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Contrasts in active transport behaviour across four countries: How do they translate into public health benefits?

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ABSTRACT

Objective. Countries and regions vary substantially in transport related physical activity that people gain from walking and cycling and in how this varies by age and gender. This study aims to quantify the population health impacts of differences between four settings.

Method. The Integrated Transport and Health Model (ITHIM) was used to estimate health impacts from changes to physical activity that would arise if adults in urban areas in England and Wales adopted travel patterns of Switzerland, the Netherlands, and California. The model was parameterised with data from travel surveys from each setting and estimated using Monte Carlo simulation. Two types of scenarios were created, one in which the total travel time budget was assumed to be fixed and one where total travel times varied.

Results. Substantial population health benefits would accrue if people in England and Wales gained as much transport related physical activity as people in Switzerland or the Netherlands, whilst smaller but still considerable harms would occur if active travel fell to the level seen in California. The benefits from achieving the travel patterns of the high cycling Netherlands or high walking Switzerland were similar.

Conclusion. Differences between high income countries in how people travel have important implications for population health.

Introduction

Regular physical activity provides a wide range of health benefits. Active travel (primarily walking and cycling) has gained attention from the transport and environmental sectors for its advantages as low-emission and space-efficient travel modes (Banister, 2008). Active travel is also increasingly recognized for its potential to contribute to overall physical activity (Craig et al., 2012; Dora, 1999). As active travel combines mobility and activity, it may offer a lower hurdle to be active than sports or other recreational activity. Nonetheless, steps to increase active travel have generally been hesitant, although some countries (e.g. the Netherlands, Switzerland, Germany or Denmark) have been more proactive than others (e.g. UK, USA). Health impact modelling is used to quantify effects of active travel on health outcomes in a specified population and as such can support informed decision making and cost-effective investment of limited resources.

In recent years, various methods to model health impacts of active travel have been developed. These typically compare benefits of physical activity with potential harms from injury risk and increased exposure to air pollution. When modelling substantial changes at the population level, such studies have overwhelmingly found large net benefits from active travel (de Hartog et al., 2010; Rabl and De Nazelle, 2012; Rojas-Rueda et al., 2011, 2013; Woodcock et al., 2013, 2014), although this may not apply in younger age groups when injury risks are high (Woodcock et al., 2014).

Typically health impact models of transport have used hypothetical scenarios with simplistic assumptions on changes in active travel (e.g. de Hartog et al., 2010; Gotschi, 2011; Grabow et al., 2011; Kahlmeier et al., 2011). Such studies may arguably struggle to realistically reflect travel behaviour, particularly in the context of advanced models which consider distributions of physical activity across age and gender. The objective of this study is therefore to create alternative scenarios using data from major travel surveys reflecting population-wide distributions of travel behaviour, in particular across age and gender. England and Wales (E&W) served as the reference scenario. To illustrate the potential range of the magnitude of health impacts from changes in active transport, comparison areas were chosen for exceptionally high

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or low levels of active transport, respectively. Specifically, the health impacts on the urban population of E&W were modelled, assuming shifts to travel patterns of Switzerland, the Netherlands, and California.

Methods

Travel survey data

Travel survey data were used from E&W and three comparison areas selected based on substantial contrasts in travel patterns, namely Switzerland for high levels of walking, the Netherlands for high levels of bicycling, and California for high levels of car usage. As such, they were used to inform hypothetical yet realistic scenarios for the population of E&W. Table 1 shows descriptive data of E&W and the three comparison areas.

Data on travel patterns were extracted from national travel surveys (Bundesamt für Statistik et al., 2007; Department of Transport, 2013; Federal Highway Administration, 2010; Ministerie van Verkeer en Waterstaat, 2010) (Supplementary Table A.1). To increase survey comparability, small communities of less than 10,000 inhabitants were excluded, and minimum trip duration was standardized to 3 min.

Health impact modelling

Health impacts were modelled as changes in population health due to changes in active travel time (walking, cycling) in the E&W population. The model was estimated using Monte Carlo simulation in Analytica version 4.4. (www.lumina.com), running 50,000 iterations. The current E&W travel pattern was compared against the counterfactual scenarios in which E&W would adopt the travel patterns from Switzerland, the Netherlands or California, respectively. Travel patterns were modelled as changes in absolute terms (minutes of each mode), as well as relative terms (percent of total travel time of each mode). Travel behaviour was modelled as population wide distributions of travel times spent in different modes, stratified by sex and age groups for E&W and each comparison area. For all other variables, i.e. age distribution, background mortality and morbidity rates, age and sex-specific E&W data was used.

The study was conducted using a substantially improved and updated version of the Integrated Transport and Health Impact Modelling tool (ITHIM) (Woodcock, 2014), which now models variability and uncertainty of parameters using Monte Carlo simulation. Earlier versions were previously described elsewhere (Maizlish et al., 2013; Woodcock et al., 2013, 2014). ITHIM was used to model health benefits of physical activity using a range of non-linear dose–response functions specific to exposure domains (total physical activity, non-work physical activity, or physical activity from active travel) and outcomes (all cause mortality, morbidities). Because most previous health impact models of active travel found that associated risks are at least one order of magnitude smaller than benefits of physical activity when changes are modelled across all age groups (de Hartog et al., 2010; Rabl and De Nazelle, 2012; Rojas-Rueda et al., 2011), the approach to impact modelling presented here is only applied to impacts from physical activity.

