



# Contribution of nitrogen oxide and sulfur dioxide exposure from power plant emissions on respiratory symptom and disease prevalence



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## ABSTRACT

This study investigates the association between exposure to ambient NO<sub>x</sub> and SO<sub>2</sub> originating from power plant emissions and prevalence of obstructive pulmonary disease and related symptoms. The Orot Rabin coal-fired power plant is the largest power generating facility in the Eastern Mediterranean. Two novel methods assessing exposure to power plant-specific emissions were estimated for 2244 participants who completed the European Community Respiratory Health Survey. The “source approach” modeled emissions traced back to the power plant while the “event approach” identified peak exposures from power plant plume events. Respiratory symptoms, but not prevalence of asthma and COPD, were associated with estimates of power plant NO<sub>x</sub> emissions. The “source approach” yielded a better estimate of exposure to power plant emissions and showed a stronger dose–response relationship with outcomes. Calculating the portion of ambient pollution attributed to power plants emissions can be useful for air quality management purposes and targeted abatement programs.

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## 1. Introduction

Nitrogen oxides (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>) are gaseous air pollutants which have been shown to cause increased incidence of asthma exacerbation and respiratory symptoms. Specifically, exposure to NO<sub>x</sub> has been associated with increased respiratory related hospitalizations (Barnett et al., 2005; Iskandar et al., 2012; Tramuto et al., 2011), increased susceptibility to respiratory infection (Brauer et al., 2002; Chen et al., 2007), increased frequency of respiratory symptoms (van Strien et al., 2004; Zhao et al., 2008), and increased mortality (Heinrich et al., 2013; Moolgavkar et al., 2013). Similarly, exposure to SO<sub>2</sub> has been associated with increased total and respiratory mortality (Chen et al., 2012), increased risk of asthma diagnosis (Clark et al., 2010), exacerbation of pre-existing respiratory illness (Chen et al., 2007) and increased prevalence of respiratory symptoms such as wheezing and

shortness of breath (Zhao et al., 2008). Previous studies on the associated health effects of NO<sub>x</sub> and SO<sub>2</sub> in the Israeli population have provided conflicting results. While increased frequency of outpatient clinic and emergency room visits (Garty et al., 1998) have been reported, Goren et al. (1995), Goren and Hellmann (1997) did not find an association between clinic visits or the prevalence of asthma with increased exposure to NO<sub>x</sub> and SO<sub>2</sub>. More recently, an association between childhood asthma was reported for exposure to PM<sub>10</sub> but not to SO<sub>2</sub> (Portnov et al., 2011).

While power plants are a significant source of air pollution (Hao et al., 2007), contributing over 70% of total SO<sub>2</sub> emissions in the United States (US EPA, 2013a), little research exists on assessing the specific fractional contribution of power plant emissions to respiratory health in neighboring communities, and findings from previous studies are inconclusive (Cohen et al., 1972; Carbonell et al., 2007). Residents of villages within 5 km of a coal-fired power plant in Turkey had statistically significant increased frequency of respiratory symptoms and decreased spirometry parameters when compared to villagers residing greater than 30 km from the source (Karavus et al., 2002). Levy and Spengler (2002) estimated that use of Best Available Control Technology (BACT) to reduce NO<sub>x</sub> and SO<sub>2</sub>

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emissions in two Massachusetts power plants would lead to a reduction of 70 deaths per year. In part, the inconclusive findings from previous studies are due to the different exposure metrics utilized and the difficulty in differentiating exposure to power plant emissions from exposure to the same pollutants originating from other urban and mobile sources.

The Orot Rabin coal-fired power plant is the largest power generating facility in the Eastern Mediterranean with an installed capacity of 2580 MW. Over 363,000 people live within a 20 km radius from the plant's two 250 m and one 300 m stacks. Goren et al. (1991) followed changes in the prevalence of asthma and respiratory symptoms in grade-school children who lived in the vicinity of the Orot Rabin power plant. While they reported increased prevalence of respiratory symptoms in children who resided in high pollution areas in the years following the initiation of operation of the plant, there is significant concern of exposure misclassification in this study. Increased prevalence of asthma and reduced pulmonary function have also been observed in children residing near the Orot Rabin power plant (Goren and Hellmann, 1997), however individual exposure and proximity to the power plant were not included in the exposure assessment. Based on an "event" driven exposure

estimation (see Methods), an association with reduced pulmonary function has been reported in school children living in the vicinity of the power plant (Dubnov et al., 2007).

