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RESEARCH ARTICLE

In utero exposure to organochlorine pesticide residues and their potential impact on birth outcomes and fetal gender

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Abstract

Being the largest agriculture country in the Arab world, Egypt was one of the major consumer of organochlorine pesticides (OCPs) in this area, continued to have a heavy burden of OCPs in the environment. There is growing concern that OCPs could pass from the maternal circulation through the placenta to the fetal circulation and pose several health risks to their fetuses. The current study was intended to identify OCPs residue exposure in healthy pregnant women and to justify the potential impacts of these residues on their fetuses. In this study, the prevalence of 18 OCPs was estimated in 81 maternal and cord blood samples, using Agilent 7890, gas chromatograph equipped with micro-electron capture detector (GC-μECD). Our data signposted that the heptachlor epoxide has the highest detection rate among all residues in both maternal (32%) and cord blood serum (27.16%). DDTs were still quantifiable, but with the lowest quantifiable percentage. More than 85% of mothers' serum with detectable residues transfer OCPs residue to their fetuses in a statistically significant manner ($x = 42.9$, p value < 0.001). The present findings showed no significant growth retardation, or preterm delivery induced by in utero exposure to the most abundant residues. There is growing evidence that exposure to OCPs residue has profound impact on sex ratio. Methoxychlor, in this study be deemed as testosterone triggers which yields high boys ratio ($x = 4.37$, $p < 0.05$). In conclusion, Egypt continued to have a heavy burden of OCPs residues, and fetuses and infants are especially the most vulnerable groups to their adverse health effects. Exposure to OCPs may disrupt the maternal hormones, which regulate the offspring gender, but these results need to be validated in larger sample sizes.

Keywords In utero exposure · Organochlorine pesticide residues · Birth outcomes · Methoxychlor · Gender of fetuses

Introduction

Since the 1940s, organochlorine pesticides (OCPs) have been extensively and widely used to control pests in agriculture sector all over the world and in public health for governing vector borne diseases such as mosquito. Large quantities of OCPs had been released into the environment, and numerous of them have been banned or restricted by the Stockholm agreement, for their environmental consequences and human health impacts (UNEP 2001).

Being the largest agriculture country in the Arab world, Egypt was one of the supreme consumer of OCPs in this area, and accordingly, continued to have a heavy burden of OCPs in the environment (Mansour 2008). Although stoppage utilization of OCPs, several reports still revealed that OCPs residues are still detectable in the Egyptian environment (Abou-Arab et al. 1998; Khairy et al. 2012; Barakat et al. 2013, and El Nemr et al. 2016). Importantly, OCPs residues have been detected also in the blood, in normal and cancerous tissue (Eldakroory et al. 2017, Ghazy et al. 2017), in adipose tissue, and in breast milk of the general population (Sharaf et al. 2008; Sharaf et al. 2013). Multiple concerns are related to OCPs potential health effects, which originate from their relative stability and lipophilic properties, which enhance their bioaccumulation in human adipose tissue following exposure (Sharaf et al. 2013).

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Several studies, during the last decades, had documented their trans-placental transfer from maternal stores (Pereg et al. 2002; Siddiqui et al. 2003; Chao et al. 2007), and even extremely low levels can damage the immune system of the developing fetuses and may lead to unfavorable developmental insults (Al-Saleh et al. 2012; Dewan et al. 2013; Guo et al. 2014; Tyagi et al. 2015), including reduced birth weight (Rylander et al. 2006), preterm birth (Longnecker et al. 2001), growth retardation (Siddiqui et al. 2003), altered psychomotor, and cognitive functions (Rogan et al. 1986).

The extent of trans-placental transfer of the toxic chemical compounds depends on the characteristic properties of the xenobiotics, like the molecular weight, the degree of chlorination (Mori et al. 2014; Vizcaino et al. 2014; Lancz et al. 2015; Zhang et al. 2018). Passive diffusion has been proposed to control the transport of most xenobiotic across the placenta (Myllynen et al. 2005). The underlying mechanisms are not clearly understood also, data about OCPs exposure in the Egyptian pregnant women and their fetuses are currently deficient.

