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Association between air pollution and sperm quality: A systematic review and meta-analysis

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ABSTRACT

Exposure to ambient air pollution has been clearly linked to adverse reproductive outcome and fecundation index, but its effects on male semen quality are still uncertain. In this study, we reviewed information from ten studies to get the qualitative evidence of the influence of the ambient air pollution on sperm quality and collected data from six of the ten studies to conduct meta-analysis. The original studies classified participants into different exposure levels and the highest and lowest expose levels were chosen as high expose and low expose groups, respectively. The random-effect model was used in the meta-analysis with the weight mean difference (WMD) as the measure indicator. The WMDs (95% confidence intervals, CIs) of sperm volume, sperm count, semen concentration, sperm progressive motility, total motility, and normal morphology were 0.09 (−0.04, 0.23), 0.46 (−4.47, 5.39), −8.21 (−20.38, 3.96), −7.76 (−16.26, 0.74), −7.61 (−16.97, 1.74) and −3.40 (−7.42, 0.62), respectively. In conclusion, although the differences are not statistically significant between the two groups, the overall trends and evidence from this review indicate the chronic exposure to ambient pollutants at high level may alter men sperm quality.

1. Introduction

The sperm parameters contain semen volume, sperm concentration, sperm count, progressive motility, total motility, and normal morphology (WHO, 2010). Unfortunately, a decreasing trend was witnessed for the sperm quality during the past decades, in particular for the sperm concentration and the sperm volume (Carlsen et al., 1992; Irvine et al., 1996; Swan et al., 1997). A cohort study from France showed that the semen concentration constantly decreased by 1.9% per year as well as the normal sperm morphology significantly declined in the percentage (Rolland et al., 2013).

Some people think the decreasing infertility is mainly due to female because of the distinct physiological structure. However, those couples who cannot conceive baby more than half owe to the reproductive dysfunction of males (WHO, 2010). Nowadays, men confront with heavy stress as well as increasing occupation exposure in their daily life. To date, we have known loads of factors might have a negative influence on male sperm quality such as air pollutants, smoking, drinking, overweight, obesity, polycyclic aromatic hydrocarbon (PAH), heavy metal, social stress, and special diseases. Furthermore, the spermatogenesis last about 90 days, which provided enough exposed time for these factors (Clermont, 1963; Heller and Clermont, 1963; Johnson and Varner, 1988).

On account of the adverse influence on health, the ambient air pollution has become a global hot issue. Many countries, particularly for developing countries, are experiencing the deterioration of the air conditions owing to the chronic activity of human beings. Plenty of studies have proved the strong association between air pollution and the diseases of respiratory system and cardiovascular system (Jevtić et al., 2014; Yang et al., 2014). In recent years, the escalating animal research showed that chronic exposure on poor ambient pollutants would lead male animal to the reduction of their fertility. Watanabe et al. found the decrease of sperm volume when exposure to diesel exhaust during fetus (Watanabe, 2005). The sperm function and the endocrine hormone were impaired for the male mice after chronic exposure to PAHs (Jeng and Yu, 2008). Pires et al. proved that PM2.5 could affect spermatogenesis of mice by damaging the sperm production (Pires et al., 2011). Limited field

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research also indicated that ambient air pollutants could impair the male reproductive system, which involved changing hormone level, disturbing testosterone and altering sperm parameters.

The infertility is not only a public health issue, but also a social problem. The vicious trend of the ambient air pollution would result in plenty of the reproductive issue, and trigger many social detriments such as labor shortage and the society overload pressure. However, the uncertainty still exists for the linkage of sperm quality and air pollution because of scattered studies and distinct designs. Therefore, we conducted this systematic review and meta-analysis. In this paper, we attempt to synthesize all the related information coming from previous literature to investigate the association between air pollution and sperm quality.

2. Materials and methods

2.1. Literature search

We systematically searched PubMed and Web of Science (before 30 may 2015) with detailed search terms for: “air pollution”, “particulate matter”, “ozone”, “carbon monoxide”, “Sulphur dioxide”, “nitrogen dioxide”, “semen”, and “sperm” (see Fig. 1 for detailed search strategy). The “and” was used to connect the first six keywords and the last two keywords which indicated the air pollution and sperm quality, respectively. The first six keywords were jointed by “or”, and so did the last two keywords. All the procedures were conducted by two reviewers (Zibing Deng and Fei Chen) independently and any discrepancies were adjudicated by research team. We got the objective literature with the steps as follows. First, we combined the keywords to search the references from the two databases, and then removed the duplicated records. After that, according to the title and abstract, we screened those deduplicated records. Lastly, we read the remainder full-text articles in-depth to identify the aim articles.

