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Transport-related measures to mitigate climate change in Basel, Switzerland: A health-effectiveness comparison study☆

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ABSTRACT

Background: Local strategies to reduce green-house gases (GHG) imply changes of non-climatic exposure patterns.
Objective: To assess the health impacts of locally relevant transport-related climate change policies in Basel, Switzerland.
Methods: We modelled change in mortality and morbidity for the year 2020 based on several locally relevant transport scenarios including all decided transport policies up to 2020, additional realistic and hypothesized traffic reductions, as well as ambitious diffusion levels of electric cars. The scenarios were compared to the reference condition in 2010 assumed as status quo. The changes in non-climatic population exposure included ambient air pollution, physical activity, and noise. As secondary outcome, changes in Disability-Adjusted Life Years (DALYs) were put into perspective with predicted changes of CO_2 emissions and fuel consumption.
Results: Under the scenario that assumed a strict particle emissions standard in diesel cars and all planned transport measures, 3% of premature deaths could be prevented from projected $PM_{2.5}$ exposure reduction. A traffic reduction scenario assuming more active trips provided only minor added health benefits for any of the changes in exposure considered. A hypothetical strong support to electric vehicles diffusion would have the largest health effectiveness given that the energy production in Basel comes from renewable sources.
Conclusion: The planned local transport related GHG emission reduction policies in Basel are sensible for mitigating climate change and improving public health. In this context, the most effective policy remains increasing zero-emission vehicles.

1. Introduction

It is now recognized that climate change has diverse and interconnected consequences for health and that urgent action is needed to limit impacts in the next century (Haines et al., 2014; McMichael, 2013). Urban areas are responsible for up to 70% of the production of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions causing global warming (UN-Habitat, 2011). Aware of their responsibility to curb and reduce GHG emissions, local government in many cities have implemented or are planning policies in different sectors of activities, such as transport, energy production or residential heating, to reduce their GHG footprint.

Many of these climate change policies imply changes of several non-climatic exposure patterns known to be related to health. Those secondary consequences of GHG policies may be of immediate or mid-term

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relevance to health whereas the reduction in GHG is a long-term target (Cheng and Berry, 2013). Important secondary changes in exposure relate to ambient and indoor air pollutants, redistribution of urban green spaces or mode of transport. These exposures may have direct (positive or negative) effects on health and well-being of the population. The interrelationship between exposure changes, health impacts and climate change policy frameworks was evaluated in a series of papers in 2009 in large European and Asian cities in relation to hypothetical scenarios of policy changes in the household energy, transport, food and agriculture, and electricity generation sectors (Friel et al., 2009; Haines et al., 2009; Wilkinson et al., 2009; Woodcock et al., 2009). While these studies have been influential in raising awareness on the large health co-benefits of mitigating climate change, the synergies existing between mitigating climate change and health promotion are still largely unknown, especially among local policy-makers. Thus the choice of prioritizing local policies may currently not be optimal nor for GHG reduction nor for benefitting health. In addition, an important gap of knowledge in the perspective of coming climate discussions is to better understand to what extent local actions can really contribute to mitigation of climate change impacts given other local needs, priorities and realities.

Here we present the framework, methodology and results of the health benefits and impacts of locally relevant transport-related climate change policies in the Swiss city of Basel. Basel has been a case study in the 7th European Research Framework programme funded project URGENCHE (Urban Reduction of Greenhouse gas Emissions in China and Europe). We focused our analysis on scenarios related to transport policies. In Basel, the national CO_2 emission reduction targets have been met for several years now and 100% of the electricity is produced by renewable energy (as of 2010). As such, the climate change debate in Basel may seem closed. However, traffic is and will remain a challenging problem due to the difficult to control internal and external traffic growth- a large contributor to GHG emissions- in Basel as in most urban areas. To fulfil the requirements of a citizen referendum that took place in 2010, the city of Basel is in an ongoing process to evaluate to what extent these measures can control traffic. The referendum requires that traffic on urban roads in the city of Basel be reduced by 10% by 2020, and that further increases in air pollution in living quarters be avoided in accordance with the air quality law. Given the unique context of a long history of environmental sustainability policies, Basel is also an interesting case study to understand the extent to which future local transport development plans can contribute climate change mitigation.

