Health Equity Outcomes Arising from Transport Scheme Innovation, Utilizing New Generation Mobility Data

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Abstract

Improved understanding of the spatial distribution of health impacts arising from the introduction of new travel initiatives will support more targeted and efficient policy development across both the transport and health sectors. Typical health impacts include those arising from changes in levels of personal activity with alternative mode choices. With a sectoral approach to policy development, positive impacts for one sector (i.e. improved transport services) may be negated by dis-benefits in another (e.g. low levels of active travel choice and increased obesity related disease burden). The goal of this research is to extend beyond an improved understanding of the overall consequential health impacts (positive and negative) for the travelling public, however, and to identify the distribution of impacts. To research this, the horizontal notion of equity (Thomopoulos, Grant-Muller and Tight, 2009) is applied using a range of transport-related health outcomes including cancer, heart disease and depression. The aim is to identify those segments of the population (or city sub-areas) where the travelling public are particularly advantaged or disadvantaged in terms of health related outcomes from new transport schemes. The research methodology interfaces new generation 'Track and Trace' information on individuals location and mode choices (detected as mobile phone app-based sensor data) with a new integrated transport and health model (IHITM), finally calculating an equity indicator based on distributional impacts.

The work presented here represents on-going research to harness the potential of new generation data ('Big Data') arising from innovative policies (based on persuasive technologies) in the transport sector. The case study data arises from the large scale implementation of positive incentives to encourage changes to travel choices using mobile phone apps in Newcastle (UK), which is part of a large project involving related studies in 10 other cities across Europe.

Methodology

A better understanding of the interfaces between travel choices and the chain of consequential impacts is needed to improve liveability in cities and communities, in Europe and globally. In particular, interfaces relating to health and particularly the disease burden from exposure to pollutants, obesity consequences from inactivity. Globally, exposure to ambient air pollution was estimated to have caused 3.7 million deaths in 2012 (WHO, 2014).

A number of models go some way to capturing the links between the transport sector and other sectoral impacts, for example the ITHIM model (Woodcock et al, 2013) to explore transport-health interrelations. These cross-sectoral models have, however, been largely developed based on traditional (and mainly aggregate) data sources such as travel diaries, fixed based traffic counts etc. This type of modelling is based on a 'snapshot' of the transport system at fixed-base locations. The models are prone to a number of weaknesses, such as over-reporting in the input data (PHE, 2014) and difficulties in identifying distributional impacts as a result of the granularity of the inputs. As a result, the outputs are necessarily at a high spatial level of aggregation. The Health Effects Institute recommends models that account for personal exposure or include time-activity data can produce the “best” estimates of human exposure (Health Effects Institute, 2010). The ability to understand the health equity consequences at a much more refined level than city-wide or at a fixed base location in the city is an important next step in policy development. Analysis to reveal whether particular residential locations or corridors in the city have a greater adverse health outcome from a transport initiative than other locations is key information in order to direct mitigating resources in a more targeted way. In comparing the expected benefits between alternative transport schemes ex-ante, an equity indictor of the health consequences will give a further dimension to decision making according to policies concerning transport, health and an equitable society.

The emergence of a next generation of transport and other data with extended use of ICT not just in the transport sector, but across society as a whole, has given rise to ‘unprecedented volumes of data across all modes and transport systems’ (EC 2016). The volume is not the only key characteristic however. It has a granularity, immediacy and geo-location aspects that are fundamentally of a different order to traditional data streams. PHE (2014) identify technology as a key strategic area to improve the accuracy in reporting activity and travel effectively without huge investment costs or imposition. The research here harnesses the opportunity provided by mobile phone sensor-generated location data to collect the day-to-day movement patterns of individuals (with their informed consent), including the mode, route and other information. This can be used to build a mobility profile of individuals choices before and after introduction of a transport related initiative (Figure 1)

Figure 1: Spatial patterns in T&T trip data

<u>Case study for Newcastle City Region, UK</u>

Track and Trace Data (T&T) is being generated from a large scale implementation involving members of the public in the Newcastle City region (UK) over a six month period in 2017 using a smartphone application (EMPOWER project, 2015). An example of some of the variables for which data is collected is shown in Figure 2 below. This is an extremely rich datasource with more than 40 variables generated for each trip.

