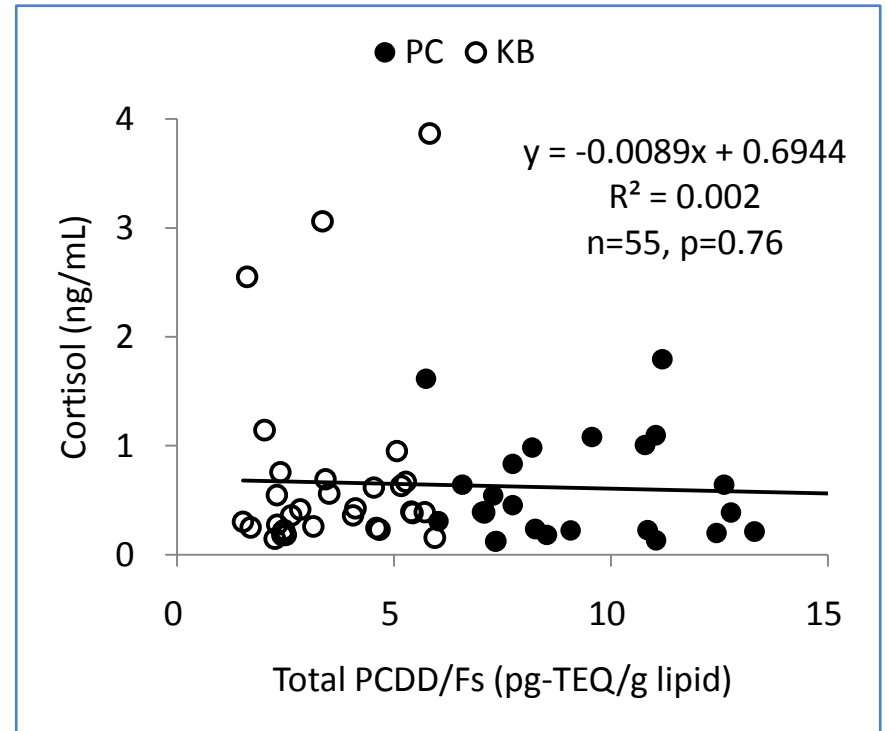
Indicators	Hot spot		Non-exposed		p Value
	n	Median (inter-quartile range)	n	Median (inter-quartile range)	
Cortisol (ng/mL)	23	0.39 (0.21-0.98)	32	0.39 (0.25-0.66)	0.85
Cortisone (ng/mL)	23	2.74 (1.32-6.0)	32	3.14 (2.04-3.83)	0.7
<b>DHEA (pg/mL)</b>	<b>23</b>	<b>32 (25-55)</b>	<b>32</b>	<b>77 (54-118)</b>	<b>&lt;0.001 ***</b>

