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Health impact assessment of transport policies in Rotterdam: Decrease of total traffic and increase of electric car use

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ABSTRACT

Background: Green house gas (GHG) mitigation policies can be evaluated by showing their co-benefits to health.
Method: Health Impact Assessment (HIA) was used to quantify co-benefits of GHG mitigation policies in Rotterdam. The effects of two separate interventions (10% reduction of private vehicle kilometers and a share of 50% electric-powered private vehicle kilometers) on particulate matter ($PM_{2.5}$), elemental carbon (EC) and noise (engine noise and tyre noise) were assessed using Years of Life Lost (YLL) and Years Lived with Disability (YLD). The baseline was 2010 and the end of the assessment 2020.
Results: The intervention aimed at reducing traffic is associated with a decreased exposure to noise resulting in a reduction of 21 (confidence interval (CI): 11–129) YLDs due to annoyance and 35 (CI: 20–51) YLDs due to sleep disturbance for the population per year. The effects of 50% electric-powered car use are slightly higher with a reduction of 26 (CI: 13–116) and 41 (CI: 24–60) YLDs, respectively. The two interventions have marginal effects on air pollution, because already implemented traffic policies will reduce $PM_{2.5}$ and EC by around 40% and 60% respectively, from 2010 to 2020.
Discussion: The evaluation of planned interventions, related to climate change policies, targeting only the transport sector can result in small co-benefits for health, if the analysis is limited to air pollution and noise. This urges to expand the analysis by including other impacts, e.g. physical activity and well-being, as a necessary step to better understanding consequences of interventions and carefully orienting resources useful to build knowledge to improve public health.

1. Introduction

There have been many recent efforts to reduce greenhouse gas (GHG) emissions at national and international level following the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, for example the 1997 Kyoto Protocol and EU directives (2003/87/EC, 2009/29/EC). Alongside energy production and the building sector, the transport sector is a leading contributor to carbon dioxide (CO_2) emissions. It represented around 22% of worldwide CO_2 emissions in 2010 (International Energy Agency, 2012).

In the transport sector, decisions concerning interventions to reduce GHG emissions can have both positive and negative environmental, social, economic and health effects (Haines et al., 2009; Thomas et al., 2014). Transport, especially road transport, enables access to employment and social events as well as essential services, such as medical treatment (Thomson et al., 2008).

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Several recent studies have addressed the impacts of transport policies on health and well-being (e.g. Braubach et al., 2015; Dhondt et al., 2013; Hosking et al., 2011; Perez et al., 2015; Schram-Bijkerk et al., 2009; Thomson et al., 2008). Transport increases air pollution levels, noise and the risk of accidents which in turn are responsible for several health outcomes, such as an increased risk of cardiovascular or respiratory disease due to air pollution (e. g. Brunekreef and Holgate, 2002; Hoek et al., 2013; Künzli et al., 2000; Pope III and Dockery, 2006), injuries caused by dangerous driving behavior (Peden et al., 2004), traffic noise related mortality (Tobias et al., 2015) and annoyance caused by traffic noise (Miedema et al., 2011; Miedema and Oudshoorn, 2001). Likewise transportation can influence physical activity patterns in a positive as well as in a negative way by supporting or averting active transportation (WHO, 2010, 2013). Yet, attributing health effects to transport policies is problematic due to data limitations, variations in methodologies, and equipment used for measuring pollutants such as air pollution and noise. In addition there is a need for detailed health statistics and exposure-response functions, based on pooled and averaged estimates published in the scientific literature, which are then applied to local contexts. A systematic assessment of the impacts and especially health impacts of transport policies is usually lacking, although there is a recognized need to inform the decision-making process by evaluating the consequences of planned policies. Health Impact Assessment (HIA) can help advising policy makers and especially non-health related sectors by revealing objectively the effects of interventions, projects or policies on health (Kemm and Parry 2004; Mindell et al., 2003; WHO European Centre for Health Policy, 1999).

In order to do so, it is important to integrate HIA of air pollution and noise exposure and related health effects with traffic modeling (Dora and Phillips, 2000; Negev et al., 2012). Two issues are important to be considered (1) the specific plans developed to address the impacts of GHG mitigation policies for cities and (2) the way to assess decisions on reduction of GHG emissions at a local level that are related to the transport sector. The first issue leads us to utilize HIA methodologies, whereas the second issue leads on the ways to operationalize HIA related to planned policies in the transport sector and to use the results for policy making.

