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Modeled and perceived RF-EMF, noise and air pollution and symptoms in a population cohort. Is perception key in predicting symptoms?

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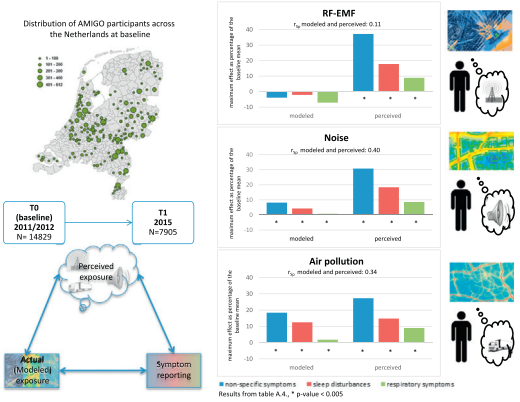
HIGHLIGHTS

- We studied RF-EMF, traffic noise and air pollution in a general population cohort.
- Perceived and modeled exposures were associated with symptoms except modeled EMF.
- Modeled exposures effects were attenuated upon adjustment for perceived exposures.
- Risk assessment may be biased unless modeled and perceived exposures are considered.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Psychosocial research has shown that perceived exposure can influence symptom reporting, regardless of actual exposure. The impact of this phenomenon on the interpretation of results from epidemiological research on environmental determinants of symptoms is unclear.
Objective: Our aim was to compare associations between modeled exposures, the perceived level of these exposures and reported symptoms (non-specific symptoms, sleep disturbances, and respiratory symptoms) for three different environmental exposures (radiofrequency electromagnetic fields (RF-EMF), noise, and air pollution). These environmental exposures vary in the degree to which they can be sensorially observed.
Methods: Participant characteristics, perceived exposures, and self-reported health were assessed with a baseline (n = 14,829, 2011/2012) and follow-up (n = 7905, 2015) questionnaire in the Dutch population-based

Abbreviations: AMIGO, Occupational and Environmental Health Cohort Study; 4DSQ-S, somatization scale of the Four-Dimensional Symptom Questionnaire; ESCAPE, European Study of Cohorts for Air Pollution Effects; MOS, Medical Outcomes Study; STAMINA, Standard Model Instrumentation for Noise Assessments.

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Occupational and Environmental Health Cohort (AMIGO). Environmental exposures were estimated at the home address using spatial models. Cross-sectional and longitudinal regression models were used to examine the associations between modeled and perceived exposures, and reported symptoms.
Results: The extent to which exposure sources could be observed by participants likely influenced correlations between modeled and perceived exposure as correlations were moderate for air pollution ($r_{Sp} = 0.34$) and noise ($r_{Sp} = 0.40$), but less so for RF-EMF ($r_{Sp} = 0.11$). Perceived exposures were consistently associated with increased symptom scores (respiratory, sleep, non-specific). Modeled exposures, except RF-EMF, were associated with increased symptom scores, but these associations disappeared or strongly diminished when accounted for perceived exposure in the analyses.
Discussion: Perceived exposure has an important role in symptom reporting. When environmental determinants of symptoms are studied without acknowledging the potential role of both modeled and perceived exposures, there is a risk of bias in health risk assessment. However, the etiological role of exposure perceptions in relation to symptom reporting requires further research.

1. Introduction

Radiofrequency electromagnetic fields (RF-EMF) from mobile phone base stations, noise exposure from road traffic, and air pollutants are environmental exposures often clustered in more densely populated area (Allen et al., 2009; Davies et al., 2009). The general population is involuntarily exposed to these exposures, and many people have concerns about potential health risks. Recent studies have highlighted a complex interplay between these environmental exposures, perceptions of exposure and health risks, and symptom reporting (Claeson et al., 2013; Héritier et al., 2014; Martens et al., 2017). For example, for residential RF-EMF exposure from mobile phone base stations we recently showed, using a longitudinal design, that perceived, but not modeled exposure, was associated with self-reported symptoms (Martens et al., 2017). For noise from road traffic and air pollutants, perceptions mediated the effect of exposure on symptoms (Claeson et al., 2013; Héritier et al., 2014). These studies show that research into environmental determinants of symptoms can benefit from applying insights from both psychosocial and epidemiological research disciplines.