The objective of the present work was to recognize OCPs residue exposure rate among healthy pregnant women by examining their proportion in maternal and umbilical cord blood serum, to identify the relationship between OCPs residue, dietary habits, and socio-demographic characteristics of this population, and to explore the possible association of OCPs residue with the birth consequences.

Subjects and methods

Target population

This cross-sectional study was conducted on 81healthy pregnant women (free from any chronic diseases) at the time of labor and their healthy fetuses. They were chosen randomly from those attending El-Galaa Teaching Hospital as a research project, funded by the National Research Centre 10th research plan, entitled "Immunological Profile in Cord Blood and Growth Assessment of the Newborn About Maternal Exposure To Environmental Contaminant" (Grant number 11010140). The study was conducted in the period from September 2016 to June 2017.

The study protocol was approved by the Institutional Ethical Committee for Medical Researchof the National Research Centre, Egypt (Code Number 16–295).

The mother's ages ranged between 18 and 40 years. Neonates were of both sexes. Pregnant mothers with a history of chronic diseases or major illnesses during pregnancy were excluded. Neonates with any apparent congenital abnormalities, genetic, metabolic, or neurological problems were also excluded.

Socio-demographic data about mothers included age, social status, economic responsibility, water source availablility, sanitary disposal, smoke exposure, and education. Gestational age, type of labor, history of delivery problems, and chronic diseases were also registered. Maternal anthropometric measurements of weight in kilograms (kgs) and height in centimeters (cm) (WHO 1995) were done. In addition, neonatal Apgar scores, at 1 and 5 min., were recorded to assess neonatal condition at birth (Apgar et al. 1958). As well, neonatal anthropometric parameters of weight (kgs) and height (cm) were all taken (WHO 2006).

Blood sampling

All mothers gained comprehensive and clear knowledge about the aim of our work, plan of action of the study, as well as blood sample collection, and the written consents were signed according to the guidelines of the Institutional Ethical Committee for Medical Research of the National Research Centre, Egypt before enrollment in the study. Five milliliters of blood was withdrawn from the mothers, whether in normal or section delivery at the time of labor and put in EDTA free tube. Another 5 ml of blood was collected from the cord blood during delivery before placental separation and put in EDTA free tube. The blood samples were centrifuged at 1800× *g* for 10 min. using the cooling centrifuge at 4 °C. The supernatent (serum) was separated and preserved at – 20 °C till the time of use.

Analytical procedure

Standard preparation

Multi-standard M-508 P-A of the pesticides used in this study was obtained from AccuStandard Company, leader in analytical reference standards (125 market street, New Haven CT 06513 USA) with purity higher than 96%. Pesticides stock solution (100 μg/mL) was prepared by using hexane in 100 mL volumetric flask and kept in refrigerator at 4 °C. Then the intermediate solution (10 μg/mL) was constructed and used for the preparation of the calibration standards in hexane.

Extraction method

All serum samples were extracted according to the method of Frías et al. (2004) with some modifications. Samples (1 mL each) were transferred into test tubes and methanol (2 mL) was added and agitated for 1 min. Then 5 mL of n-hexane: diethyl ether (1:1 v/v) was added and agitated for 2 min. The samples were centrifuged for 5 min at 1700× *g* using Heraeus Labofuge 400R (Kendro Laboratory Products GmbH, Germany). The aqueous phase was extracted twice and all

organic phases were collected and evaporated. The residues were dissolved in 1 mL n-hexane of HPLC grade.

Gas chromatographic analysis

The pesticides were analyzed on an Agilent 7890, gas chromatograph, equipped with micro-electron capture detector (GC-μECD). GC analysis was conducted on an HP-5 MS capillary column of 30 m length, 0.25 mm diameter and 0.25 μm film thicknesses. The oven temperature was programmed from an initial temperature 80 °C for 1 min, and then increasing at 30 °C/min up to 160 (2 min hold) after that, increasing to 260 °C at a rate of 3 °C/min and was maintained at 260 °C for 12 min. Injector and detector temperature were maintained at 300 °C and 320 °C, respectively. Nitrogen was used as a carrier at a flow rate of 3 mL/min. With each set of samples to be analyzed, a solvent blank, a standard mixture and a procedural blank were run in sequence to check for contamination, peak identification and quantification. The recovery of the spiked matrix sample was between 60 and 130%.

