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Estimating the health benefits of planned public transit investments in Montreal

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ABSTRACT

Background: Since public transit infrastructure affects road traffic volumes and influences transportation mode choice, which in turn impacts health, it is important to estimate the alteration of the health burden linked with transit policies.
Objective: We quantified the variation in health benefits and burden between a business as usual (BAU) and a public transit (PT) scenarios in 2031 (with 8 and 19 new subway and train stations) for the greater Montreal region.
Method: Using mode choice and traffic assignment models, we predicted the transportation mode choice and traffic assignment on the road network. Subsequently, we estimated the distance travelled in each municipality by mode, the minutes spent in active transportation, as well as traffic emissions. Thereafter we estimated the health burden attributed to air pollution and road traumas and the gains associated with active transportation for both the BAU and PT scenarios.
Results: We predicted a slight decrease of overall trips and kilometers travelled by car as well as an increase of active transportation for the PT in 2031 vs the BAU. Our analysis shows that new infrastructure will reduce the overall burden of transportation by 2.5 DALYs per 100,000 persons. This decrease is caused by the reduction of road traumas occurring in the inner suburbs and central Montreal region as well as gains in active transportation in the inner suburbs.
Conclusion: Based on the results of our study, transportation planned public transit projects for Montreal are unlikely to reduce drastically the burden of disease attributable to road vehicles and infrastructures in the Montreal region. The impact of the planned transportation infrastructures seems to be very low and localized mainly in the areas where new public transit stations are planned.

1. Introduction

Transportation and urban planning policies affect road traffic volumes, influence transportation mode choice which in turn impact health and the environment (de Nazelle et al., 2011). The volume of motor vehicle traffic has been recognized as one of the fundamental causes of road injuries for all road users (Fuller and Morency, 2013). Motor vehicles have also been identified as one of the main sources of air pollutants. Traffic related outdoor air pollutants like nitrogen dioxide (NO_2) and particulate matter have been linked to asthma, cardiovascular diseases, cancers and premature deaths (Health Effects Institute, 2010). The 2010 World Bank Global Burden of Disease

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estimates that the number of deaths attributable to motor vehicles surpasses those of HIV, tuberculosis or malaria (Bhalla et al., 2014). The World Bank group assessment (Bhalla et al., 2014) is likely an underestimation of the burden linked to road transport, since only the burden of traffic related injuries and air pollution were considered in this assessment.

On the other hand, physical activity in general and active transportation has been shown to reduce the risk of a number of illnesses such as diabetes, cardiovascular diseases, breast and colorectal cancers (Lee et al., 2012). Furthermore, walking or cycling to public transit access points can contribute significantly and event be sufficient to reach the daily recommended duration of physical activity (Morency et al., 2011; Wasfi et al., 2013). Thus promoting a mode shift from car travel to active transportation or to public transit use could reduce the burden of road transport by increasing physical activity.

The need for integrated health impact assessments (HIA) to orient transportation policies has been recently recognized (Bhalla et al., 2014; de Nazelle et al., 2011), but only a few studies performed HIA that covered multiple transport-related risk factors (Maizlish et al., 2013; Rojas-Rueda et al., 2012; Woodcock et al., 2009, 2013).

Estimating the health impacts associated with transport policies and infrastructure investments is key to the development of more meaningful transport-related decisions and to meet the objectives of sustainability and healthy living. However, to our knowledge, no study ever assessed the alteration of the integrated burden of transportation in association with planned modifications of the public transit infrastructure; so far studies have only assessed hypothetical, not planned projects.

In this study, we quantify the variation in health benefits and burden in 2031 between a business as usual scenario (no new transportation infrastructure) and a public transit scenario of all planed public transit infrastructure in the greater Montréal region. Compared to previous work published to date, here we use concrete scenarios based on planned projects. We also developed a comprehensive transportation prediction module that considers individual travel mode choice (in response to travel time by mode, socio-demographics and urban form) and traffic assignment (assign vehicular traffic on the transportation network) accommodating for the interaction between transportation modes commonly ignored in previous HIAs.

2. Methods

The method used in this study is complex and involved several databases and models. A figure providing an overview of the methods is presented in the supplemental material (Fig. S1).