Unique trip ID	Start hour	Start day	Start week	End hour	Trip quality, Missing indicates an inserted trip	Average speed	Total trip distance	Trip modality, possibly corrected by the traveller	Total travelling cost, estimate	Total calories spend during trip, estimate	Emitted particle	Emitted amount in grams	
1706027132	16	27	35	17	Good	1.3	1600	Foot	0.02	102	CO2	39	
1706027132	17	27	35	18	Unknown	0.4	430				CO2	0	
1706027132	18	27	35	18	Good	1.2	1700	Foot	0.02	111	CO2	44	
1706027132	18	27	35	9	Missing	0	0				CO2	0	
1706027132	9	28	36	9	Bad	0.3	40				CO2	0	

Unique trip ID	Weather temperature in degrees Celsius	Amount of rain in mm	Weather condition	Latitude in WGS84	Longitude in WGS84	Accuracy in meters	Place name of origin	Place type	Postal code	PC4	Total stay duration in origin	Total stay percentage in origin	Number of visits to this place
1706027132	19	0	clear	-21.537	15.09316	10	The grove	home	LS2	BD21	1228445	78.1	28
1706027132	0	0		-11.544	15.084416	10	City	place	LS2	BD21	13796	0.9	2
1706027132	17	0	clear	-11.544	15.084416	10	City	place	LS2	BD21	13796	0.9	2
1706027132	0	0		-21.537	15.09316	10	The grove	home	LS2	BD21	1228445	78.1	28
1706027132	0	0		-21.537	15.09316	10	The grove	home	LS2	BD21	1228445	78.1	28

Figure 2: Trip data generated by smartphone application (anonymised here)

Model development underway with the IHITM model is interfacing the T&T data at individual level with the underlying transport-health models, enabling more disaggregate level outputs. A cross-section of society are expected to download the app during the course of the implementation and a separate analysis will test model developments using synthetic data. The T&T data will give full O-D data, a range of data on externalities, habitual patterns, dwell time, phone type, confidence/quality indicators and more. Initial processing takes place on the device, with further processing by the data supplier.

The combination of T&T data with the IHITM model allows a calculation of the health outcomes on a sub-region level. Health outcomes generated include a number of indicators including those related to different cancers, heart disease, depression and dementia. Safety (accident exposure) related outcomes are also generated. According the scheme definition, these may be expected to arise in different spatial sectors of the city and according to different age groups or gender.

In order to generate an equity index for those transport-health outcomes, we propose the following statistic, adapted from Thomopoulos and Grant-Muller (2013).

Each of the q health-indicator values are normalised using a re-scaling method (OECD-JRC, 2008). Each indicator x^t_{qc} for a given sub-area of the City c, and time t, is transformed:

$$I^t_{qc} = \frac{x^t_{qc} - \min_c(x^t_q)}{\max_c(x^t_q) - \min_c(x^t_q)} \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where $\min_c(x^t_q)$ = minimum value of x^t_{qc} across all sub-areas c at time t

$\max_c(x^t_q)$ = maximum value of x^t_{qc} across all sub-areas c at time t

In this way the normalised indicators I^t_{qc} have values between 0 and 1. Alongside the standardised sub-region values for each indicator, a composite transport-health impact equity indicator (THEQ indicator) is given by:

$$THEQ = \sum w_q I^t_{qc} \qquad (2)$$

where w_i is the weight for the ith health indicator and can be calculated according to a number of approaches. Given the relationship between various health outcomes (e.g. cancer, heart disease, depression) and particular main drivers (age and gender), we explore the changes in the value of THEQ with scheme interventions, according to the estimated age and gender distribution in sub-regions of Newcastle.