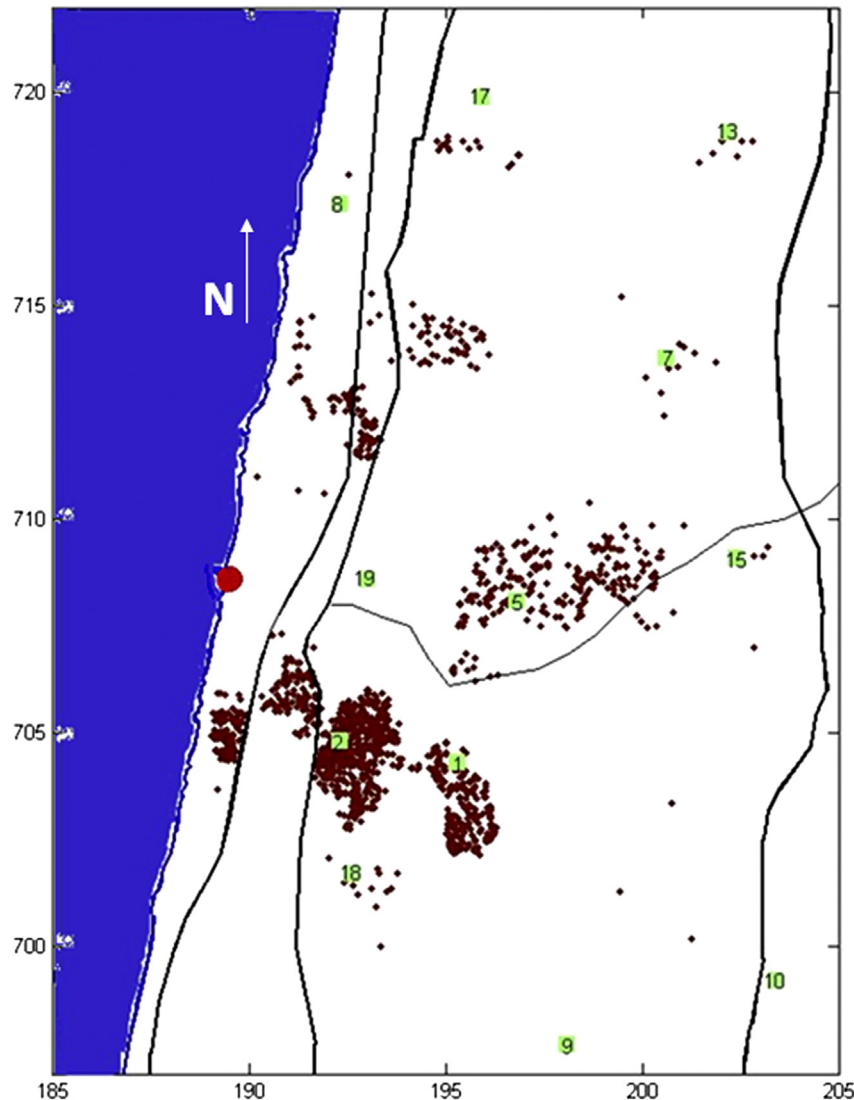
In the present study we compare different metrics of exposure to nitrogen oxides and sulfur dioxide emanating from a major coal-fired power plant and assess their relationship to prevalence of respiratory symptoms and diagnoses in adults. Our primary objective is to assess the association of power plant-specific and total ambient  $\text{NO}_x$  and  $\text{SO}_2$  exposures with respiratory health outcomes among a population residing downwind from a major coal-fired power plant.

## 2. Materials and methods

### 2.1. Study area

The study was undertaken in the Hadera sub-district of Israel, located on the Mediterranean coast approximately 50 km north of Tel Aviv and 50 km south of Haifa, Israel's first and third largest cities, respectively (Fig. 1). The Hadera sub-district includes 17 municipalities within a distance of up to 20 km from the Orot Rabin power plant. The district is a coastal strip approximately 45 km in length and 15 km wide, with a total population of about 363,000 (ICBS, 2008).

The Orot Rabin power plant is the primary source of  $\text{SO}_2$  and  $\text{NO}_x$  in the region, with six coal-fired production units, a total power capacity of 2580 MW, and an



**Fig. 1.** Map of the study area. The Orot Rabin power plant is marked by the red circle, monitoring stations locations are marked with green squares and subjects locations are marked with brown dots. The coordinate tickmarks are in km on the "new Israel grid". (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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