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A method for the inclusion of physical activity-related health benefits in cost-benefit analysis of built environment initiatives

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ABSTRACT

The built environment has a significant influence on population levels of physical activity (PA) and therefore health. However, PA-related health benefits are seldom considered in transport and urban planning (i.e. built environment interventions) cost-benefit analysis. Cost-benefit analysis implies that the benefits of any initiative are valued in monetary terms to make them commensurable with costs. This leads to the need for monetised values of the health benefits of PA. The aim of this study was to explore a method for the incorporation of monetised PA-related health benefits in cost-benefit analysis of built environment interventions. Firstly, we estimated the change in population level of PA attributable to a change in the built environment due to the intervention. Then, changes in population levels of PA were translated into monetary values. For the first step we used estimates from the literature for the association of built environment features with physical activity outcomes. For the second step we used the multi-cohort proportional multi-state life table model to predict changes in health-adjusted life years and health care costs as a function of changes in PA. Finally, we monetised health-adjusted life years using the value of a statistical life year. Future research could adapt these methods to assess the health and economic impacts of specific urban development scenarios by working in collaboration with urban planners.

1. Introduction

It is now well established that city and transport planning influence the health and wellbeing of urban populations (Giles-Corti et al., 2016). Worldwide, transport and land-use policies have contributed to the increasing burden of non-communicable diseases and injuries, mainly via physical inactivity, air pollution and road trauma (Sallis et al., 2016). The transport and land planning sectors are part of the broader "built environment" (BE) concept, defined by the World Health Organization as 'Elements of the physical environment that are man-made, in contrast to the natural environment. The BE includes everything from metropolitan land-use patterns to urban transportation systems to individual buildings and the spaces around them'(World Health Organization, 2009 p28). There is a growing body of evidence on the influence of the BE on health, specifically by either facilitating or hindering physical activity (PA) (Zapata-Diomedi and Veerman, 2016; McCormack and Shiell, 2011). However BE initiatives that improve population levels of PA may expose individuals to increased risk from road trauma and air pollution (e.g. active travel programs). There is evidence to suggest that PA benefits outweigh these other health harms (Mueller et al., 2015; Doorley et al., 2015).

For public initiatives in the transport and land use sectors, cost-benefit analysis (CBA) is the recommended method for the ex-ante appraisal of public policies in Australia and elsewhere (van Wee and Börjesson, 2015; Transport for New South Wales, 2013). As per Prest and Turvey, CBAs aim to 'maximise the present value of all benefits less that of all costs, subject to specified constraints'(Prest and Turvey, 1965 p686). CBAs of public sector initiatives are commonly referred to as Social Cost-Benefit Analysis (Dobes et al., 2016; Mulley et al., 2013; Campbell and Brown, 2003). The philosophical underpinnings of CBA are in welfare economics (Drummond et al., 2005). Welfare economics is a branch of economics that aims to maximise societal welfare,

Abbreviations: BE, Built environment; CBA, Cost-benefit analysis; PA, Physical activity; SP, Stated preferences; VSL, Value of statistical life; VSLY, Value of statistical life year; WTP, Willingness to pay

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interpreted as the sum of individuals' welfare (or utility) (Lange, 1942). CBA aims to support the decision-making process by providing relevant information, and is used together with other information to make decisions on the allocation of scarce resources (Campbell and Brown, 2003).

There are increasing calls for PA-related health benefits to be included in the appraisal of BE initiatives (van Wee and Börjesson, 2015; Mulley et al., 2013; Litman, 2017). Lack of full consideration of health outcomes may misdirect allocation of resources toward developments that do not facilitate PA (e.g. motorways, disconnected streets, isolated housing developments, etc.), which may lead to societally sub-optimal outcomes. The United States of America, Australia, New Zealand and countries in Europe already produce guidance for the incorporation of PA-related health benefits in CBAs of initiatives within the transport sector (Mackie et al., 2014). For Australia, a range of values have been suggested for incorporation of PA-related health benefits in CBAs of transport initiatives. Such values are expressed on a per kilometre basis and range from less than A\$0.02 to A\$1.46 (2016) (Australian Transport Assessment and Planning (ATAP), 2016a; PriceWaterhouseCoopers (PWC), 2009) per kilometre cycled (Fig. S1 supplementary material). For walking, values ranged from A\$1.79 to A\$2.92 (2016) (Transport for New South Wales, 2013; Australian Transport Assessment and Planning (ATAP), 2016a) (Fig. S2 supplementary material). The range of values identified can be explained by both differences in the benefits included in the evaluation (e.g. mortality and morbidity, healthcare costs and productivity gains) and differences in the methods used to quantify those benefits. In Table S1 of the supplementary material we present a summary of the methods used to estimate per kilometre monetised values. These values are easily applicable to transport interventions with an active travel component where estimates of additional kilometres walked or cycled are available or can inferred (see Table S2 in the supplementary material). However, these estimates were produced in the grey literature, and have not been scrutinized in a formal peer-review process. In addition, per kilometre estimates from the literature are applicable specifically in the transport sector, rather than the BE more broadly. It would therefore be useful to link the health benefits directly to characteristics of the BE (such as density, design characteristics and diversity of land use), where estimates of the effects are not readily translated into increases in kilometres travelled.