# Cortisol

## Male

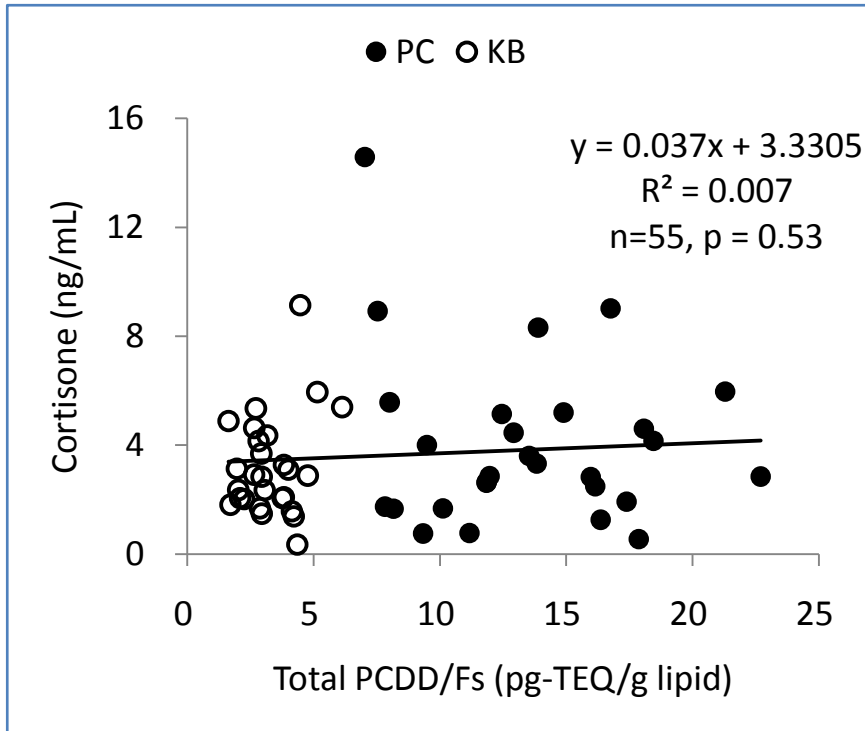


## Female

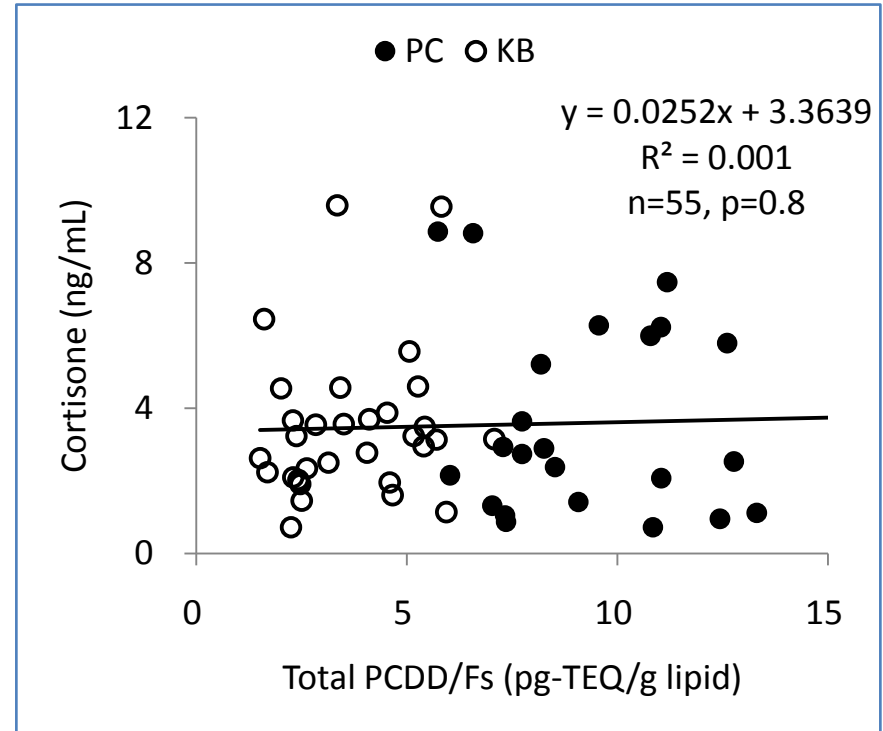


# Cortisone

## Male

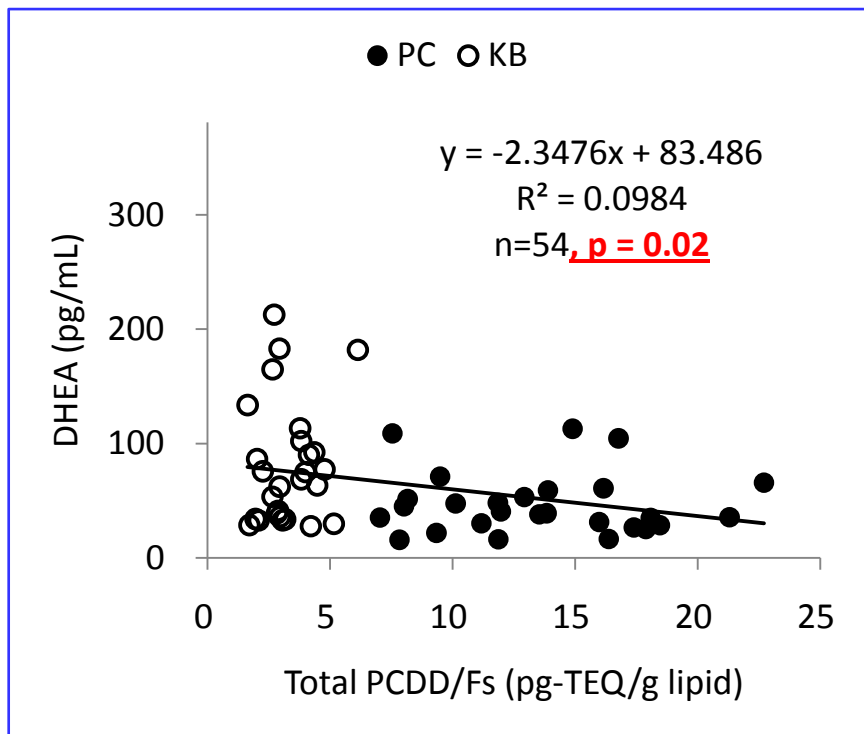


## Female

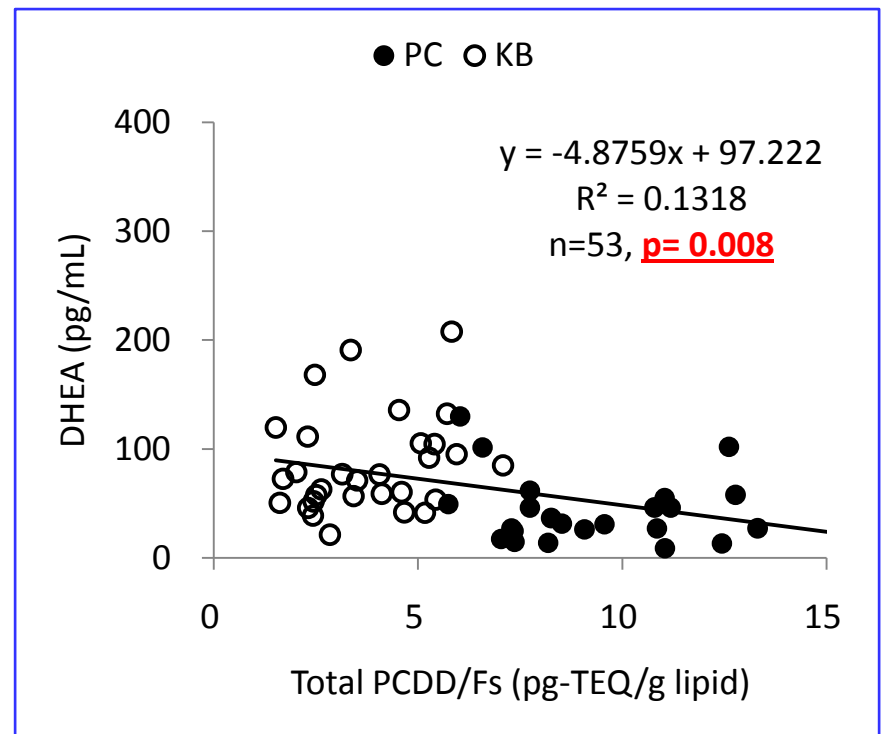


# DHEA

## Male

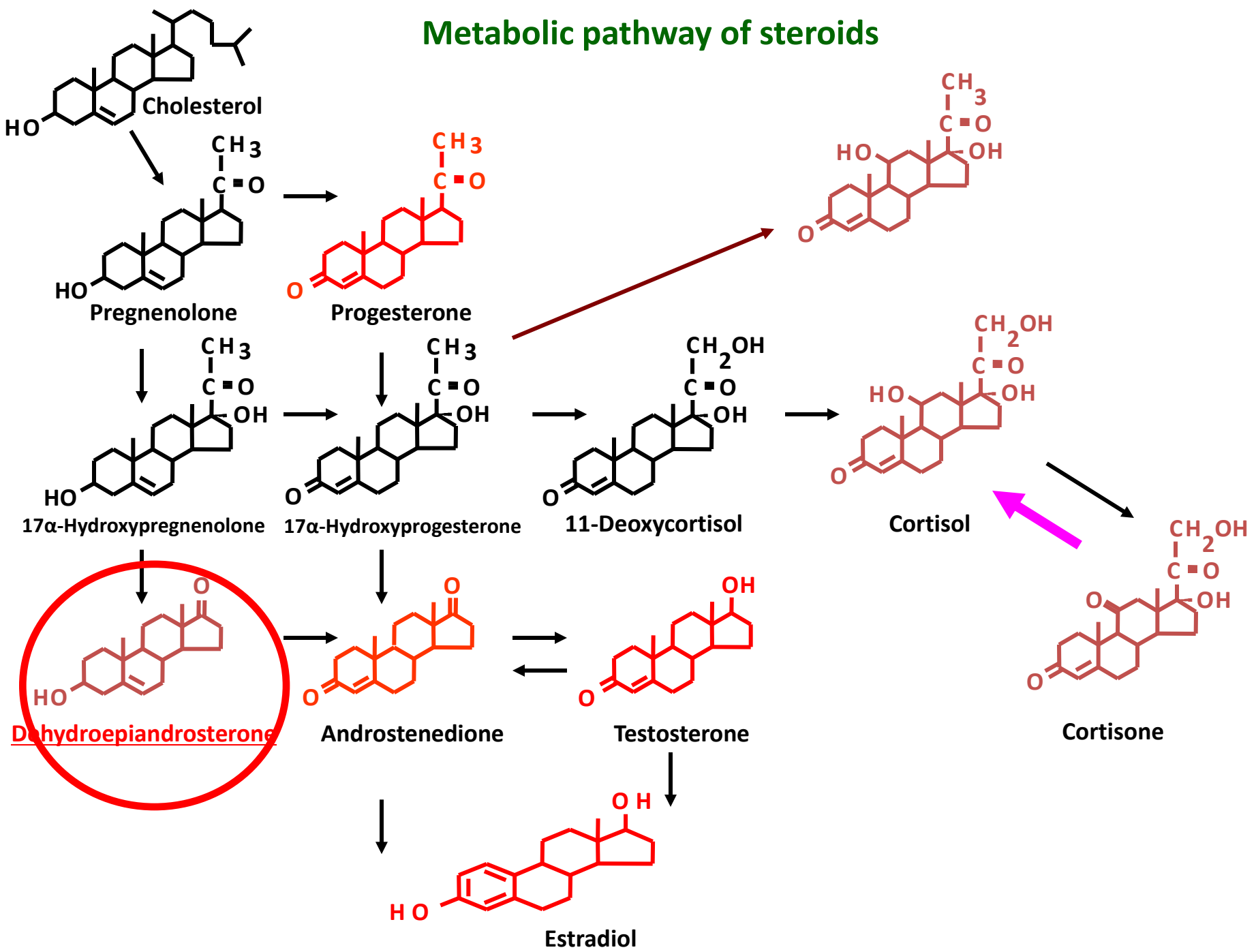


## Female



# *Discussion*

# Metabolic pathway of steroids



## *What is DHEA (Dehydroepiandrosterone)?*

- **The precursor of all potential sex steroids.**
- **A substrate for peripheral sex hormone biosynthesis.**
- **Loss of production could results in pronounced androgen deficiency in women. Clinical manifestations in women frequently include loss of axillary and pubic hair, dry skin and reduced libido.**
- **It has also been suggested that DHEA exerts direct effects on neurotransmitter receptors in the brain and may have potential antidepressant properties.**

(Endocrinology Vol. II Adult and pediatric, Saunders)

# *Conclusion*

- **This is the first report to find out that dioxin induces the inhibition of DHEA synthesis in infants.**
- **It is necessary to observe these infants consecutively and also increase the number of infants.**

**III. The relationship between dioxin  
and steroid hormones in serum  
of Vietnamese men**

# *Purpose (1)*

*To determine serum dioxin levels in Vietnamese old men from a dioxin hot spot and a non-exposed area.*

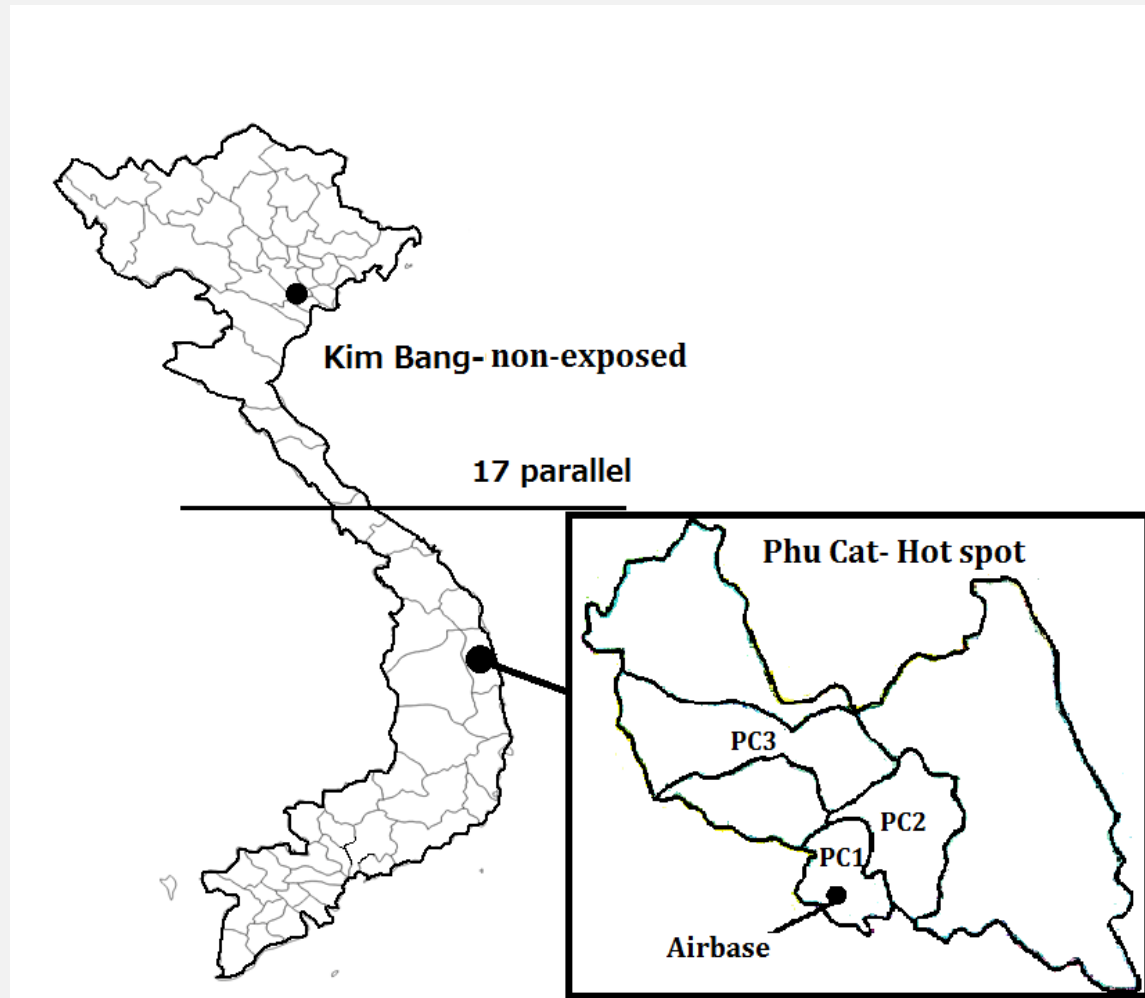
# Study design

Period: 2010 – 2011

Sample: 10-mL blood

Hot spot: 97 men

Non-exposed: 85 men



# Analysis of dioxins in blood

- Samples were analyzed in Shimadzu Techno-Research Inc., Kyoto, Japan
- Based on “Provisional manual of dioxin analysis in human blood” (Ministry of Health and Welfare, Japan, 2000)

