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Associations between PBDEs exposure from house dust and human semen quality at an e-waste areas in South China—A pilot study

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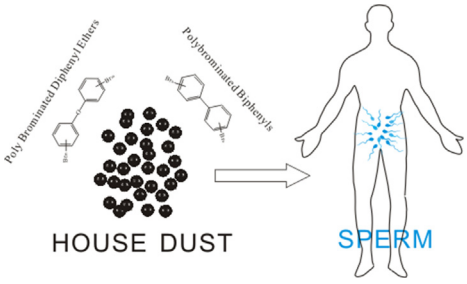
HIGHLIGHTS

- The quality of semen from e-waste area was lower than that in control area.
- BDE28,47 and 153 level in semen was positively associated with that in dust.
- The semen quality was negatively correlated with dust PBDEs level.
- House dust PBDEs might have adverse effects on male fertility.

GRAPHICAL ABSTRACT



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ABSTRACT

Previous studies have confirmed that house dust is one of the main sources of polybrominated diphenyl ethers (PBDEs) exposure, and also indicated that PBDEs might affect human semen quality. The aim of this study was to explore the association between PBDEs concentration in house dust and the semen quality of male resident. Results showed that the semen qualities of the residents living around the e-waste dismantling workshops for a long time (3–17years) at the e-waste areas in South China significantly decreased, and the DNA damage of sperms were aggravated. The adjusted correlation analysed by multiple linear regression model showed that the sperm concentration and count both had negative correlation with BDE47 level in semen ($\beta = -0.295$, 95%CI: −0.553~-0.036; $\beta = -0.400$, 95%CI: −0.708~-0.092, respectively). In addition, the sperm progressive motility [(A+B)%] and sperm viability both had negative correlation with BDE100 level in dust ($\beta = -0.360$, 95%CI: −0.680~-0.040; $\beta = -0.114$, 95% CI: −0.203~-0.025, respectively). And there were significant linear positive correlation between PBDE congener (e.g. BDE28, 47, 153) concentrations in dust and in paired semen samples ($r_s = 0.367–0.547$, $p < 0.05$). This study suggested that exposure to PBDEs from house dust might have adverse effects on

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human semen quality. But the results need to be confirmed in further studies with a large-scale sampling, and find out more direct and convincing evidence.

1. Introduction

Polybrominated diphenyl ethers (PBDEs), which have been used widely in producing a variety of consumer products such as plastics, electronics, construction and textile as additive of flame retardants, are a groups of ubiquitous organic pollutants. PBDEs are known as persistent organic pollutants (POPs) with the characteristics of environmental persistence, long distance transmission, biological accumulation and toxic effects on organisms and human (Hauser et al., 2005).

People generally spend more than 80% of their time indoor, thus great emphasis is placed on PBDEs contamination in the indoor environment (Jones-Otazo et al., 2005; Betts, 2008). On global comparison, PBDE levels in house dust differed by two to three orders of magnitude (Kim et al., 2016). Much higher levels of PBDEs are found in the US/Canada vs. Europe. In turn, UK PBDEs levels are much higher than in other European countries (Wilford et al., 2005; D'Hollander et al., 2010; de Boer et al., 2016). Levels of PBDEs in house dust at e-waste areas in China are quite high compared with other areas in the world (Wang et al., 2007; Jiang et al., 2014; Yu et al., 2016). Moreover, BDE209 was the dominant congener in the majority of house dust samples (Harrad and Abdallah, 2011; Sahlstrom et al., 2015; Korcz et al., 2017). Compared with BDE209, penta- and octa-BDEs have higher bioaccessibility and longer half-life, thus all of these congeners may greatly impair human health (Bramwell et al., 2016).

