Applied Energy 128 (2014) 284–295

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Evaluating the impacts of new walking and cycling infrastructure on carbon dioxide emissions from motorized travel: A controlled longitudinal study

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HIGHLIGHTS

- The first controlled, longitudinal cohort study evaluating effects of new walking and cycling routes on CO_2 emissions.
- We found no significant change in transport CO_2 emissions despite the new routes being well used by walkers and cyclists.
- We found no significant change in transport CO_2 emissions despite increases in active travel and physical activity.
- A more comprehensive approach to active travel promotion may be needed to achieve transport CO_2 savings.

ARTICLE INFO

Article history:
Received 18 October 2013
Received in revised form 4 April 2014
Accepted 22 April 2014
Available online 20 May 2014

Keywords:
Transport
CO_2 emissions
Walking and cycling
Infrastructure
Longitudinal analysis
Impact evaluation

ABSTRACT

Walking and cycling is widely assumed to substitute for at least some motorized travel and thereby reduce energy use and carbon dioxide (CO_2) emissions. While the evidence suggests that a supportive built environment may be needed to promote walking and cycling, it is unclear whether and how interventions in the built environment that attract walkers and cyclists may reduce transport CO_2 emissions. Our aim was therefore to evaluate the effects of providing new infrastructure for walking and cycling on CO_2 emissions from motorized travel.

A cohort of 1849 adults completed questionnaires at baseline (2010) and one-year follow-up (2011), before and after the construction of new high-quality routes provided as part of the Sustrans Connect2 programme in three UK municipalities. A second cohort of 1510 adults completed questionnaires at baseline and two-year follow-up (2012). The participants reported their past-week travel behaviour and car characteristics from which CO_2 emissions by mode and purpose were derived using methods described previously. A set of exposure measures of proximity to and use of the new routes were derived.

Overall transport CO_2 emissions decreased slightly over the study period, consistent with a secular trend in the case study regions. As found previously the new infrastructure was well used at one- and two-year follow-up, and was associated with population-level increases in walking, cycling and physical activity at two-year follow-up. However, these effects did not translate into sizeable CO_2 effects as neither living near the infrastructure nor using it predicted changes in CO_2 emissions from motorized travel, either overall or disaggregated by journey purpose. This lack of a discernible effect on travel CO_2 emissions are consistent with an interpretation that some of those living nearer the infrastructure may simply have changed where they walked or cycled, while others may have walked or cycled more but few, if any, may have substituted active for motorized modes of travel as a result of the interventions.

While the findings to date cannot exclude the possibility of small effects of the new routes on CO_2 emissions, a more comprehensive approach of a higher 'dosage' of active travel promotion linked with policies targeted at mode shift away from private motorized transport (such as urban car restraint and parking pricing, car sharing/pooling for travel to work, integrating bike sharing into public transport system) may be needed to achieve the substantial CO_2 savings needed to meet climate change mitigation and energy security goals.

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http://dx.doi.org/10.1016/j.apenergy.2014.04.072
0306-2619/

1. Introduction

Passenger transport has been a priority sector for reducing its significant impacts of fossil energy use and associated greenhouse gas emissions for many years. Replacing motorized travel with low carbon modes such as walking and cycling is increasingly recognised as important in low carbon and energy demand reduction strategies [1–7]. In many countries, the majority of trips made by car are short-distance journeys to work, education or shopping [6,8]. In the United Kingdom (UK), for instance, about one fifth of carbon dioxide (CO_2) emissions[1] and transport energy use come from car journeys of less than 8 km which could be made by foot or bicycle [10,11]. Walking and cycling for transport ('active travel') are widely assumed to substitute for at least some motorized travel and thereby reduce CO_2 emissions [3,12–16]. This assumption is supported by the findings that bicycle access is negatively correlated with CO_2 emissions from motorized travel [17], that energy expenditure from walking is negatively correlated with fossil fuel use from car driving [18] and that individuals in more 'walkable' neighbourhoods make more walking trips and travel fewer vehicle kilometres [19]. For these reasons, promoting active travel has been discussed as one area with potential climate change, energy and health 'co-benefits' [4,20,21].

While it has been argued that a supportive built environment may be needed to promote and sustain increases in population physical activity [22,23], a number of reviews have highlighted the lack of controlled, longitudinal studies evaluating the effects of new infrastructure on walking and cycling [24–27]. More recently we have shown that new high-quality walking and cycling routes in the UK were well-used at both one- and two-year follow-up [28] and were associated with population-level increases in walking, cycling and physical activity at two-year follow-up [29]. In all these studies, however, it was unclear whether increased activity and/or infrastructure use reflected (i) the generation of new walking and cycling trips, (ii) the substitution of trips previously made by motorized modes of transport, or (iii) the displacement of walking and cycling trips formerly conducted elsewhere. Reductions in transport CO_2 emissions would only be expected if motorized trips were substituted (scenario ii) or if, for example, recreational walking trips at locations formerly reached by car [14] were now conducted closer to home (a special case of scenario iii). We are not aware of any controlled, longitudinal studies evaluating the effects of new infrastructure on CO_2 emissions from (displaced) motorized travel.