The current study compares effects of RF-EMF from mobile phone base stations, noise and air pollutants from road traffic for the following symptom-based health outcomes: non-specific symptoms, sleep disturbance, and respiratory symptoms. These health outcomes are chosen based on variation in the plausibility of the link with the different environmental exposures. For environmental RF-EMF exposure, there is evidence of changes in sleep electroencephalography (EEG) (Regel et al., 2007), but no convincing epidemiological evidence for specific effects on symptoms, nor a known biological mechanism (Baliatsas et al., 2012; Röösli et al., 2010). However, people who regard themselves as electrohypersensitive report a wide variety of non-specific symptoms, such as headache, fatigue, and pain which they attribute to EMF exposure (Dieudonné, 2016; Hagström et al., 2013). Noise exposure on the other hand, can induce arousal, which can be observed during sleep through changes in EEG, heart rate, and respiration (Joseph, 2009). Prior epidemiological studies reported associations between noise exposure and sleep disturbances e.g., (Muzet, 2007; Öhrström, 1989; Pirrera et al., 2010), and there is also evidence for effects on wellbeing and overall symptoms (Laszlo et al., 2012). Air pollutants can cause oxidative stress and an inflammatory response (Kelly, 2003). Epidemiological studies have found associations between exposure to air pollutants and respiratory symptoms such as shortness of breath, coughing, and wheezing (Mar et al., 2004; Modig and Forsberg, 2007; Patel et al., 2010).

The expectation that negative health effects may occur, can itself induce symptoms when people think they are exposed, regardless of the actual exposure and risk (Crichton et al., 2014; Szemerszky et al., 2010; Witthöft and Rubin, 2013). This is also described as nocebo-effect, as the counterpart of placebo (Hahn, 1997). Nocebo-effects may be part of a circular process, where experiencing symptoms can also influence perceptions of potential environmental health hazards (Dieudonné, 2016; Köteles et al., 2011). Perceptions of environmental exposures, perceived health risks and worries play an important role in symptom experiences (Petrie et al., 2001; Porsius et al., 2015a; Rief et al., 2012). The type of symptoms that people report and associate with an environmental hazard differs depending on biological characteristics of the hazard and the content of media reports (Spurgeon, 2002; Witthöft and Rubin, 2013). There are differences in the degree to which environmental exposures can be sensorially detected by humans, and this may affect perceived exposure. For RF-EMF from mobile phone base stations, only the exposure source can be perceived (f.i. visibility of antennas on nearby buildings). While black smoke or diesel exhaust can sometimes be seen on windows, or smelt, there is no sensory system in humans that can directly perceive the level of air pollutants such as NO_2. Traffic noise is the only exposure, in this study, which is perceived by a specific sensory system in humans (Muzet, 2007) and we therefore expect higher correlations with self-reported perceived exposure than for air pollutants and in particular RF-EMF.

1.1. Aims and research questions

This paper applies insights from epidemiological and psychosocial research to study environmental determinants of symptom-based health outcomes within the Dutch population-based Occupational and Environmental Health Cohort study (AMIGO). We have formulated three research questions, with the purpose of achieving a better understanding of the interplay between environmental exposures, perceptions and reported symptoms: 1) To what extent are participants able to assess personal exposure levels, and how does this differ between environmental exposures?; 2) What are the associations between modeled exposures and symptom-based health outcomes, and between perceived exposures and symptom-based health outcomes, and how do these associations change when both modeled and perceived exposures are taken into account simultaneously?; 3) Lastly, what is the impact on perceived exposures and on symptom-based health outcomes, after a change in exposures due to moving to a different home? With these final longitudinal analyses, we aim to improve our understanding of the processes that underlie the relations between modeled and perceived exposures, and symptom-based health outcomes.

2. Material and methods

2.1. Study population

Data for this study were collected within the Dutch population-based AMIGO cohort. This cohort was set up in 2011 and 2012 to study environmental and occupational determinants of chronic diseases and symptoms in the general population (see (Slottje et al., 2014) for a full description of the AMIGO cohort). Participants were recruited through general practices, and were 31–65 years old at baseline (T0, 2011/2012). Of the invited 93,849 people, 14,829 participants