Studies conducted over the past decades show that indoor dust and diet are the two main source of PBDEs (Frederiksen et al., 2009; Johnson-Restrepo and Kannan, 2009; Bramwell et al., 2016). Despite the high proportion of total exposure being from diet, neither study found correlation between PBDEs in duplicate diet and internal dose (Fromme et al., 2009; Bramwell et al., 2016). Nevertheless, internal exposure dose of PBDE congeners generally correlated strongly with the levels of PBDE in house dust (Bramwell et al., 2016). For example, PBDE levels in human serum and human breast milk had significant positive correlations with PBDE concentrations in house dust (Karlsson et al., 2007; Wu et al., 2007). For the concentrations of PBDEs, PCBs, and OCPs in serum of residents in an e-waste dismantling region (Guiyu, South China), PBDEs typically accounted for 46% of the total organohalogen chemicals in serum samples, but only 8.7% in the serum samples collected from nearby non e-waste region (Frederiksen et al., 2009).

It is known that PBDEs are endocrine disruptors and may affect male reproduction (Yang et al., 2009; Eskenazi et al., 2017). Previous studies observed that BDE153 level in human serum was negatively correlated with the concentration of sperm ($r = -0.841$, $p = 0.002$) and the size of testis ($r = -0.764$, $p = 0.01$) (Akutsu et al., 2008). Studies also found that semen mobility was negatively related to BDE-47, BDE-100 and $\sum$BDE, and thyroxin levels were negatively associated to serum BDE-47,BDE-99, and $\sum$BDE (Abdelouahab et al., 2011). Furthermore, the concentrations of total PBDEs varied from 15.8 to 86.8 pg g^{-1} ww (median = 31.3 pg g^{-1} ww) in semen samples ($n = 101$) collected from e-waste dismantling region (Taizhou, East China), and this was the first time PBDEs were detected in human semen (Liu et al., 2012). However, studies about the effect of PBDEs in dust on human reproductive health, especially on male semen quality, are still insufficient.

In our previous studies, high concentrations of PBDEs were found in house dust from Longtang town, which was one of the largest e-waste dismantling areas in China (Wang et al., 2010; Zheng et al., 2015). Because of the primitive e-waste recycling processes, such as open burning and acid processing, there were large numbers of polluted compounds (including PBDEs) released into the environment. The objective of this exploratory study was to investigate the relationship between external exposure of PBDEs in house dust from Longtang town and the semen quality of the residents who have lived around the e-waste dismantling workshops for a long time (3–17years) without working in e-waste dismantling facilities. The semen samples of control group without any known occupational exposure were selected from the semen bank of hospital, and were also assessed. The concentration of PBDEs in indoor dust and in paired semen of the residents, and the quality of sperm samples were analysed. The associations between them was discussed as well.

2. Materials and methods

2.1. Recruitment of study participants

The area of investigation (Longtang town) is located in the rural area of Qingyuan (South China), where electrical and electronic waste (e-waste, such as television sets, computers, and electric fans, etc) dismantling industry has existed for decades, and there are no other industrial activities nearby.

Between October 2015 and July 2016, males between 18 and 50 years of age were recruited to participate in this study. These males were recruited from e-waste dismantling areas at Longtang town, and were also long-time residents (3–17 years) in this town. Excluding those who had reproductive health problems such as epididymitis, vasectomy, varicocele, orchiditis, vesiculitis and thyroid disorder, a total of 32 adult men were recruited. So they were convenience samples. Meanwhile, corresponding house dust samples were collected from their home.

The study protocol was approved by the Ethics Committee of the First Affiliated Hospital of Jinan University, and all participants gave informed consent prior to enrollment.

2.2. Questionnaire

An interview-administered questionnaire was conducted at the time of recruitment by study staff under the guidance of the medical staff of the First Affiliated Hospital of Jinan University. Questionnaire was used to obtain detailed information of participants, which covered age, residence time, abstinence days, occupational history, smoking and drinking, workplace, as well as health information. Participants' height and weight were measured and body mass index (BMI) was calculated as weight (kg)/height (m^2).

2.3. Sample collection

House dust samples ($n = 32$) were obtained from the floors, furniture, and windowsills. They were collected from October 2015 to July 2016 using woolen brushes that were pre-cleaned with 70%