This paper therefore sought to extend our previous evaluation of high-quality, traffic-free walking and cycling routes [28,29] by examining impacts on CO_2 emissions from motorized travel. Specifically, given that the routes were well used and associated with population-level increases in walking, cycling and physical activity (after two years), we aimed to explore the extent to which proximity to and use of the routes predicted decreases in transport CO_2 emissions over one- and two-year follow-up, and whether any associations varied across different journey purposes. In other words, we aimed to answer the questions: do people living closer to the new routes or use them have lower/higher CO_2 emissions from motorized travel than people living further away or do not use them?

2. Methods

2.1. Intervention, study sites and sample

Led by the sustainable transport charity Sustrans, the Connect2 initiative is building or improving walking and cycling routes at multiple sites across the United Kingdom (map in Appendix A). Each Connect2 site comprises one flagship engineering project (the 'core' project) plus new or improved feeder routes (the 'greater' project) (Fig. 1). These projects are tailored to individual sites but all embody a desire to create new routes for *"everyday, local journeys by foot or by bike"* [30].

The independent iConnect research consortium (www.iconnect.ac.uk) was established to evaluate the travel, physical activity and CO_2 emissions impacts of Connect2 [31,32]. As previously described in detail [31], three Connect2 projects were selected for detailed study according to criteria including urban/rural location, relative size, implementation timetable, likelihood of measurable population impact and heterogeneity of overall mix of sites. These core study sites were: Cardiff/Penarth, where a traffic-free bridge was built over Cardiff Bay to Penarth; Kenilworth, where a traffic-free bridge was built over a busy trunk road; and Southampton, where an informal riverside footpath was turned into a boardwalk (see also [31]). None of these projects had been implemented during the baseline survey in April 2010. At one-year follow-up, most feeder routes had been upgraded and the core projects had opened in Southampton and Cardiff in July 2010. At two-year follow-up, almost all feeder routes were complete and the core Kenilworth project had opened in September 2011.

The baseline survey used the edited electoral register to select 22,500 adults living within a 5 km road network distance of the core Connect2 projects, using a stratified (by distance), randomised sampling approach [14,17,31]. In April 2010 potential participants were posted a survey pack, which 3516 individuals returned. These 3516 individuals were posted follow-up surveys in April 2011 and 2012; 1885 responded in 2011 and 1548 in 2012. After excluding individuals who had moved house, the one-year follow-up study population cohort comprised 1849 participants (53% retention rate, 8% of the population originally approached) and the two-year study population cohort comprised 1510 (43% retention, 7% of the original population). The University of Southampton Research Ethics Committee granted ethical approval (CEE200809-15).

2.2. CO_2 emissions calculations

The CO_2 emissions[2] calculation methods for motorized travel modes have been published previously in [14,17]. In brief, weekly travel activity was measured using a seven-day recall instrument [31] covering five journey purposes: 'commuting for work', 'travel for education', 'travel in the course of business', 'shopping or personal business', and 'social, visiting friends or other leisure activities'. For each journey purpose, participants recalled the total number of trips made, distance and time spent travelling by seven modes: 'walking', 'cycling', 'car/van as driver', 'car/van as passenger', 'bus', 'train' and 'other' (taxi, motorcycle, etc.). From this information, mean speeds and mean trip distances were derived for each journey purpose. If only distance or time was reported then the counterpart was imputed using the mean observed speed for each mode and journey purpose.

As fully described previously [14,17], we used these travel activity data to derive CO_2 emissions, with different methods for car and non-car modes. For cars and vans, the self-reported data on weekly travel activity, vehicle fuel, size and age allowed for the use of a disaggregate method including the estimation of 'hot' CO_2 emissions, which are a function of distance travelled, mean speed, fuel type, size and age (calculated separately in 2010, 2011 and 2012 to reflect the ageing vehicle fleet), and 'cold

[1] For land-based passenger transport, CO_2 is by far the most important greenhouse gas, comprising approximately 99% of direct greenhouse gas emissions [9].

[2] We used CO_2 and not CO_2 equivalent (CO_2e) as our primary outcome measure because (a) CO_2 emissions dominate direct CO_2e emissions from surface passenger transport, making up approximately 99% of direct CO_2e [9], and (b) vehicle emissions rates for the non-CO_2 greenhouse gases methane (CH_4) and nitrous oxide (N_2O) are much less certain than for CO_2 [33], thus potentially introducing uncertainty in outcome measures for little added benefit.