2.1. Study area and policy scenarios

Our study aims at investigating the population health effects under a base case (reflecting the year 2008) and future scenarios (2031) using an integrated modelling approach including travel demand modelling, traffic assignment on the road network, emission estimation, and atmospheric dispersion modelling. Our study is set in the greater Montreal Region (a description of the region is available in the supplemental material). Briefly, in 2008, the central Montreal Region included roughly 29% of the population of the greater Montreal and was the most densely populated region (19,196 persons per km^2 of residential area). In contrast, the population of the inner and outer suburbs were scattered over a larger territory (respectively 6867 and 2487 persons per km^2 of residential area). They included respectively 40% (inner) and 31% (outer) of the greater Montreal population. In 2031, according to the Institut de la statistique du Québec (Pelletier and Kammoun, 2010), the population distribution should shift in favour of the inner (41%) and outer (33%) suburbs. Our analysis was conducted for three portions of the region forming concentric circles (Fig. 1). These regions were formed by aggregating some of the 108 municipalities of the greater Montreal (Table S2).

The first scenario is a *business as usual* (BAU) scenario for 2031 in which transportation infrastructures remained identical to those of 2008. The second scenario is the *public transit* (PT) scenario in which the 2008 transport infrastructure is supplemented by new public transit infrastructures planned for the year 2031 (CMM-2012). Specific new and old transportation infrastructures are presented in Fig. 1. For both scenarios, the 2031 population size and distribution was based on the *Institut de la Statistique de Quebec* reference projection for 2031 by local community service centre (Pelletier and Kammoun, 2010). For both scenarios, the age and sex distributions of the population were maintained to be identical to those in 2008.

2.2. Databases and exposure models

2.2.1. Individual mobility

Information on trips (length, mode of transport, frequencies, etc.) accrued by the population of the greater Montreal region was retrieved from the Origin-Destination (OD) trip diary survey conducted during the fall of 2008 by a consortium of transportation authorities (AMT (Agence métropolitaine de transport), 2010) (described in the supplemental material). In brief, the OD survey is a telephone-based survey conducted every five years in greater Montreal and targeting a 5% sample of the region's population (66,100 households). Entire households are recruited and asked to list all the trips conducted by every household member (5 years and older) throughout a particular workday. Such snapshot of the region's population is typically used to develop statistical models that can predict travel behaviour including the choice of a transportation mode (as well as other attributes of a trip).

2.2.2. Mode choice models

In order to ascertain changes in travel behaviour from 2008 to 2031, we predicted mode choice for 2031 trips with mode choice models developed for the year 2008. The mode choice models (multinomial logit models) were used to predict the mode probability (i.e. biking/walking, taking the car, public transit, or combinations of these modes) of each trip for the BAU and the PT scenario. For each trip, we used the mode with the highest predicted probability from the different models. Thus if the probability of taking public transit was 0.8 and the probability of walking was 0.2, this trip was considered to be made in public transit. The predictions were based on travel time and cost, individual and household attributes and accessibility measures for the trip considered (Eluru et al., 2012) (models are described in the mode choice models section of the supplemental material). In both scenarios, a weight was also associated with each trip in order to take into account the population increase expected for 2031. When new subway or train stations were impletemented in the PT scenario, we identified a factor to consider the change in travel time by transit. The factor was computed by considering the ratio of travel time for people with and without subway stations. Basically, people with access to the subway have lower travel times; so a new subway station will reduce the travel time of people in the surrounding neighborhoods. This factor was applied for travel time by transit (while other travel times remained the same) to all trips with origin or destination occurring within 1 km of the new stations (see mode choice models supplemental material for further details). Multi-modality, i.e. multiple modes used per trip, was only assessed for public transit users. Firstly, trips made by PT always included walking and are thus multi-modal; Secondly, our mode choice models also predicted “park/ride” (i.e. being a car driver and using public transit on the same trip) as well as “kiss/ride”(i.e. being a car passenger and using public transit on the same trip). These modes refer to trips taken partially in public transit and partially by car (respectively as a driver or a passenger). We did not find a reasonable number of cycling to public transit stations. Thus we could not consider this mode in our multi-modal models.