# Results

# Characteristics of men in the two areas

	Hotspot (n=97)		Non-exposed (n=85)		
Continuous variables	Mean	SD	Mean	SD	p Value
Age (years)	68	6	67	5	0.9
Height (cm)	157	5	159	5	<b>0.001</b>
Weight (kg)	49	7	52	8	<b>0.005</b>
BMI (kg/m <sup>2</sup> )	20	2	21	3	0.1
Residency	65	11	58	10	<b>0.001</b>
Income(*1000 VND)	1300	1380	1314	1246	0.4
Category variables	N	%	N	%	
Soldier	33	34	67	69	<b>0.001</b>
Smoking	60	62	62	64	0.1
Alcohol	46	47	42	43	0.8

# Dioxins in hot spot and non-exposed area

pg/g lipid

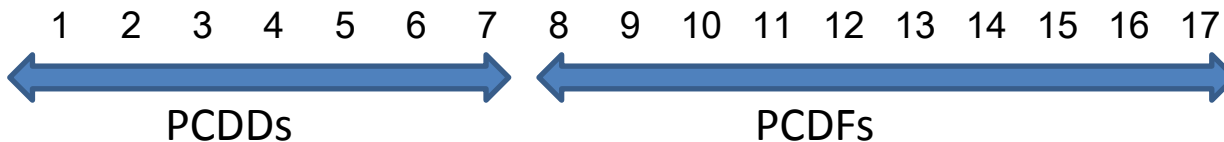
300  
200  
100

Hot spot (n=97)  
Non-exposed (n=85)

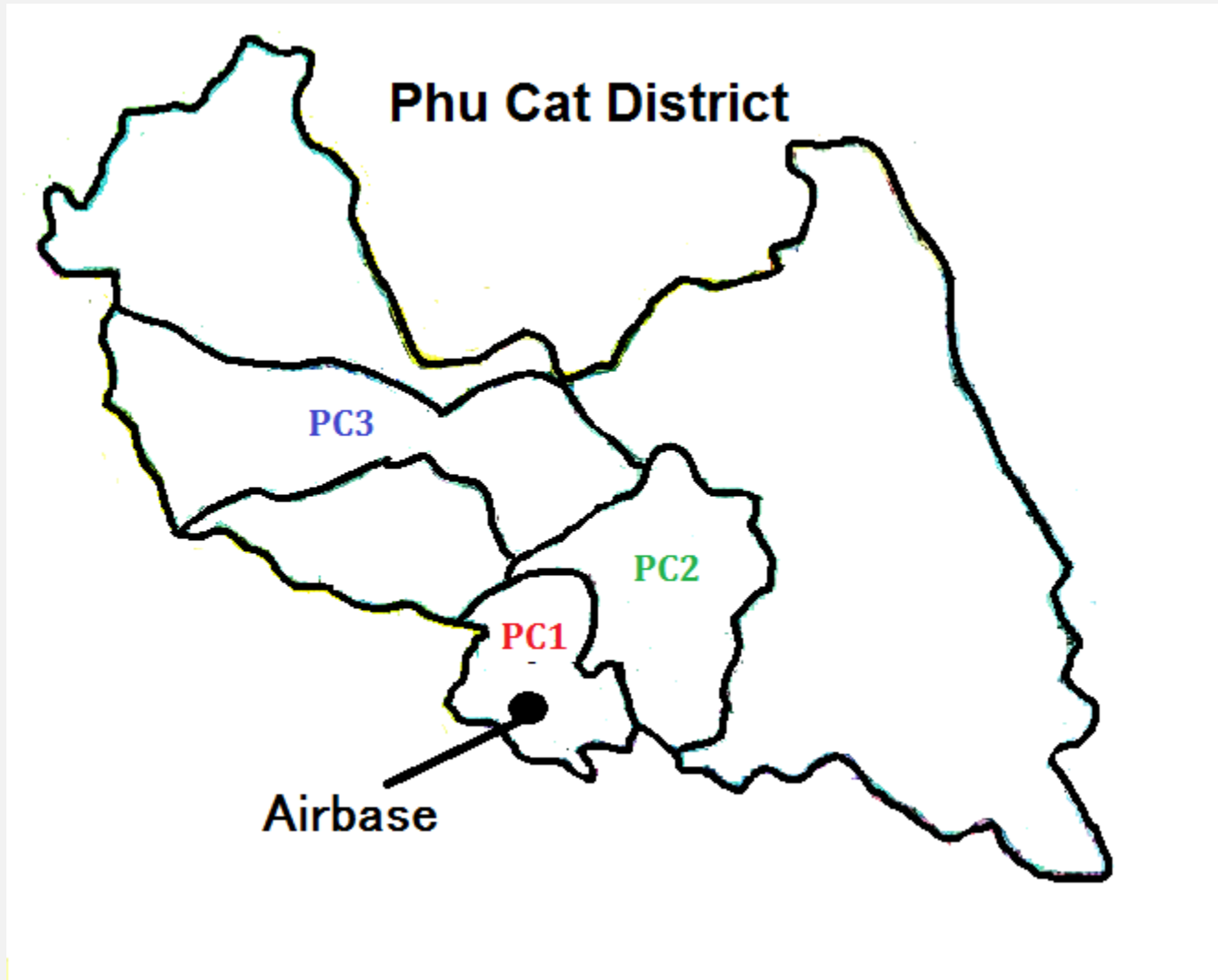


40  
20  
0

- |    |               |
|----|---------------|
| 1  | 2378-TeCDD    |
| 2  | 12378-PeCDD   |
| 3  | 123478-HxCDD  |
| 4  | 123678-HxCDD  |
| 5  | 123789-HxCDD  |
| 6  | 1234678-HpCDD |
| 7  | OCDD          |
| 8  | 2378-TeCDF    |
| 9  | 12378-PeCDF   |
| 10 | 23478-PeCDF   |
| 11 | 123478-HxCDF  |
| 12 | 123678-HxCDF  |
| 13 | 123789-HxCDF  |
| 14 | 234678-HxCDF  |
| 15 | 1234678-HpCDF |
| 16 | 1234789-HpCDF |
| 17 | OCDF          |



# Hot spot area



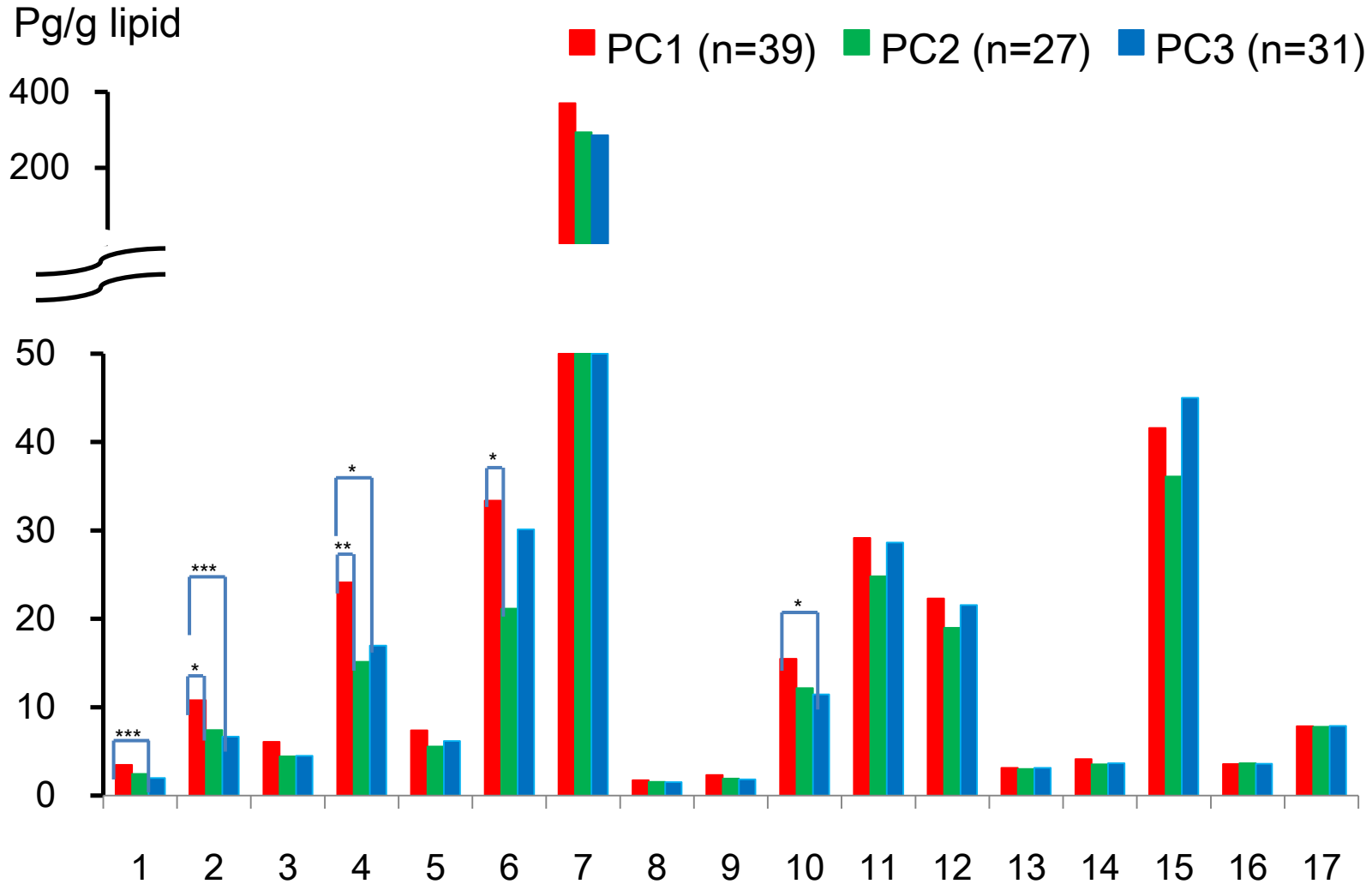
Total areas:

PC1: 40 km<sup>2</sup>

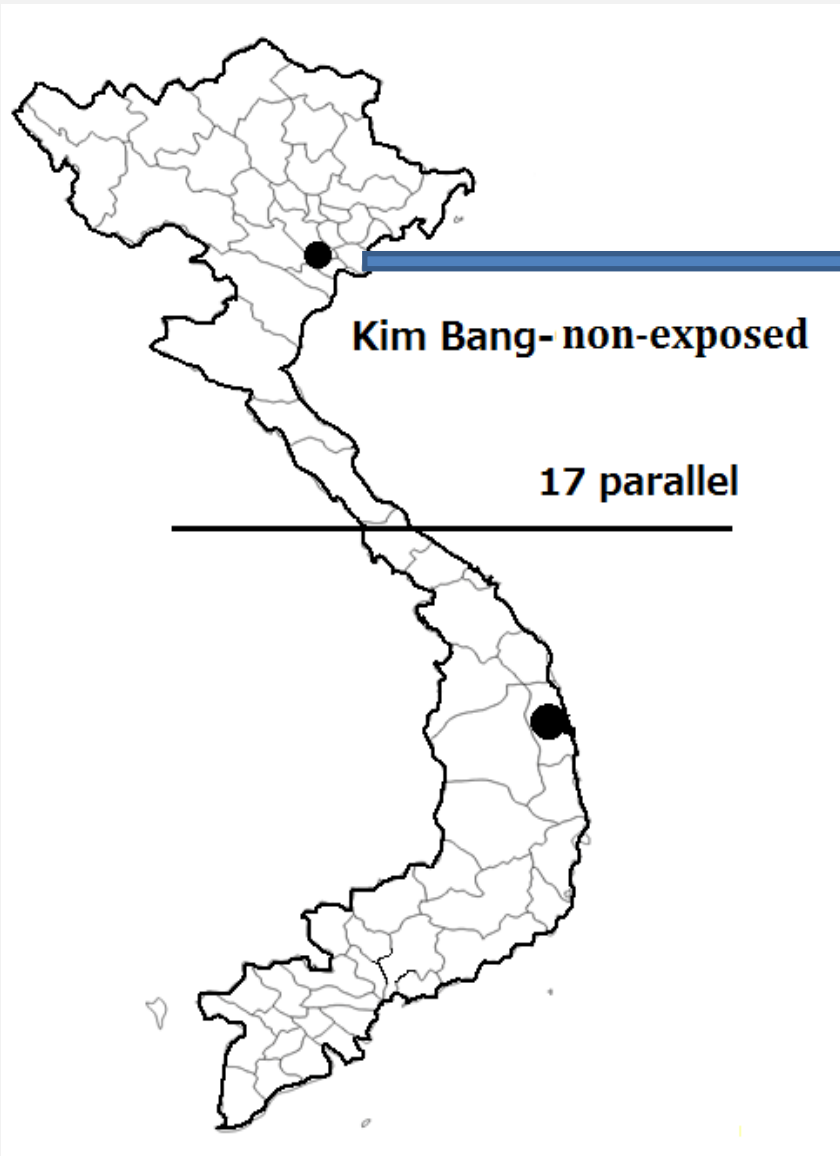
PC2: 80 km<sup>2</sup>

PC3: 110 km<sup>2</sup>

# Dioxin in 3 sub-areas in hotspot



# 3 groups in non-exposed area



Group A: stayed only in the North all their life time.

Group B: went to the South during herbicide spraying (1961-1971).

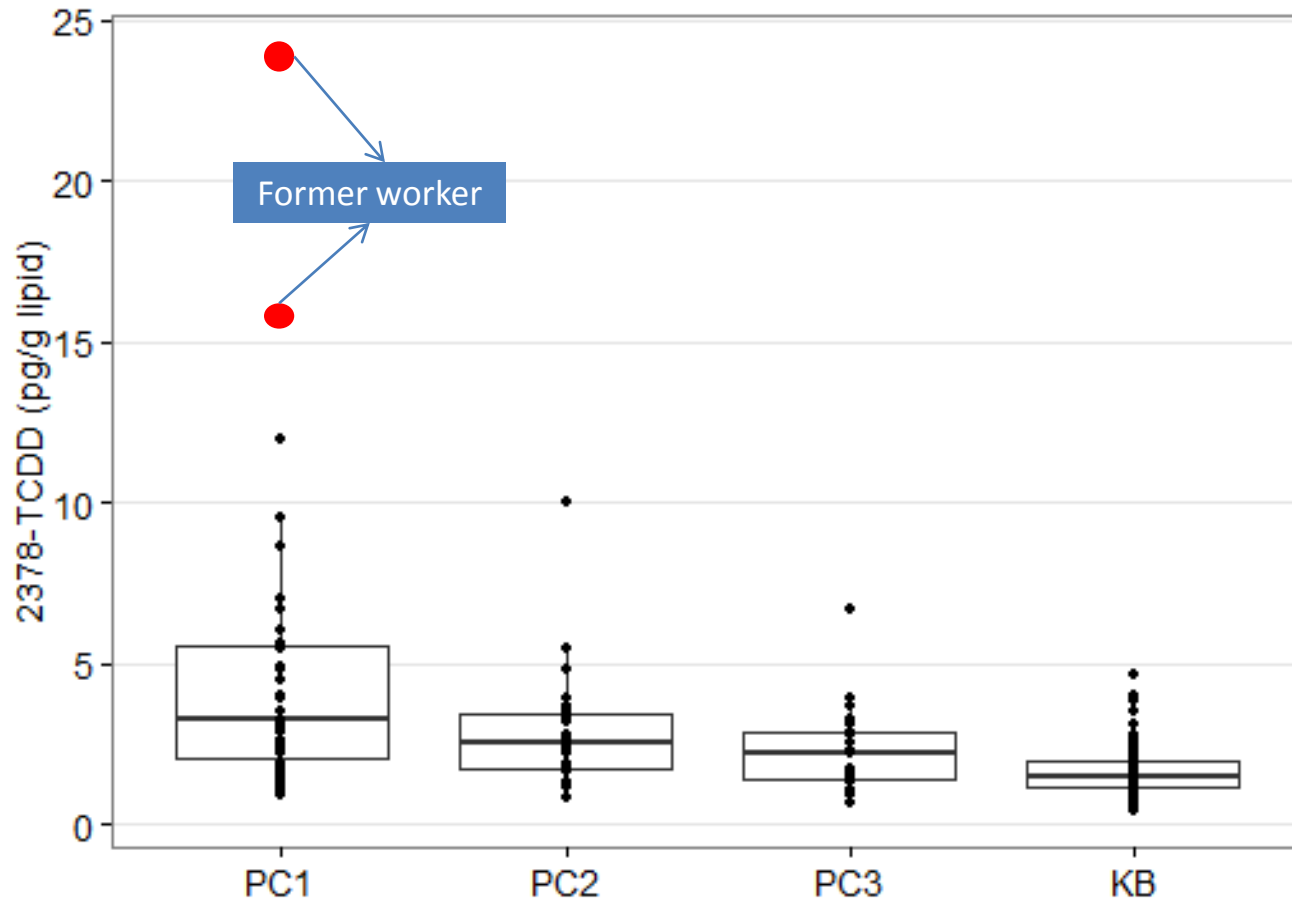
Group C: went to the South after 1971

# Dioxin among 3 groups in non-exposed area

	Group A (n=35)	Group B (n=38)	Group C (n=12)
<b>Geometric mean (Pg/g lipid)</b>			
2378-TeCDD	1.5	1.4	1.6
12378-PeCDD	2.5	2.2	2.7
123678-HxCDD	4.5	4.3	4.8
1234678-HpCDD	6.8	6.5	6.1
OCDD	57	57	76
23478-PeCDF	7.4	6.6	8.2
123478-HxCDF	4.2	4.2	5.5
123678-HxCDF	4.9	4.6	5.5
1234678-HpCDF	3.7	4.0	5.1
<b>TEQ pg/g lipid</b>			
Total PCDFs	4.0	3.7	4.6
Total PCDDs	5.4	4.8	5.8
Total PCDD/Fs	9.6	8.6	10.4

**We found no significant difference**

# TCDD levels



# Dioxin in hot spot compared with non-exposed area

Pg/g lipid	PC1		PC2		PC3		Overall R <sup>2</sup>
	10 <sup>β</sup>	p value	10 <sup>β</sup>	p value	10 <sup>β</sup>	p value	
2378-TeCDD	2.3	<0.001	1.6		1.2		0.31
12378-PeCDD	4.4	<0.001	3.0	0.04	2.5		0.52
123478-HxCDD	2.2	<0.001	1.6		1.5		0.33
123678-HxCDD	5.3	<0.001	3.3	0.05	3.5	0.01	0.65
123789-HxCDD	2.5	<0.001	1.8		1.9		0.38
1234678-HpCDD	4.9	<0.001	3.2		4.3	<0.001	0.65
OCDD	6.1	<0.001	5.0	0.002	4.7		0.69
23478-PeCDF	2.1	0.001	1.6		1.5		0.32
123478-HxCDF	6.5	<0.001	5.4	<0.001	5.9	<0.001	0.75
123678-HxCDF	4.4	<0.001	3.7	0.003	3.9	<0.001	0.66
1234678-HpCDF	9.8	<0.001	8.2	<0.001	9.6	<0.001	0.76
TEQ pg/g lipid							
Total PCDFs	2.8	<0.001	2.3	0.03	2.3	0.04	0.56
Total PCDDs	3.5	<0.001	2.4		2.1		0.55
<b>Total PCDD/Fs</b>	<b>3.2</b>	<b>&lt;0.001</b>	<b>2.4</b>	<b>0.04</b>	<b>2.2</b>		<b>0.58</b>

β is regression coefficients

Using multiple linear regression to adjust for age, BMI, residency, smoking

# Discussion


# TCDD levels

- Agent Orange mainly contaminated by TCDD
- Breast milk collected after the war show elevated TCDD, which account for > 90% TEQ PCDD/Fs
- In this study, serum TCDD levels were low, account for ~ 10% TEQ PCDD/Fs (maximum is 24 pg/g lipid)
- TCDD was degraded over time

# Higher chlorinated PCDD/Fs

- Generally, PCDD/Fs come from many sources, mainly anthropogenic combustion process  
(transportation, heating, cooking, incineration, waste burning, industrial)
- This studies found elevation in both TCDD and other higher chlorinated PCDD/Fs and PCB169  
→ Existing other contamination sources in hotspot area besides herbicide used in the past

# Dioxin in Northern soldiers

- Half-life of TCDD: ~7 years ( Milbrath, 2009)
  - Only one study analyzed dioxin in Northern soldier in ~1990 (Schechter, 1992)
    - Pooled adipose tissue was 8.1ppt. Until now 3 half-lives passed, this level must become ~ 1ppt
  - Our study showed serum TCDD level ~1.5ppt in three groups in non-exposed area
-  Currently, dioxin in Northern soldier become low as general population

# Conclusion

- First dioxin study on old men from a hot spot and a non-exposed area.
- Serum dioxin levels were higher in hotspot.
- In hotspot, the closer to Airbase, the higher dioxin levels.
- In non-exposed area, dioxins were not elevated in former soldiers

## **Purpose(2)**

The aim of this study was therefore to explore the impact of Agent Orange on serum steroid hormones in Vietnamese men with comparison of the steroid hormones levels between hotspot area and non-sprayed area.