The aim of this study was to explore a method and a range of values that could incorporate monetised PA-related health benefits in CBAs assessing a broad range of BE initiatives. In addition, we used our methods to produce monetised values of the PA health gains per kilometre walked and cycled for comparison with existing estimates from the Australian 'grey literature'.

2. Methods

The work presented here is based on the framework depicted in Fig. 1 (Zapata-Diomedi and Veerman, 2016; Zapata-Diomedi et al., 2016). First, we systematically reviewed Australian contemporary literature for measures of the association between BE attributes and PA outcomes (Zapata-Diomedi and Veerman, 2016). Secondly, we translated effect sizes (e.g. odd ratios, beta coefficients) reported in our systematic review into average minutes of PA per week per adult living in a neighbourhood where an attribute of the BE changes (Zapata-Diomedi et al., 2016). Minutes of PA per week (walking and cycling) as well as times per week are the most commonly collected type of data for studies of PA within the neighbourhood area (Giles-Corti et al., 2006). We grouped effect sizes reported in the literature according to five of the six 'D's proposed by Ewing and Cervero (2010) (density, diversity of land uses, destinations, distance to transit and design) plus aggregated neighbourhood measures (i.e. walkability index). Third, we predicted annual average health-adjusted life years (HALYs) and healthcare costs per adult residing in a neighbourhood where there is a change in a

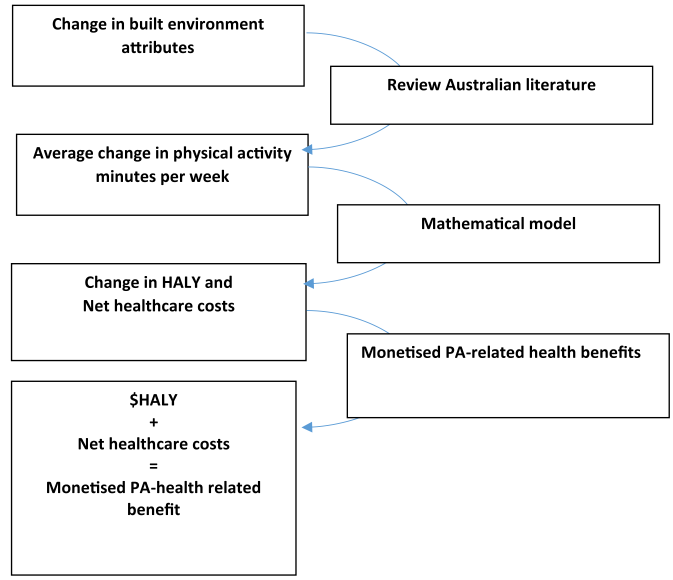

Fig. 1. Study framework.

feature of the BE using a mathematical model (Zapata-Diomedi et al., 2016). HALYs are population health measures that incorporate mortality and quality of life (Gold et al., 2002). Healthcare costs include both savings from a reduction in physical inactivity related diseases and increases in costs due to health needs in the prolonged life years attributable to improvements in PA. Lastly, we multiplied predicted HALYs by the value of statistical life year (VSLY) and added net healthcare costs to produce overall monetised values linked to changes in features of the BE.

Detailed information about the literature review and calculation of average minutes of PA per week per adult living in a neighbourhood with a change in a BE feature can be found in Zapata-Diomedi and Veerman (2016), Zapata-Diomedi et al. (2016). The mathematical model and monetisation of HALYs are discussed below. Lastly, for comparison with values published in the grey literature, we used our methods to estimate monetised values per kilometre walked and cycled.

As highlighted in the introduction, we aimed to explore a methodology, and our methods can be adapted to specific evaluation needs. We used estimates from the literature to derive the difference in minutes walking per week for alternative BE exposures. Using these estimates demonstrates how the multi-cohort proportional multi-state life table model can be used to produce monetised values that can be applied in CBAs of BE interventions.

3. Mathematical model

Our mathematical model is based on the multi-cohort proportional multi-state life table Markov model (model) developed for the 'Assessing Cost-Effectiveness in Prevention' project (ACE Prevention) (Barendregt et al., 1998, 2003; Cobiac et al., 2009; Vos et al., 2010). The model consists of a life table, a separate section for each of the modelled diseases and a section for population impact fraction (PIF) calculations. We included five diseases related to low levels of PA (ischemic heart disease, ischemic stroke, type 2 diabetes, colon cancer and breast cancer in women (Danaei et al., 2009; Bull et al., 2004; Kyu et al., 2016). We modelled 5-year age groups by sex until everyone reaches the age of 100 or dies. The PIF 'relative risk shift' method was used to estimate the effect of changes in PA on disease incidence rates (Barendregt and Veerman, 2010). Changes in incidence impact on prevalent numbers of cases in later years, and consequently on years lived with disability and mortality. HALYs represent life years adjusted for disability attributable to disease and injury. The 'relative risk shift'