Statistical analysis

The analysis was performed using SPSS version 21 (SSPS Inc., Pennsylvania, USA). Mean ± SD was used for age distribution calculations. The correlation was done using Pearson correlation. $P < 0.05$ value was considered significant and $p < 0.005$ value was highly significant.

Results and discussion

Socio-demographic characteristics of the target population

The general characteristics of the 81 mother-infant pairs are shown in Table 1. The age of the mothers ranged from 16 to 42 years old with a mean age of 25.9 ± 5.4 years. All of the mothers lived in independent homes with their husbands and their homes had the municipal sanitary disposal and tape water. Of the 81 mothers, 98.8% were married. None of the mothers had ever smoked, but 80% were exposed to passive smoking and 71.4% were exposed to smoke in their homes. Thirty-six percent had a high school education, 28% had elementary education, 16% had a preparatory school education, and less than 10% of them were illiterate, had no education. Among all of them, an estimated 73% were multipara with a mean gestational age 37.2 ± 1.8 weeks ranged from 32 up to 42 weeks. All of the participated mothers are healthy; they had no history of adverse outcomes or diseases of pregnancy, such as diabetes, hypertension or any other troubles. The BMI of the mothers ranged from 19.2 to 51.6 at the time of delivery with a mean BMI of 29.8 ± 6.1 kg m^{-2}.

Table 1 General characters of the mother–infant pairs

Maternal Characters	*N* = 81
Age (years)	
Mean (min-max)	25.9 ± 5.4 (16–42)
BMI (kgm^{-2}) at delivery	
Mean (min-max)	29.8 ± 6.1 (19.2–51.6)
Weight (kg) at delivery	
Mean (min-max)	73.5 ± 14.3 (48.6–14.3)
Height (cm) at delivery	
Mean (min-max)	157.3 ± 14.3 (132–180)
Marital status	
Married	98.8%
Divorced	1.2%
Education level	
None	9.9%
Elementary school	28.4%
Preparatory school	16%
High school	35.8%
College or University	9.9%
Parity	
Primipara	27.2%
Multipara	72.2%
Gestational age	
Mean (weeks)	37.2 ± 1.8
(min-max)	(32–42)
Infant Characters	
Sex	
Boy	44.1%
Girl	55.9%
Birth weight (g.)	
Mean (min-max)	2940 ± 0.57 (0.975–4200)
< 2500	25.9%
2500–4000	71.6%
> 4000	2.5%
Birth length (cm)	
Mean (min-max)	47.7 ± 2.9 (35–54)
Head circumference (cm)	
Mean (min-max)	34.2 ± 1.06 (26–37)
Apgare Score1(after 1 min)	
Mean (min-max)	5.8 ± 0.5 (3–8)
Apgare Score 2(after 5 min)	
Mean (min-max)	8.09 ± 1.5 (5–10)

Of the 81 newborns, 44.1% were boys and 55.9 were girls; their mean birth weight was 2940 ± 0.57 g. The majority of them (71.6%) had a birth weight ranged between 2500 and 4000 g. The birth length ranged from 35 to 54 cm with a mean length of 47.7 ± 2.9. Their head circumference ranged from 26 to 37 cm with a mean of 34.2 ± 1.06 cm. The mean of their

Apgare score became 8.09 ± 1.5 after 5 min with a range from 5 to 10.

The percentage of detection of OCPs residues in maternal and cord blood serum

All serum samples (maternal and fetal) had detectable levels of one or more residues. The percentage of the quantifiable samples for each OCP in the maternal and fetal cord blood sera are depicted in Table 2.

The heptachlor epoxide revealed the highest detection rate among all residues in both maternal (27.16%) and cord blood sera (27.16%) followed by the methoxychlor, endrinaldehyde, dieldrin, and endrin, endosulphan I, II (18.5%), (13.6%), (9.9%), (8.6%), (8.6%), and (8.6%), respectively, in the maternal serum. Whereas, in the cord blood serum methoxychlor, endosulphan I, endrinaldehyde, endrin, and dieldrin were the following most quantifiable residues with (14.8%), (13.6%), (11.1%), (9.9%), and (7.4%) frequency rate, respectively.

