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Comparing the impact of fine particulate matter emissions from industrial facilities and transport on the real age of a local community

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HIGHLIGHTS

- We predicted health risks of local PM air pollution from industry and traffic.
- We used the rate advancement period (RAP) of mortality.
- The RAP is the period by which mortality risks are advanced among those exposed.
- Of the local sources, road traffic is the most important contributor for health.
- The RAP is a promising technique to communicate potential health impacts.

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ABSTRACT

For policy-making, human health risks of fine particulate m($PM_{2.5}$) are commonly assessed by comparing environmental concentrations with reference values, which does not necessarily reflect the impact on health in a population. The goal of this study was to compare health impacts in the Moerdijk area, The Netherlands resulting from local emissions of $PM_{2.5}$ from industry and traffic in a case study using the risk advancement period (RAP) of mortality. The application of the RAP methodology on the local scale is a promising technique to quantify potential health impacts for communication purposes. The risk advancement period of mortality is the time period by which the mortality risk is advanced among exposed individuals conditional on survival at a baseline age. The RAP showed that road traffic was the most important local emission source that affects human health in the study area, whereas the estimated health impact from industry was a factor of 3 lower. $PM_{2.5}$ due to highway-traffic was the largest contributor to the health impact of road traffic. This finding is in contrast with the risk perception in this area.

1. Introduction

Emissions from pollution sources such as industrial facilities, traffic, households and waste disposal sites may result in adverse health effects. It is the responsibility of the authorities to ensure that these risks are properly assessed and managed. In environmental risk management, local authorities usually rely on preventing exceeding of environmental quality standards or emission targets. In this context, health risks are often quantified by means of a risk quotient, i.e. the ratio between the estimated or measured ambient concentration and a reference value or environmental quality standard. Although this type of risk quotients is relevant from an administrative point of view, they do not necessarily reflect the impact on health in a population (Geelen et al., 2009). This is because the underlying reference values are generally not simply and solely based on health considerations, but also on other considerations such as technical feasibility and socio-economic consequences of emission-reduction measures (Geelen et al., 2009). Furthermore, risk quotients do not necessarily

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reflect perception of risks in a population since perception is only partly based on scientific information (Brody et al., 2004; Elliott et al., 1999; Poortinga et al., 2008; Renn, 2004; Slovic, 1999; Stewart et al., 2010; Weber, 2006). If so, this difference should be addressed by developing a suitable risk communication and management strategy (Morgan et al., 2002; Renn, 2007).

For the local authorities, it is important to gain insight in the health impact of local emission sources, so local emission sources and mitigation strategies can be prioritized regarding health. Also, it provides input for the communication on health risks in order to enhance acceptance and adoption of preventive measures (Briggs and Stern, 2007). Risk maps constitute a powerful tool to communicate the outcome of environmental risk assessments to the public and policy makers, as they present the spatial differentiation of toxicant effects (Lahr and Kooistra, 2010; Pistocchi et al., 2011). For example, individual excess lifetime health risks – in the order of magnitude of 10^{-2} down to 10^{-9} – have been mapped in geographic information systems (GIS) in several studies (Bień et al., 2005; Hellweger et al., 2002) and Ragas et al. (2006) presented maps of local health risks on a right-to-know-website. However, a disadvantage of theoretical health risks is that they are difficult to interpret for layman, making them less suitable for communication purposes.

A more intuitive indicator than plain health risks or risk quotients is the risk-advancement period, which is the time period by which a health risk – in this case the mortality risk – is advanced among exposed individuals conditional on survival at a baseline age (Brenner et al., 1993). In other words: the increased mortality risk due to exposure causes a shift on the age-specific mortality curve. The RAP resembles the shift of this curve. The RAP can be used in risk communication as follows: “The ‘real age’ of exposed individuals is *x* years older than that of unexposed individuals.” The RAP has been proposed as a suitable indicator for communication of health risks of air pollution (Brunekreef et al., 2007; Morfeld, 2004, 2007). Finkelstein applied this method in an observational epidemiological study on air pollution (2004). The risk advancement period has also shown its strength in communication with laypeople in relation to change of risky lifestyle behavior (Allegrante et al., 2008) and in health programs like RealAge® in the United States (RealAge Inc) and other countries, including The Netherlands (Advance Amsterdam). Yet, it has not been applied in the setting of health impact assessment and risk mapping of air pollution.