# Methods

Subjects:

Hotspot area: 48 men.

Non-sprayed area: 36 men.

Age: Above 50 years old.



# Results

Table 1 Demographic characteristics of participants in the hotspot and non-sprayed areas

Characteristics		Hot spot area			Non-sprayed area			P-value
		N	Mean±SD number	%	N	Mean±SD number	%	
Age	(years)	48	67.8±6.4(59-81)		35	64.8±4.4(56-77)		0.013 <sup>1)</sup>
Height	(cm)	48	156.6±4.2		36	159.8±5.0		0.002 <sup>2)</sup>
Weight	(kg)	48	49.3±7.8		36	52.4±7.4		0.072 <sup>2)</sup>
BMI	(kg/m <sup>2</sup> )	48	20.1±2.8		36	20.5±2.4		0.490 <sup>2)</sup>
Alcohol habit	(Yes)	48	21	43.8	36	16	44.4	0.949 <sup>3)</sup>
Smoking habit	(Yes)	48	27	56.3	36	29	80.6	0.019 <sup>3)</sup>
Present Job	(Yes)	48	32	66.7	36	14	38.9	0.011 <sup>3)</sup>
Kind of present job								
Multiple-choice	(Yes)	32	2	6.3	14	0	0	
Farmer	(Yes)	30	24	80	14	7	50	
Worker	(Yes)	30	0	0	14	2	14.3	
Fisher	(Yes)	30	0	0	14	1	7.1	
Teacher	(Yes)	30	0	0	14	0	0	
Other job	(Yes)	30	6	20	14	4	28.6	

<sup>1)</sup> Welch test <sup>2)</sup> Student's t- test <sup>3)</sup> Chi-squared test

SD: standard deviation, BMI: body mass index

Table 2 A comparison of dioxins levels in the serum between hotspot and non-sprayed areas

Dioxins		Hotspot area	n-sprayed area	p-value
		n=48	n=36	
PCDDs(GM GSD)	(pg-TEQ/g lipid)	16.6 1.9	4.8 1.5	<0.0001 <sup>1)</sup>
PCDFs(GM GSD)	(pg-TEQ/g lipid)	11.9 1.7	3.6 1.5	<0.0001 <sup>1)</sup>
PCDDs+PCDFs(GM GSD)	(pg-TEQ/g lipid)	29.0 1.7	8.4 1.5	<0.0001 <sup>1)</sup>
PCBs(GM GSD)	(pg-TEQ/g lipid)	7.7 2.0	3.4 1.9	<0.0001 <sup>2)</sup>
PCDD/DFs+PCBs(GM GSD)	(pg-TEQ/g lipid)	37.2 1.8	12.2 1.5	<0.0001 <sup>1)</sup>

<sup>1)</sup> Welch test    <sup>2)</sup> Student's t- test

GM: geometric mean, GSD: geometric standard deviation

Table 3 A comparison of serum steroid hormone in male between hotspot and non-sprayed areas

Characteristics		Hotspot area (n=48)	Non-sprayed area (n=36)	p-value
Cortisol(Mean±SD)	(ng/mL)	81.8 ± 31.9	81.3 ± 31.3	0.941
Cortisone(Mean±SD)	(ng/mL)	15.4 ± 4.6	15.6 ± 3.3	0.784
Progesterone(GM GSD)	(pg/mL)	38.0 1.8	41.9 1.7	0.575
Dihydrotestosterone(GM GSD)	(pg/mL)	615.2 1.5	548.3 1.4	0.179
<b>Testosterone(GM GSD)</b>	<b>(pg/mL)</b>	<b>6309.6 1.4</b>	<b>5395.1 1.4</b>	<b>0.029</b>
Dehydroepiandrosterone(Mean±SD)	(pg/mL)	1388.2 ± 550.0	1727.6 ± 717.6	0.016
Androstenedione(GM GSD)	(pg/mL)	1552.4 1.5	1671.1 1.4	0.358
<b>Estradiol(Mean±SD)</b>	<b>(Pg/mL)</b>	<b>12.5 ± 4.1</b>	<b>10.8 ± 3.3</b>	<b>0.042</b>
Estrone(Mean±SD)	(Pg/mL)	28.4 ± 8.2	30.1 ± 9.2	0.366

Student's t-test

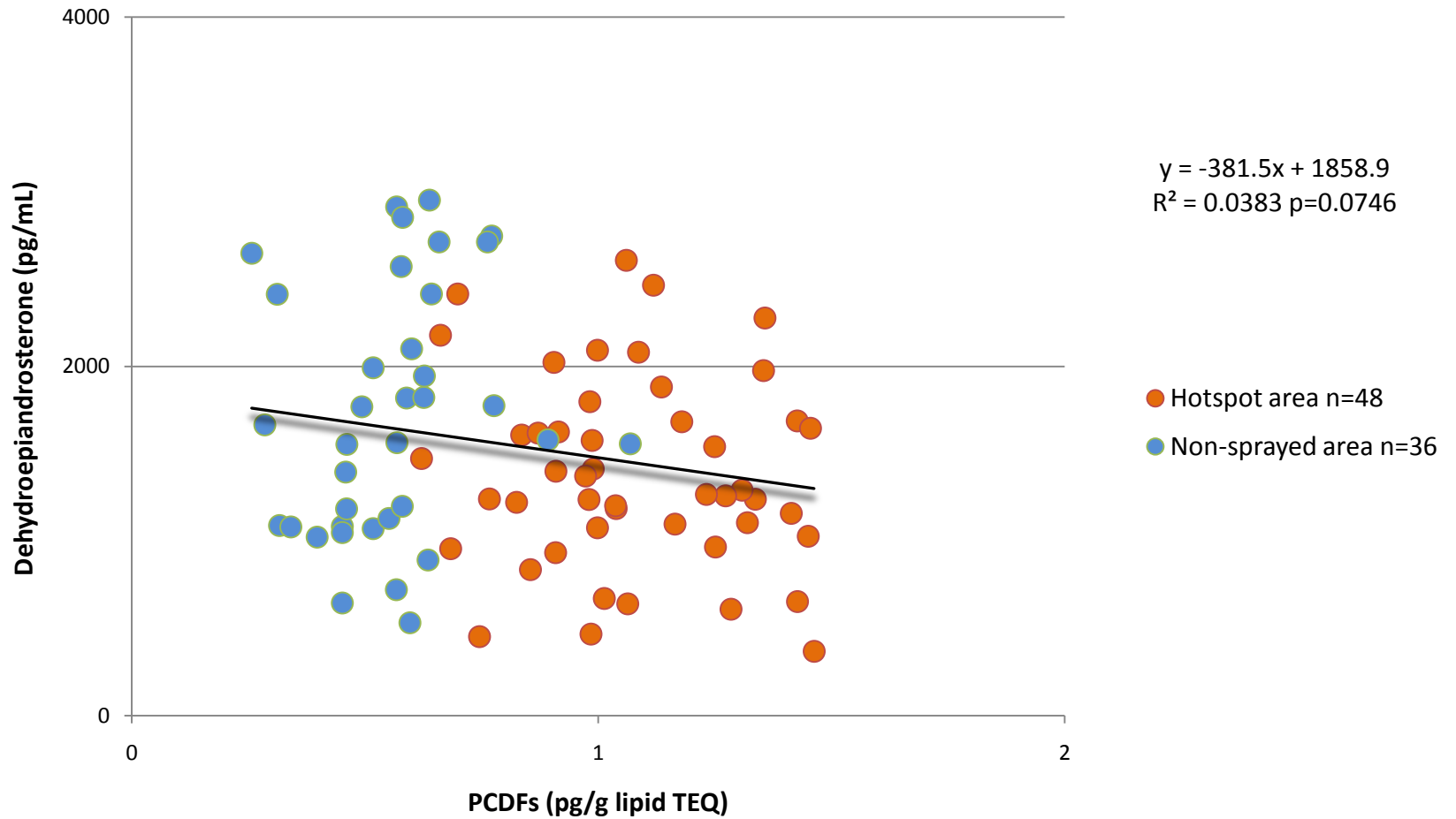
SD: standard deviation, GM: geometric mean, GSD: geometric standard deviation

Table 4 Correlation of steroid hormone and dioxin levels in hotspot and non-sprayed areas

Characteristics	PCDDs	PCDFs	PCDD/DFs	PCBs	PCDD/DFs+PCBs
Cortisol	0.081	0.038	0.063	0.099	0.072
Cortisone	0.075	0.038	0.062	0.082	0.076
Progesterone	0.094	0.090	0.098	0.079	0.109
Dihydrotestosterone	0.125	0.145	0.141	0.004	0.116
Testosterone	0.179	0.124	0.162	0.077	0.147
Dehydroepiandrosterone	0.192	0.200	0.198	0.179	0.204
Androstenedione	0.021	0.040	0.033	0.056	0.046
<b>Estradiol</b>	<b>0.235*</b>	0.184	<b>0.223*</b>	0.135	<b>0.216*</b>
Estrone	0.035	0.024	0.028	0.113	0.024