Table 2 The limit of detection (LOD) and percentage of quantifiable samples for each organochlorine pesticide residue in the maternal and cord blood serum

OCP Residues	*LOD pg/ml*	*Mothers*		*Newborns*	
		n	*Q%*	*n*	*Q%*
DDTs					
p,p'-DDE		*3*	*3.7%*	*1*	*1.2%*
p,p'-DDD		*2*	*2.5%*	*0*	*0%*
p,p'-DDT		*1*	*1.2%*	*0*	*0%*
BHCs					
α-BHC		*2*	*2.5%*	*4*	*4.9%*
β-BHC		*0*	*0%*	*0*	*0%*
γ-BHC		*6*	*7.4%*	*0*	*0%*
δ-BHC		*3*	*3.7%*	*1*	*1.2%*
HCB		*0*	*0%*	*0*	*0%*
Heptachlors					
Heptachlor		*1*	*1.2%*	*0*	*0%*
Heptachlor epoxide		*22*	*27.16%*	*22*	*27.16%*
Endosulfan					
Endosulfan-I		*7*	*8.6%*	*11*	*13.6%*
Endosulfan-II		*7*	*8.6%*	*3*	*3.7%*
Endosulfansulphate		*1*	*1.2%*	*1*	*1.2%*
Chlordane					
Aldrin		*0*	*0%*	*0*	*0%*
Aldrin A		*0*	*0%*	*1*	*1.2%*
Dieldrin		*8*	*9.9%*	*6*	*7.4%*
Endrin		*7*	*8.6%*	*8*	*9.9%*
Endrinaldehyde		*11*	*13.6%*	*9*	*11.1%*
Methoxychlor		*16*	*18.5%*	*12*	*14.8%*

The DDT's were still quantifiable, but with the lowest quantifiable percentage. For DDT's group, p,p'-DDE had the highest detection rate both in maternal (3.7%) and cord blood serum (1.2%), followed by the p,p'-DDD in the maternal blood serum (2.5%) while it was not detected in the cord blood serum, and then p,p'-DDT (1.2%) in the maternal blood serum and also it was not detected in the cord blood serum.

The OCPs are widely dispersed throughout the world and the largest sector of the communities is exposed to them through their polluted environment. Exposure even to extremely low levels of OCPs, before or shortly after birth, produces more profound damaging health effects than exposure to them even in high level during childhood or adult life (Shonkoff and Garner 2012). Due to their small size and their lipophilicity, the OCPs residues can pass easily through the placental barrier by passive diffusion from maternal circulation to fetal circulation (Patayová et al. 2013; Myllynen et al. 2005). In addition, the metabolic enzymes and proteins of transportation across the placenta may affect the habitual transfer and the distribution patterns (Evseenko et al. 2006; Myllynen and Vähäkangas 2013). In Egypt, utero exposure to OCPs is one of the potential risk factors that may result in many hazardous health consequences for the mothers and their newborns.

In this study, we evaluated OCPs exposure in 81 pairs of mothers and their newborn babies. The heptachlor epoxide was the first most frequently quantifiable residue in both maternal and cord blood serum. This could be explained by the extensive usage of heptachlor in the past for killing insects in homes and on food crops, when the compound was incubated with a mixed culture of organisms, bacteria and soil microorganism to transform it by epoxidation, hydrolysis, and reduction. So the epoxide is more likely to be found in the environment than heptachlor. In addition heptachlor epoxide dissolves more easily and sticks strongly to soil particles and stay in water and soil for many years. So plants (fruits and vegetables) can take it up from the soil, and its level can build up in tissues of fish and cattle, via food chain, and it can bioaccumulate in human tissue and serum. Eating fish, dairy products, and fatty meats can expose the pregnant women to this compound. The Egyptian study of Barakat et al. (2013) indicated that still new inputs of heptachlor and endosulfan to Qarun Lake, and there was an earlier usage of DDT as designated by the ratios of (p,p'-DDE + p,p'-DDD)/ ∑p,p'-DDTs. Also, CHLs (chlordane, heptachlor, heptachlor epoxide), were the second dominated groups detected in the sediments and fish samples from Abu-Kir, Egypt (Khairy et al. 2012).