1.1. Context and study population

The city of Rotterdam, located 20 km from the coast of the North Sea in the west of the Netherlands, has planned and implemented a series of interventions to decrease CO_2 emissions by 50% between 1990 and 2020 as part of its GHG mitigation policies. These interventions include more biomass burning in energy production, insulation of buildings to reduce the demand for energy and traffic related policies. The latter consist of two separate interventions (a) 10% reduction of private vehicle kilometers on inner-urban roads and (b) a share of 50% electric-powered private vehicle kilometers on inner-urban streets by the year 2020 (Keuken et al., 2014). It has to be noted that, although proposed by the municipality itself, this is not a realistic scenario for 2020 as of 2014 less than 5% of private vehicles kilometers were electric vehicles. As the city of Rotterdam (and other cities) expect and have an interest in promoting a considerable increase in electric road transport, this ambitious scenario was included to assess the impact on air quality, noise and health. These interventions support the attempt by the city to become clean, green and economically robust by reducing noise levels and improving air quality with the aim of protecting the health of Rotterdam's population (Rotterdam Office for Sustainability and Climate Changes, 2011). Besides the two GHG mitigation policies an additional scenario was modeled: a business-as-usual (BAU) scenario. The BAU represents a realistic scenario that includes all transport-related interventions that are already planned by the local authorities up to 2020. The BAU scenario includes the assumptions that the consequences of today's exposure and behavior will continue without any changes to the year 2020, furthermore it includes regulations which are already decided but not yet implemented, like the exhaust emission standard Euro 6.

The aim of our study was to present an assessment of health co-benefits of GHG mitigation policies in the transport sector in Rotterdam. Effects of these policies were evaluated by comparing the burden of disease attributable to air pollution and traffic noise in 2010, chosen as a baseline, and the modeled burden when the policies will be implemented in 2020. Additionally the impact of the interventions is compared to the BAU development. This article also describes the steps that allow addressing a general issue such as GHG mitigation policies in a realistic scenario of planned interventions in a medium size European city and its indirect co-benefits on population health.

2. Material and methods

Fine particulate matter ($<2.5\ \mu m$ in aerodynamic diameter-$PM_{2.5}$) and elemental carbon (EC) were used to assess the effects of air pollution on health. There is compelling evidence of adverse health effects due to $PM_{2.5}$ exposure such as cardiovascular and respiratory effects (Brook et al., 2010; Hoek et al., 2013; WHO Regional Office for Europe, 2006; WHO Regional Office for Europe, 2013). $PM_{2.5}$ consists of a mixture of primary (soot) and secondary particles. The latter are formed in the atmosphere from natural and anthropogenic gaseous emissions, such as ammonia (e.g. arising from agriculture), sulfur dioxide (e.g. arising from energy and industry processes) and nitrogen oxides (e.g. arising from traffic and other combustion processes). Hence, $PM_{2.5}$ concentrations are only partly related to large-scale traffic emissions of nitrogen oxides, while primary emissions of soot particles from road traffic contribute little to the mass of $PM_{2.5}$. Consequently, $PM_{2.5}$ represents local traffic emissions in a limited way (Keuken et al., 2012). Black carbon or elemental carbon (EC) can be additionally used beside $PM_{2.5}$ to assess the effects of air pollution related to combustion-related interventions (Janssen et al., 2011a; WHO Regional Office for Europe, 2013). Scientific evidence linking EC exposure to health effects is limited, but a relative risk (RR) for all-cause mortality and EC exposure has been reported, which is up to ten times higher than the RR of $PM_{2.5}$ and all-cause mortality (per mass unit) (Keuken et al., 2012; Smith et al., 2009). However, EC being a specific marker for road traffic emissions it can only be used for assessing health effects for people living close to road traffic, which in Rotterdam accounts for around 3.8% of the total population (13,946 people). Thus in the HIA for Rotterdam, both $PM_{2.5}$ and EC have been examined to assess the impact of the two local transport interventions on health.

In addition to air pollution, road traffic also causes noise. Noise levels increase with higher traffic volumes and speed (Hosking et al., 2011) but also vary by road surface, surrounding vegetation and vehicle type. As determined in the EU Directive 2002/49/EC, a weighted average over 24 h was performed for traffic noise, assigning higher weights to the evening and night periods than to the day period. This weighting scheme takes into account that sleep disturbance is an important aspect of noise-related health impacts. The weighted average noise levels are called “L_{den}” (day–evening–night) and “L_{night}” (only during the night). L_{den} is associated with annoyance and hence an indicator for psychological well-being, while L_{night} is related to sleep disturbance and cardiovascular effects (Miedema et al. 2011). In the HIA for Rotterdam, noise annoyance (people exposed to L_{den} over 55 dB(A)) and sleep