The aim of this study was to compare the relative importance with respect to local health impacts of primary $PM_{2.5}$ emissions by local industry- and transport-related sources. Firstly, we estimated the contribution to the annual average concentrations of $PM_{2.5}$ experienced by the local population, of local emissions from industry and traffic-related emissions of highways, roads, shipping, railway traffic and mobile machinery. Secondly, the contributions to ambient concentrations were translated in terms of their effect on the ‘real age’ of the population using the Risk Advancement Period (RAP) for mortality. We performed this local scale health impact assessment of local emissions in an area with a high density of pollution sources: the region of Moerdijk in the Southwest of The Netherlands (Fig. 1). The health impacts of local emissions were confronted with the impact resulting from national emissions and emissions from abroad. Finally, the impact on health of the local sources was compared with the results of a risk perception study on local sources of air pollution in the same study area (Geelen et al., 2013).

2. Methods

2.1. Outline

We quantified health impacts in an area of 10 by 6.5 km in the South–West of The Netherlands enclosing the townships of Moerdijk and Klundert, an industrial area of 2600 ha with heavy industry, two highways, a harbor with shipping traffic, and a railway track (Fig. 1). The population consists of 7800 residents. Because of plans to expand the industrial area with another 600 ha an Environmental Impact Assessment (EIA) was performed (DHV, 2005, 2006). The EIA showed that environmental quality standards in the living environment were not exceeded, resulting in risk quotients smaller than 1 (DHV, 2005, 2006). However, the actual

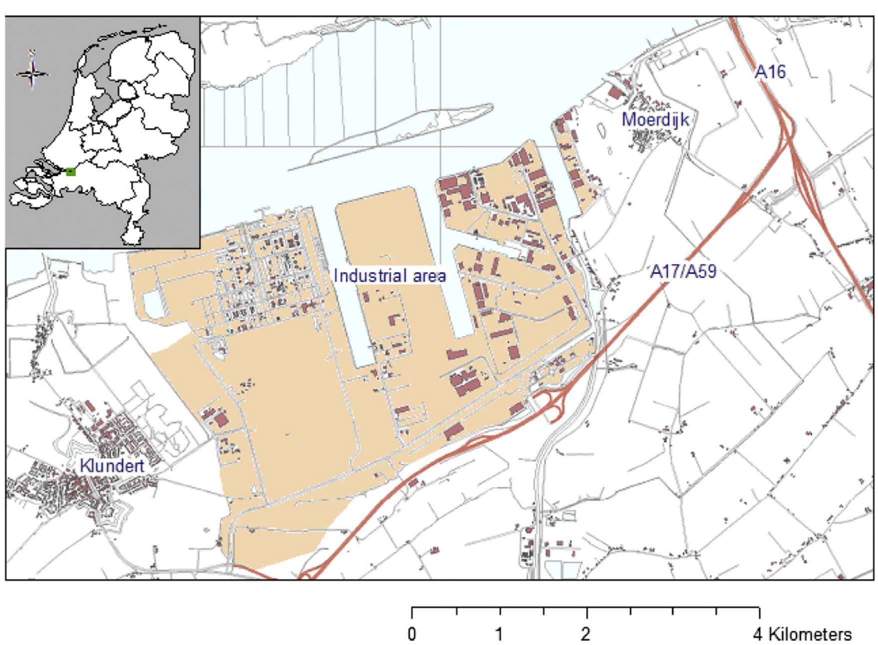

Fig. 1. Study area Moerdijk.