Exposure to DDT was through inhalation and or ingestion routes; the later is considered the main and the most important route of exposure in Egypt (Abou-Arab et al. 1998). DDT consists of around 85% p,p'-DDT and 15% o,p'-DDT isomers (ATSDR 2002); the major metabolites and breakdown

products of DDT were DDE and DDD. Meanwhile, p,p'-DDE was estimated as a chronic marker of exposure is in the environment and in living organisms, with a half-life of more than 8 years (Jaga and Dharmani 2003), and also it is the primary metabolite of DDT in the enviroment. In our study, we found that p,p'-DDD, p,p'-DDT, and p,p'-DDE are the least detectable residues in mother and infant and their percentages are the lowest. These results are in harmony with the study of Barakat et al. (2013). India is the only country still manufacturing DDT, and is the largest consumer. China ceased production in 2007. So its level has been decreased all over the world since the ban, and due to its persistence, it can still be found in the environment and detected in human serum and tissues but in a declining manner.

Methoxychlor was used to protect crops and animals against pests and others. It was intended to be a replacement of DDT after claiming it in cancer causation. Being extensively used in agriculture and aggressively threatening the environment and the wildlife, particularly after a public and scientific outcry that eventually led to its ban with other eleven chemicals, most of them are OCPs, according the Stockholm agreement, for their environmental impacts and human health insults (UNEP 2001). Methoxychlor residue in this study is the second most quantifiable percentage in the mother's serum, and the third in cord blood serum; this compound varied seasonally in the environment; its degradation takes many months, so it is ingested and absorbed by living organisms and accumulates in the food chain. The Environmental Protection Agency (EPA) indicated that the level above the maximum contaminant level (40 ppb) causes damage to the liver and kidney and growth retardation (Ghosh et al. 1999), but still little information is available regarding effects on human pregnancy and children. From animal studies, methoxychlor crosses the placenta and induces abnormal reproductive development (Umeda et al. 2016). Methoxychlor was abolished from use recently, in many countries due to its unacceptably long persistence in the environment, but still in use in other agricultural countries; so it is detected in human tissue (Eldakroory et al. 2017). These investigators detected significantly higher concentrations of methoxychlor, DDT, HCB, and chlordane in tumor samples as well as in the surrounding normal tissues but in lesser concentrations. Also the study done among pregnant women of the Huaihe River Basin in China showed that methoxychlor is one of the residue, which has high concentrations and detection frequencies, even after > 30 years of banning (Luo et al. 2016). In the Egyptian environment, El Nemr et al. (2016) found that mollusk of Mediterranean sea coast and those of the Red sea are polluted with methoxychlor, but the pollution level is still below those recommended by Swedish Food Regulation and US Food and Drug Administration.

OCPs residues have the capacity to pass through the placental barrier to be detected in the fetal serum, and so it may induce future health risk. More than 85% of mother serum with detectable residues transfer these residues to their fetus, and this relation was statistically significant, x = 42.9, p value < 0.001 (Table 3). OCPs occurrence in cord blood confirms their transplacental transfer (Dewan et al. 2013).

Maternal age has been suggested as a critical factor for accumulation of OCPs residues in their serum (Al-Saleh et al. 2012). In the present study, there was no significant relation between maternal age and any of the five most abundant residues detected in their serum.

In utero exposure to OCPs has been linked to fetal anthropometric measures. Some investigators have related fetal growth retardation and reduced anthropometric measurements at birth to exposure to OCPs' residues (Siddiqui et al. 2003; Lopez-Espinosa et al. 2011). Some other investigators found no association between maternal exposure to OCPs and fetal growth (Farhang et al. 2005). Our results showed that there is no significant growth retardation (birth weight, fetal length) nor significant preterm delivery induced by in utero exposure to the most abundant residues (Table 4). In addition, the variations in baby birth weight, baby length, and head circumference were determined by other factors, such as gestational age. Tan et al. (2009) and Wolff et al. (2007) found negative effects of chlordane residues on baby anthropometric measures, which have been noted in our study, as we observed negative effects of endrinaldehyde, one of the chlordane group, on infant weight, infant length, and infant head circumference, but these negative effects were statistically not significant. The reduction in these measures was independent on the gestational age (Al-Saleh et al. 2012).