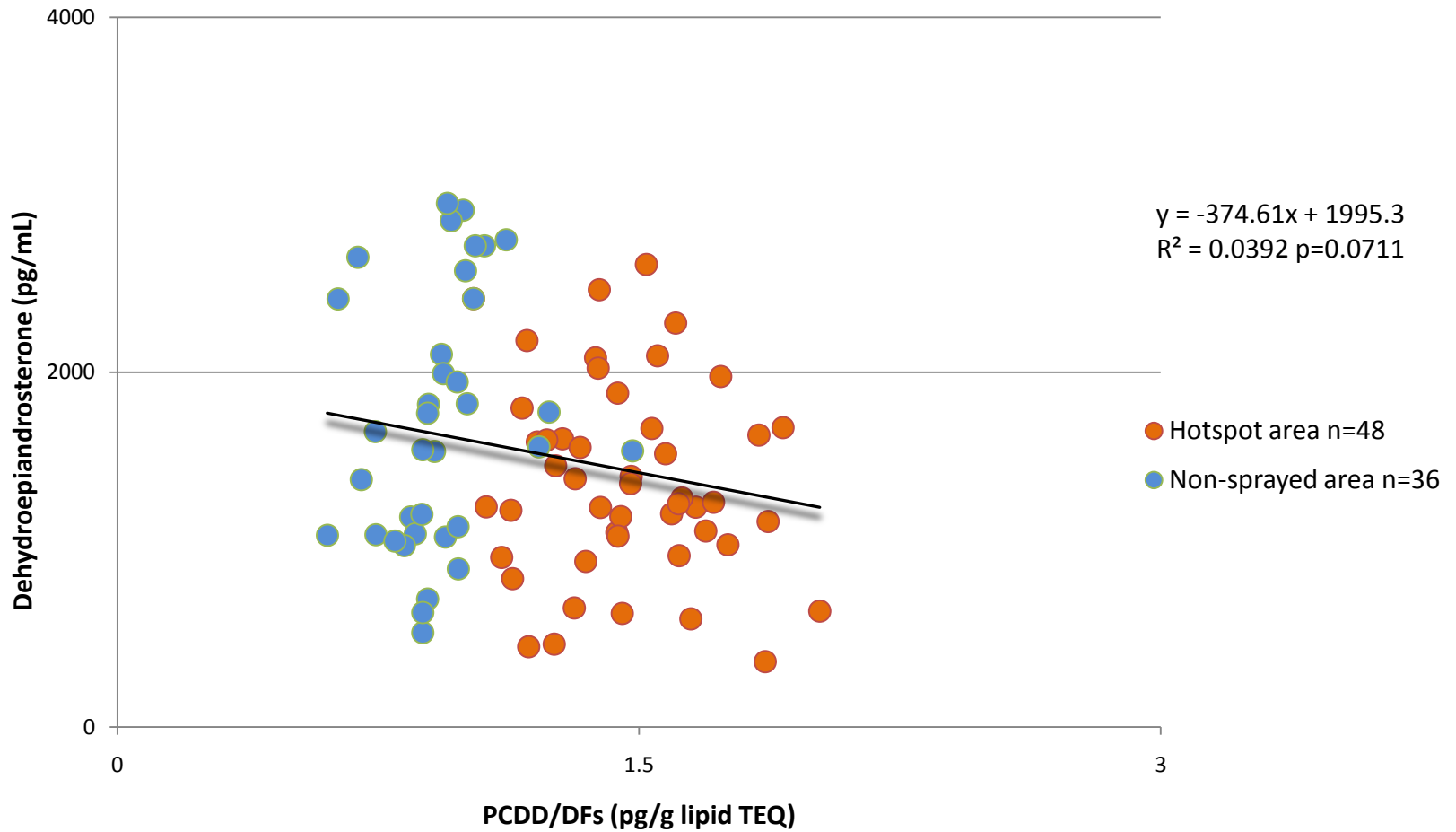
Note: \*p<0.05

# Correlation of DHEA and PCDFs



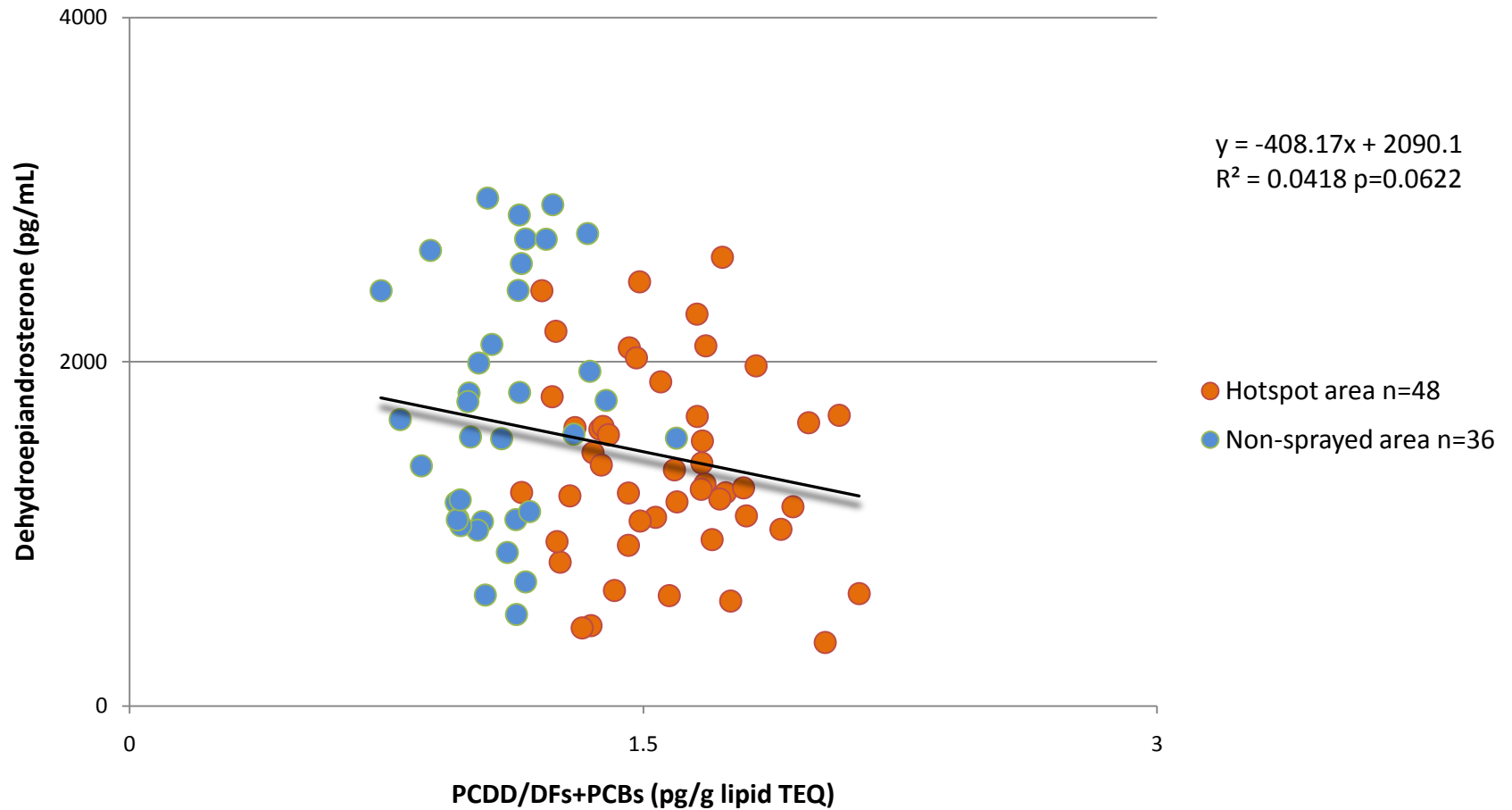
Dioxins values were log-transformed

# Correlation of DHEA and PCDD/DFs



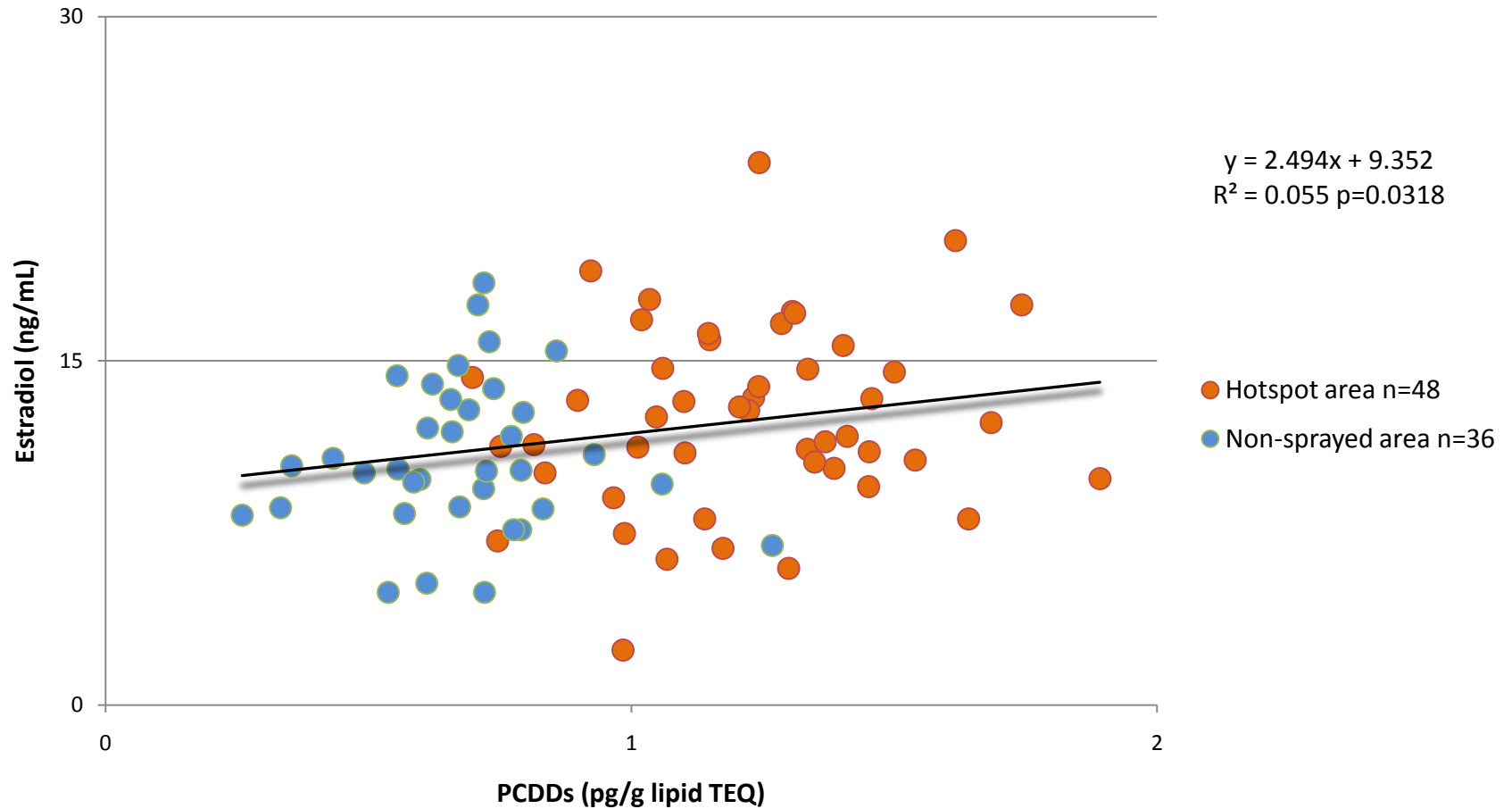
Dioxins values were log-transformed

# Correlation of DHEA and PCDD/DFs+PCBs



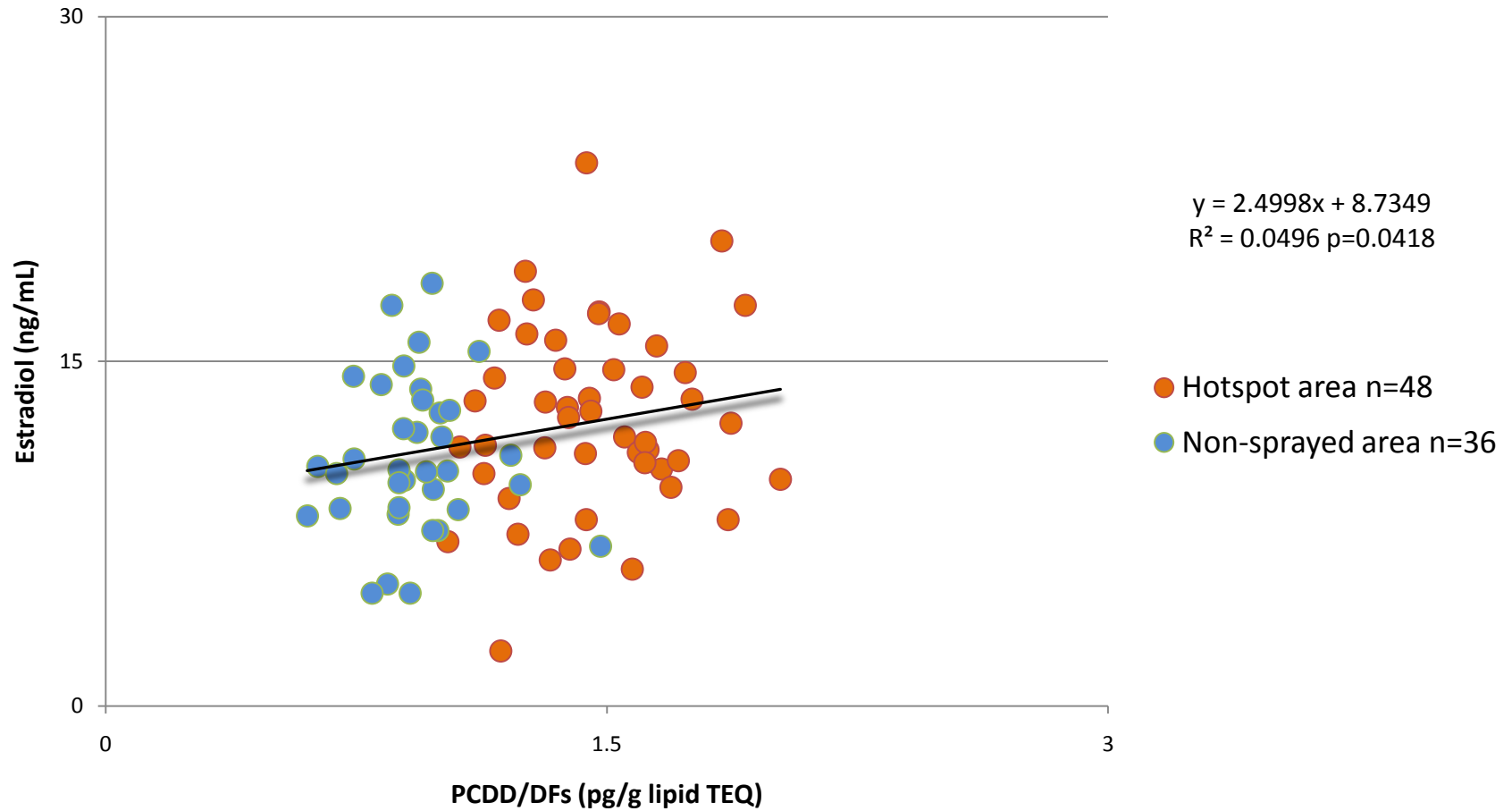
Dioxins values were log-transformed

# Correlation of estradiol and PCDDs



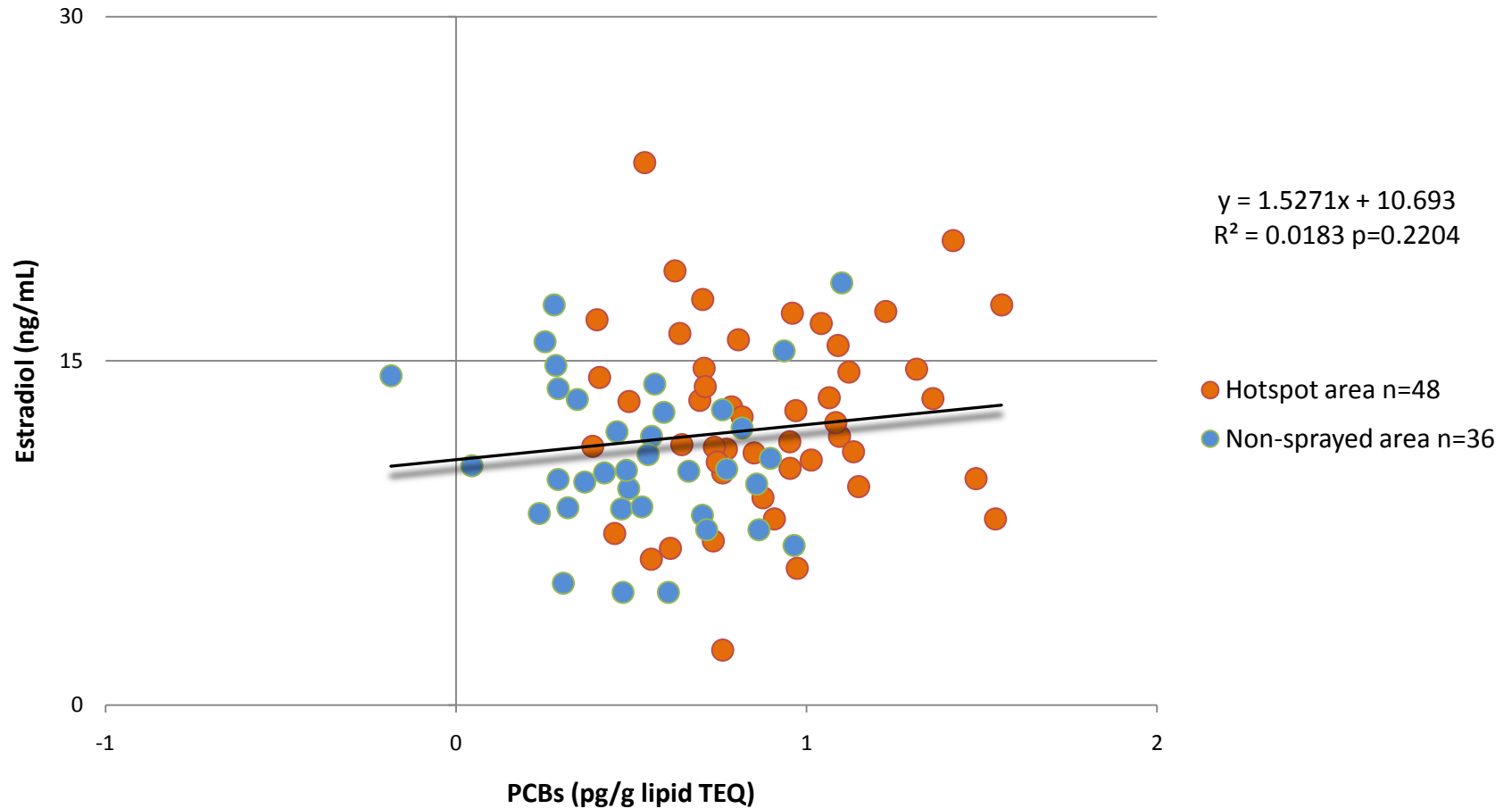
Dioxins values were log-transformed

# Correlation of estradiol and PCDD/DFs



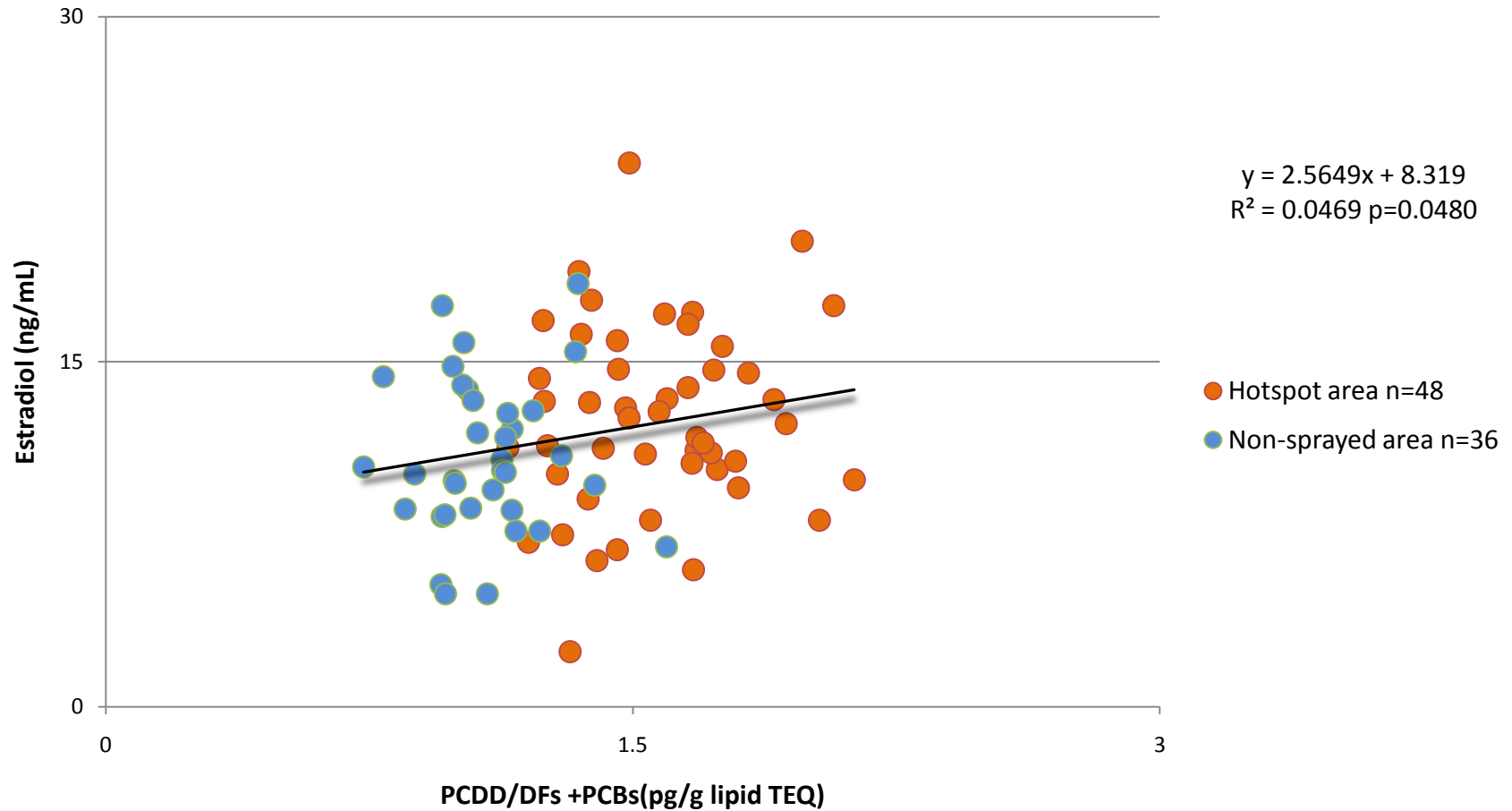
Dioxins values were log-transformed

# Correlation of estradiol and PCBs



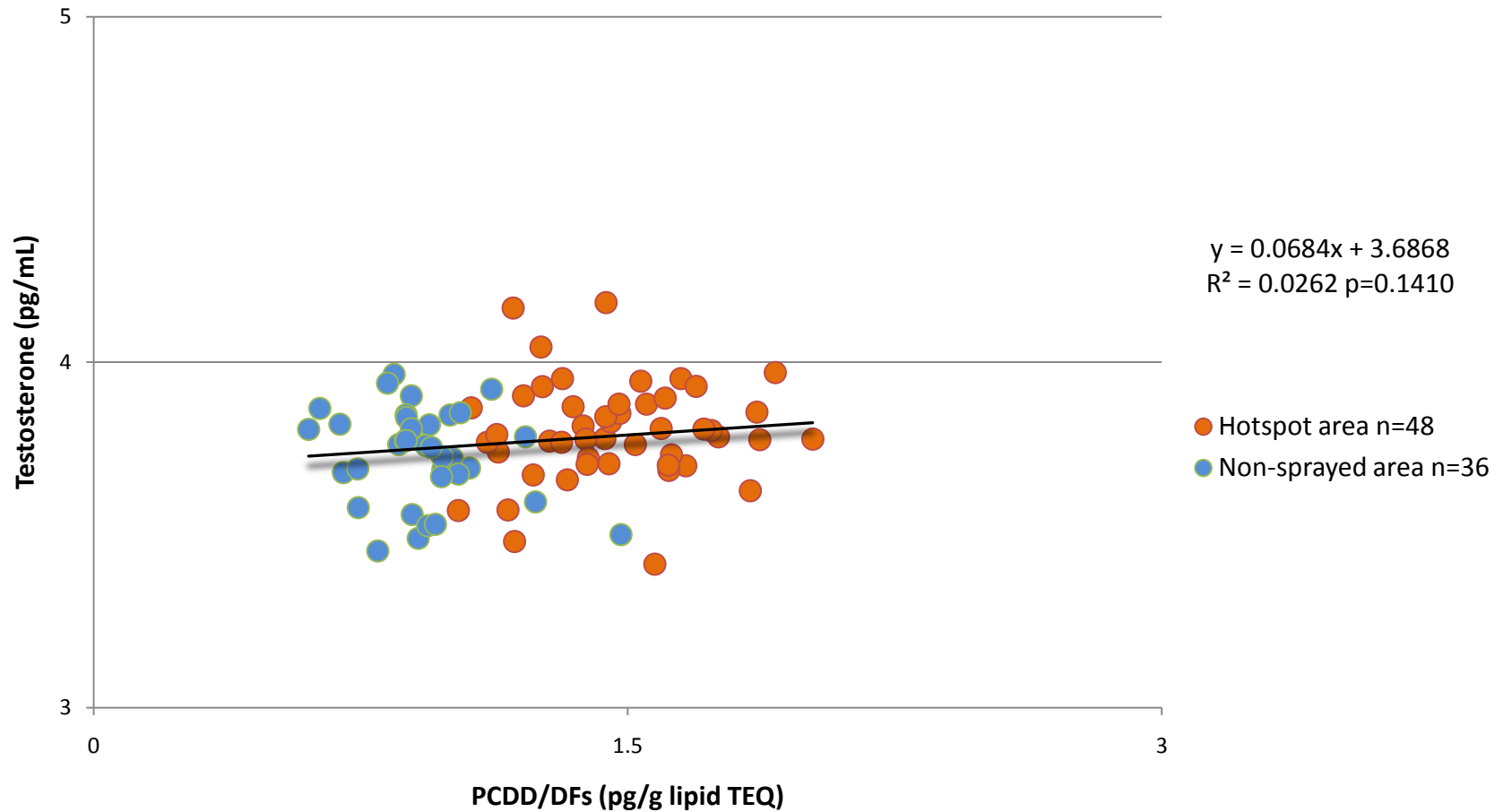
Dioxins values were log-transformed

# Correlation of estradiol and PCDD/DFs+PCBs



Dioxins values were log-transformed

# Correlation of testosterone and PCDD/DFs



Dioxins and testosterone values were log-transformed

Table 7 Multivariate analysis for estradiol

Variable	t Ratio	95% CI	p-value
PCDDs	1.13	-1.09 – 3.95	0.2625
PCDFs	0.42	-2.22 – 3.41	0.6743
PCDDs+PCDFs	0.90	-1.48 – 3.93	0.3700
PCBs	0.62	-1.75 – 3.33	0.5394