2. Methods

We modelled differences in health impacts between current conditions (2010 year of reference), assumed as status quo until year 2020, and the year 2020 under different GHG transport-related policy scenarios of relevance for Basel. The target population of our analysis included only the residents of the canton of Basel-Stadt, the administrative unit for the city of Basel. Thus we only account for impacts of policies that may contribute to local changes. The methodological steps followed for the health impact assessment (HIA) include selection of relevant scenarios for the city, selection of outcomes and concentration-response functions (CFRs) available from current revision of the epidemiological literature and HIA practices, modelling changes in population exposure under the different selected scenarios and combining all the above for calculating the health impact resulting from predicted changes in exposures.

2.1. Choice of pathways of exposure and scenarios

Transport policies act on urban development and mobility aspects and imply changes in CO_2 emissions and exposure of the population to short-lived air pollutants such particles or nitrous oxide (NO_2), as well as primary pollutants near to transport sources, such as soot. These policies also imply changes in noise exposure or physical activity patterns and in general of time-activity that may be linked to accidents and further exposure to air pollution. Changes in mobility patterns are expected to influence fuel usage within the city limits with additional consequences for CO_2 emissions. For Basel, the pathway of exposure evaluated as a result of these changes include predicting changes in CO_2 emissions, regional pollution (represented by particulate matter up to 2.5 μm in diameter [$PM_{2.5}$]), near-road traffic-related pollution (represented by elemental carbon [EC]), noise and physical activity patterns.

We retained four scenarios of transport changes compared to the reference scenario that assumes that all conditions in 2010 remain as they are until the target year 2020, except for population size:

(1) a scenario that includes all transport-related measures that are decided by the local government to be developed up to 2020. This scenario relies on the assumption that those policies are being currently implemented and likely to be maintained unless jeopardized by future political processes and decisions. We refer to this scenario as the “Decided Policies” (DP);
(2) the so-called “Z9 scenario” developed by the city that accounts for additional local transport measures beyond DP to further reduce traffic by 4% on inner roads. This local scenario complies with a successful citizen referendum requiring further traffic reduction. It includes a series of traffic measures targeted at channelling traffic along main avenues, reduce traffic and moderate speed in residential areas not contemplated in DP. This scenario also assumes a local shift of car trips to active transport (walking and cycling);
(3) A hypothetical scenario named “p10” assuming a 10% reduction of traffic on inner roads as compared to DP; in p10, all other measures of Z9 are also assumed to be implemented, thus the only difference between Z9 and p10 is the 10% instead of only 4% reduction in traffic; and.
(4) the p50 scenario expanding p10 with the assumption that 50% of the private car fleet would be based on electric vehicles.

While DP and Z9 were locally developed by the city authorities, p10 and p50 are default scenarios that the URGENCHE project team agreed upon for all cities included in the project. Supplemental Material Table 1 provides an overview of scenarios and assumptions.

2.2. Selection of outcomes and concentration-response functions

Table 1 summarizes exposure and outcomes retained in our analyses. We used $PM_{2.5}$ as the indicator of long-term exposure to air pollution. $PM_{2.5}$ has been associated with total, cardio-respiratory and lung cancer mortality and shortened life expectancy (WHO, 2013a,b). Our core analysis includes the estimation of long-term exposure to $PM_{2.5}$ on all-cause natural mortality and cause-specific mortality (lung cancer and cardiovascular diseases) in sensitivity analyses (Hamra et al., 2014; Hoek et al., 2012). In recent years, epidemiological studies have shown that local traffic emissions may be independently related to the long-term health effects of regional air pollution (HEI. Health Effect Institute (HEI) Panel on the Health Effects of Traffic-Related Air Pollution, 2009). While these local primary emissions contribute to only a small fraction of the total mass of $PM_{2.5}$, their distribution depends on the distance to source. This is less the case for $PM_{2.5}$ which is more homogeneously distributed. Thus, studies using $PM_{2.5}$ may not fully capture the effects of near-road traffic-related particles. It has been suggested that indicators of near source combustion particles such as black carbon characterized by EC could be used in addition to $PM_{2.5}$ to evaluate the effects of local traffic sources (Keuken et al., 2012a). In order to avoid double counting, the effects due to exposure to EC should not be added to the effects related to exposure to $PM_{2.5}$ (WHO, 2013a).