Also, we noticed, insignificant positive relation of heptachlor, methoxychlor, dielderin residues in the mother's serum on birth weight, birth length, and head circumference of the infant. By doing a logistic regression model for the presence of a relationship between the most quantifiable OCP residues in the mother's serum and the anthropometric measures of the newborns (infant weight, infant length, and infant head circumference), the model showed insignificant relation (Table 5). These findings are in contrast with many studies as that of Wolff et al. (2007), Al-Saleh et al. (2012), and Dewan et al. (2013), but in agreement with that of Tan et al. (2009). These differences may be attributed to geographic locations and climate differences, variations in sample size,

Table 3 Correlation between maternal and fetal OCP residues

Fetal OCP residues	*Maternal OCP residues*				*Chi square*	*p value*
	Not detected		*Detected*			
	No	*%*	*No*	*%*		
Not detected	*34*	*87.2*	*6*	*14.3*	*42.9*	*0.000*
Detected	*5*	*12.8*	*36*	*85.7*		

Table 4 Relation of the most quantifiable OCP residues in maternal serum and the age of the mother, the anthropometric measures of the newborns, and their gestational age

	Not detectable		Detectable		T test	*p* value
	Mean	Std Deviation	Mean	Std deviation		
	Mother heptachlor epoxide					
Baby weight	2.90	0.56	3.08	0.60	1.27	0.27*
Baby length	47.60	3.08	48.05	2.42	0.603	0.54*
Head Circumference	34.17	1.76	34.62	1.50	1.05	0.29*
	Mother methoxychlor				T test	*p* value
Baby weight	2.90	0.54	3.17	0.68	1.7	0.09*
Baby length	47.55	2.96	48.47	2.70	1.1	0.27*
Head Circumference	34.21	1.73	34.60	1.59	0.79	0.42*
	Mother dieldrin					
Baby weight	2.94	0.58	2.98	0.51	0.177	0.86*
Baby length	47.66	2.98	48.25	2.31	0.54	0.58*
Head Circumference	34.29	1.73	34.25	1.49	0.59	0.95*
	Mother endosulfan I					
Baby weight	2.92	0.58	3.26	0.44	1.5	0.12*
Baby length	47.61	2.95	48.86	2.41	1.08	0.28*
Head Circumference	34.24	1.76	34.71	0.76	0.69	0.48*
	Mother endosulfan II					
Baby weight	2.96	0.58	2.84	0.48	0.53	0.59*
Baby length	47.78	2.85	47.00	3.74	0.67	0.500*
Head Circumference	34.30	1.77	34.14	0.69	0.22	0.82*
	Mother endrinaldehyde					
Baby weight	2.96	0.55	2.83	0.87	1.29	0.2*
Baby length	47.82	2.63	46.57	5.26	0.79	0.43*
Head Circumference	34.32	1.44	33.86	3.63	0.54	0.58*
			Age of mother			
			Mean mother	Std deviation	T test	*p* value
Mother heptachlor epoxide		Not detectable	25.83	5.34	0.25	0.79*
		Detectable	26.19	5.76		
Mother endosulfan I		Not detectable	25.96	5.42	0.18	0.85*
		Detectable	25.57	5.80		
Mother endosulfan II		Not detectable	25.92	5.59	0.038	0.97*
		Detectable	26.00	3.37		
Mother methoxychlor		Not detectable	25.79	5.39	0.47	0.63*
		Detectable	26.53	5.68		
Mother dieldrin		Not detectable	25.92	5.54	0.04	0.96**
		Detectable	26.00	4.47		
Mother endrinaldehyde		Not detecteble	25.94	5.33	1.28	0.203*
		Detectable	25.82	6.23		
			Gestational age			
			Mean mother	Std deviation	T test	*p* value
Mother heptachlor epoxide		Not detectable	37.30	1.95	0.25	0.79*
		Detectable	37.33	1.15		
Mother methoxychlor		Not detectable	37.36	1.92	0.616	0.54*
		Detectable	36.80	1.79		
Mother dieldrin		Not detectable	37.20	1.85	1.7	0.094*
		Detectable	39.50	2.12		
Mother endrinaldehyde		Not decteable	37.24	1.92	1.3	0.174*
		Detectable	38.50	0.71		

*p value ≥ 0.05 not significant

Table 5 Logestic regression of the most quantifiable OCP residues in maternal serum and the anthropometric measures of the newborns