Aggregation of background physical activities reflected intensity of specific activities, estimated in Metabolic Equivalents of Task (METs), as listed in the Compendium of Physical Activity (Ainsworth et al., 2011). Activities under 1.5 METs were excluded. METs were converted into marginal METs by subtracting 1 MET (intensity of being at rest). This approach only considers the activity over and above the metabolic activity at rest. Variation in METs for each activity was taken into account stochastically to generate distributions of METs within age and gender strata (Table 2).

Age (15+) and gender specific data on walking, cycling, household work, sport and work included estimates of variability and were available from the health survey for England (Craig and Mindell, 2013). Background physical activity was assumed to remain unchanged throughout the different scenarios (Supplementary Table A.2).

Health benefits of physical activity were modelled using disease specific incidence and mortality of stroke, ischemic heart disease (IHD), other cardiovascular and circulatory diseases, type-2 diabetes, colon cancer, breast cancer, dementia and Alzheimer's disease, and depression. The doses were recalculated from Woodcock et al. (2009) as marginal MET/h week. See Table 3 for dose–response parameters. As part of sensitivity analysis, two alternative approaches to model impacts on all-cause mortality were applied, using relative risks from a systematic review by Woodcock et al. (2011) and a dose–response function presented in a recent large cohort study (Wen et al., 2011), respectively (Supplementary Table A.3).

A log-linear relationship was assumed between exposures and the health outcomes. Beyond this the exposure variables were transformed (using power transformations 0.25 to 1) (Sattelmair et al., 2011; Woodcock et al., 2011). Since the exact parameters of the non-linear dose–response function are unknown, these were stochastically allowed to vary across iterations of the model (see Supplementary Fig. B.1) and evaluated in sensitivity analyses.

Burden of disease data for the UK, including mortality rates as well as disability adjusted life years (DALYs), years of healthy life lost due to disability (YLDs) and years of life lost (YLLs), were obtained from the Global Burden of Disease (GBD) study 2010 (IHME, 2013) and adjusted to reflect E&W population size, and age and gender distribution. Supplementary Table A.4 presents size and age distribution and Supplementary Table A.5 the burden of disease for the study population.

Sensitivity of the model to selected parameters was illustrated with tornado plots (Table 2, Supplementary Table A.6 and Fig. B.2).

Results

Travel behaviour patterns

The three international comparison areas reveal substantial contrasts compared with E&W, both in terms of absolute travel times as well as relative distribution across travel modes assuming a constant travel time budget (Table 4). Overall, the data showed travel time to be highest in Switzerland at over 80 min per day, compared with fewer than 60 min in E&W. Californians drive the most, almost 1 h per day, compared with only around 35 min in E&W. The small differences for driving times between the different European settings reflect the fact that the Swiss

Table 1
Descriptive data on E&W and three comparison areas.

	England & Wales (study area)	Switzerland	Netherlands	California
Population (million)	55.6 (2010)[a]	8.0 (2011)	16.8 (2014)	38.3 (2013)
Area	151,036 km^2	41,285 km^2	41,543 km^2	423,970 km^2
Population density [b]	370/km^2	188/km^2	405/km^2	95/km^2
Gross domestic product (GDP)/capita ($)	37 k (UK)	54 k	42 k	46 k (USA)
Cars per household	1.2 (2011)[b]	1.15 (2010)[c]	1.0 (2005)[d]	2.2 (2010)[e]
Share of trips by walking and cycling	26% (UK, 2008)[f]	50% (2010)[d]	51% (2008)[g]	23% (2012)[h]

Sources: (Wikipedia, 2014), if not otherwise stated. See footnotes.

[a] http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk–england-and-wales–scotland-and-northern-ireland/mid-2001-to-mid-2010-revised/index.html
[b] http://www.ons.gov.uk/ons/rel/census/2011-census/key-statistics-for-local-authorities-in-england-and-wales/index.html
[c] Bundesamt für Statistik and Bundesamt für Raumentwicklung, 2012. Mobilität in der Schweiz: Ergebnisse des Mikrozensus Mobilität und Verkehr 2010. BfS, ARE, Neuchâtel.
[d] http://www.cbs.nl/en-GB/menu/themas/dossiers/nederland-regionaal/publicaties/artikelen/archief/2007/2007-2127-wm.htm
[e] http://www.clrsearch.com/Sacramento-Demographics/CA/Number-of-Vehicles-per-Household
[f] https://www.gov.uk/government/collections/national-travel-survey-statistics
[g] Ministerie van Verkeer en Waterstaat, 2010. "Onderzoek Verplaatsingen in Nederland" (OViN).
[h] Federal Highway Administration, 2010. National Household Travel Survey. US Department of Transportation.