PCDD/DFs+PCBs	0.94	-1.49 – 4.15	0.3517

CI: confidence interval

All analyses were adjusted for age, BMI, present job and smoking habit

# Discussion

# Animal studies

- In recent years, animal experiments have demonstrated that dioxins that either compose the foods in our diet or contaminate them can: (1) act like the steroid hormones, (2) increase the production or metabolism of hormones.
- To our knowledge, this is the first study concerning the relationship between dioxins and steroid hormones in Vietnamese men.

# Steroid hormone and dioxins

- The testosterone, dehydroepiandrosterone (DHEA), and estradiol levels were significant differences between the hotspot and non-sprayed areas.
- There was a significant correlation between estradiol and PCDDs, PCDDs+PCDFs, and PCDD/DFs+PCBsTEQ levels in the hotspot and non-sprayed areas.
- However, after adjusted for age, BMI, present job, and smoking habit, there were not significant correlations between serum estradiol, DHEA and testosterone and serum dioxin TEQs.

- In contrast, several previous studies have found an inverse relation between serum TCDD levels and serum testosterone in chemical production workers and Operation Ranch Hand veterans (air force veterans), and TCDD decreases estradiol production without altering either the P450<sub>arom</sub> enzyme protein or activity.

- However, previous studies are limited by the fact that serum levels were measured only for TCDD and they did not have data on the levels of other dioxin and dioxin-like congeners.
- Furthermore, half-life of dioxin in humans is estimated to be between 7 and 11 years.
- More than 40 years have passed after Vietnam war--since about 4 half-life have passed.

# Summary

- This is the first study concerning the relationship between dioxins and steroid hormones in Vietnamese men.
- All of TEQ dioxins levels in the hotspot area were significantly higher than those in the non-sprayed area.
- In addition, testosterone, dehydroepiandrosterone (DHEA), and estradiol levels were significant differences between the hotspot and non-sprayed areas.
- However, this present study found no significant correlation between testosterone, dehydroepiandrosterone, and estradiol and dioxins levels , after adjusted for age, BMI, present job, and smoking habit in the hotspot +non-sprayed area.