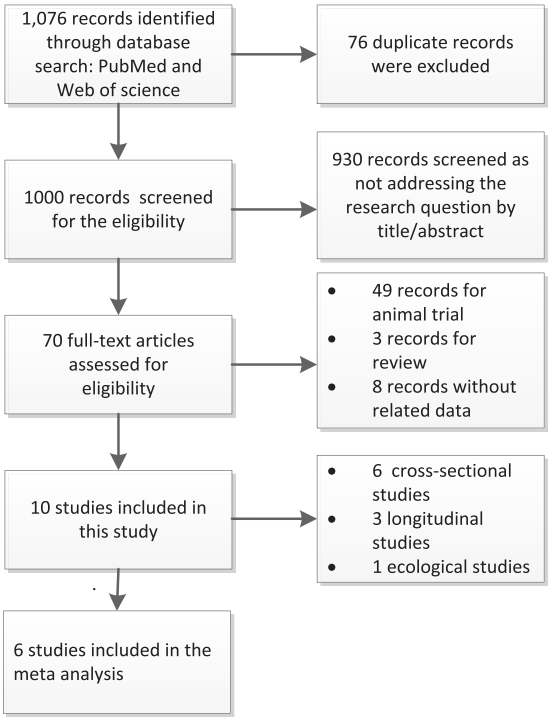

Fig. 1. Results of systematic literature search.

2.2. Inclusion and exclusion criteria

We selected studies based on the following criteria. For the systematic review, they must investigate the influence of air pollution on sperm quality; while for the meta-analysis the original studies were included if (1) the original data was presented with the mean and standard deviation of the sperm parameters (volume, concentration, motility, morphology, and count); (2) they must be quantitative to investigate the association between air pollution and sperm quality; (3) they must adjust other confounders; (4) the parameter data and exposure to ambient air pollution data both can be obtained. We limited the language only in English and we included only peer-reviewed original articles. Those articles would be excluded when (1) they focused on the animal research; (2) they were absolutely concentrated on molecule level; (3) the paper is a review or report.

2.3. Extraction of data

All the related data were extracted independently by two investigators and disagreements were resolved by discussion. We extracted the following data information from the eligible papers: authors, the year published, the year studied, the design of study, the air pollutants, population demographics, the main conclusion, and the confounders or the potential risk factors.

We made the strategy to extract the mean and standard deviation of sperm parameters. The definitions of low and high exposure level may be not consistent across the six studies included in the meta-analysis. Most the original studies classified participants into different exposure levels depending on seasonality and the highest expose level and the lowest expose level were chosen as high expose group and low expose group, respectively. We contacted authors for additional data for our meta-analysis where there were not presented. The specific strategy are showed in supplementary (part 1).

2.4. Meta-analysis

Random-effects models were used to synthesize the association between air pollution and sperm parameters (Lau et al., 1997). Random-effect models gave more weight to smaller studies and had typically wider confidence intervals because in addition to the within-study variance, they also considered potential variation between the true effects that all included studies estimate (Eze et al., 2015).

WMDs and their corresponding 95% confidence intervals (95% CIs) were used to assess the influence of air pollutants on sperm parameters. The *P*-value less than 0.05 was considered statistical significance. All the *P* values were obtained using a two-sided test. We described the between-study heterogeneity by using the I^2 metric and the between studies' variance using τ^2. Forest plots were used to summarize the results of included studies. We assessed publication bias using the Egger's test for asymmetry (Egger et al., 1997). For reporting, we followed the meta-analysis of observational studies in epidemiology and the preferred reporting items for systematic review and meta-analysis guidelines (Stroup et al., 2000; Moher et al., 2010). Analyses were performed using R software with “meta” package (v.3.22 https://cran.r-project.org/).

3. Results and discussion

3.1. Summary of collected data

The procedures of selecting literature are shown in Fig. 1. The remainders of records were 1000 from the databases after the de-