OCP residues	Wald	*p* value	R square
Mother heptachlor epoxide			
Baby weight	0.904	0.342	2.409
Baby length	0.483	0.487	0.896
Head circumference	0.051	0.821	1.063
Constant	0.004	0.951	0.584
Mother methoxychlor	Wald	*p* value	R square
Baby weight	2.290	0.130	5.010
Baby length	0.051	0.822	0.959
Head circumference	0.678	0.410	0.777
Constant	0.182	0.669	74.075
Mother endrinaldehyde	Wald	*p* value	R square
Baby weight	1.586	0.208	4.483
Baby length	0.061	0.805	0.950
Head circumference	0.517	0.472	0.783
Constant	0.161	0.688	87.596
Mother endosulfan I	Wald	*p* value	R square
Baby weight	1.523	0.217	6.225
Baby length	0.002	0.964	0.988
Head circumference	0.542	0.461	0.729
Constant	0.055	0.815	32.364
Mother endosulfan II	Wald	*p* value	R square
Baby weight	0.070	0.791	0.680
Baby length	0.249	0.618	0.892
Head circumference	0.240	0.625	1.218
Constant	0.046	0.830	0.078
Mother dieldrin	Wald	*p* value	R square
Baby weight	0.009	0.925	0.887
Baby length	0.611	0.434	1.194
Head circumference	0.263	0.608	0.816
Constant	0.078	0.780	0.034

and the methods of data analysis (detection of the residues, markers of pollution and not the concentration, marker of the effects).

Regarding infant gender, one of the basic concepts that the infant sex or gender was determined by the presence of X or Y chromosome of the sperm cell of the father, but the female may also have an indirect effect on sex determination of their offsprings (Grant 2007). Further, the scientists explained the role of females in pre-determining the gender of their fetuses through fluctuations of testosterone level in ovarian follicles, which is highly sensitive, and this provides a physiological basis for the possibility of gender selection. There is increasing evidence that exposure to OCPs has profound effects on sex ratio, as they act as EDCs, which may alter the maternal hormone levels and consequently result in an atypical sex ratio, but all of these remain speculative at present. Therefore, methoxychlor in this study could act as a testosterone triggers which lead to high ratio of boys, $x = 4.37$, p value< 0.05, (Table 6). Offspring gender can also be influenced by maternal hormone levels, which is also very like to be affected by these EDCs (James 2006; Tan et al. 2009). Further studies are needed to ascertain this impact on infant gender.

Conclusion

In conclusion, the outcomes delivered from the current study provide a scientific evidence for the presence of OCPs residues in our environment as more than one member of this family are detected in both maternal and cord blood sera. Hepatochlor epoxide residues represent the highest detection rate in the sera among all the studied residues indicating the transplacental transfer of this compound to the fetus. Methoxychlor is believed to be testosterone instigator leading to high male ratio. Further studies are needed with larger

Table 6 Relation of the most quantifiable OCP residues in maternal serum and the gender of the newborn

		Gender				Chi	*p* value
		Male		Female			
		No	%	No	%		
Mother Heptachlor epoxide	Not detecteble	23	76.7%	33	86.8%	1.19	0.27*
	Detectable	7	23.3%	5	13.2%		
Mother Endosulfan I	Not detectable	28	93.3%	33	86.8%	0.76	0.38*
	Detectable	2	6.7%	5	13.2%		
Mother Endosulfan II	Not detectable	27	90.0%	37	97.4%	1.64	0.2*
	Detectable	3	10.0%	1	2.6%		
Mother Methoxychlor	Not detectable	22	73.3%	35	92.1%	4.37	0.037**
	Detectable	8	26.7%	3	7.9%		
Mother Dieldrin	Not detectable	28	93.3%	34	89.5%	0.31	0.57*
	Detectable	2	6.7%	4	10.5%		
Mother Endrinaldehyde	Not detectable	28	93.3%	32	84.2%	1.64	0.2*
	Detectable	2	6.7%	6	15.8%		

*p value ≥ 0.05 not significant

**p value < 0.05 significant

sample size with an exact concentration of each residue in the maternal and cord blood specimens to ascertain the health impacts of these residues on the fetal features.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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