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Title: Financial incentives to promote active travel: an evidence review and economic framework

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Corresponding Author: MR ADAM MARTIN, MSC

Corresponding Author's Institution: UNIVERSITY OF EAST ANGLIA

First Author: Adam Martin, MSc

Order of Authors: Adam Martin, MSc; Marc Suhrcke, PhD; David Ogilvie, PhD

Abstract: Context: Financial incentives, including taxes and subsidies, can be used to encourage behaviour change. They are common in transport policy for tackling externalities associated with use of motor vehicles, and in public health for influencing alcohol consumption and smoking behaviours. Financial incentives also offer policymakers a compromise between 'nudging', which may be insufficient for changing habitual behaviour, and regulations that restrict individual choice.

Evidence Acquisition: The literature review, undertaken between May 2011 and January 2012, identified studies of financial incentives relating to any mode of travel in which the impact on active travel, physical activity or obesity levels was reported. It encompassed macroenvironmental schemes, such as gasoline taxes, and microenvironmental schemes, such as employer subsidised bicycles. Five relevant reviews and 20 primary studies (of which 9 were not included in the reviews) were identified.

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Conclusions: Drawing on a literature review and insights from the SLOTH time-budget model, this paper argues that financial incentives may have a larger role in promoting walking and cycling than is generally acknowledged.

Adam Martin MSc
Health Economics Group
Norwich Medical School
University of East Anglia
Norwich
UK

Kevin Patrick, MD, MS
Editor
AJPM
University of California
San Diego
9500 Gilman Drive
Dept 0811
La Jolla
CA 92093-0811

24th August 2012

Dear Professor Patrick,

Please find attached a resubmission of the manuscript for the paper "**Financial incentives to promote physical activity through active travel: an economic framework and evidence review**".

Thank you for your continued interest in the paper. The main changes have been the restructuring of some sections into the review paper format and removal of the economic framework section for inclusion in an online-only appendix.

The other comments have been addressed as listed in the table below.

This paper has been submitted solely to AJPM has not been previously published, either in whole or in part, nor have the findings been posted online.

I also confirm full access to all aspects of the research and writing process, and I take final responsibility for the paper.

Yours Sincerely

Adam Martin

Comment	Action
AJPM style for a review paper is a structured abstract with the sections: Context, Evidence Acquisition, Evidence Synthesis, Conclusions. These headers should also appear in the text. Please adjust accordingly.	Done
Another point of style is that headers will not be numbered, so cross-references should be to the section title instead. You can make this adjustment yourself, or it can be left for copyediting.	Done
Provide in both text and abstract the years during which your search was conducted.	Done, see lines 36 and 90
Please reduce the length of the manuscript to 3000 words as a maximum.	Done
Rather than including the economic framework part of the paper in the main text, editors request that you either omit it, or instead provide a technical modeling section as supplemental material to be included as an online-only appendix. Please indicate which of these options you prefer. In its place in text, you could make the suggestion that new economic approaches are needed.	We suggest that this section be included as supplemental material in an online-only appendix
For Section 2, please provide a concluding statement regarding the evidence/what was found and what is needed for better modeling, per the above.	Done, see line 210 Also, we added a short introduction at 106
Consider removing lines 84-90 since a listing of what the sections cover is probably not needed. If you wish to retain these lines, reference the sections by header/title rather than number.	Removed
P4, line 62: 'opportunities' for what?	Improved wording, see line 61
P5, line 72: Would 'low financial cost' be more appropriate than 'cheap'?	We agree, see line 72
Page 11: Please insert 'Model' before the model numbers.	Done, see appendix
Page 16, line 16: Please insert 'may' between 'who' and 'place'.	Done, see appendix line 121
Page 20, line 428: Is there any research that has looked at the efficacy of salary packing public transport passes and/or cycle purchase schemes? If so, it would be appropriate to include this information here.	We are not aware of this research, however Lachapelle (2009) is a study of workplace funded public transport passes. Shoup (1997) is also workplace-based.
Page 21, line 440: Another limitation of studies of shorter duration is that downstream changes, such as body size, may not be apparent.	Now included, see line 241

Title Page

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Financial incentives to promote active travel: an evidence review and economic framework

Author names and affiliations:

Adam Martin MSc[1,2], Marc Suhrcke PhD[1,2] and David Ogilvie PhD[2,3]

[1] Health Economics Group, Norwich Medical School, University of East Anglia, Norwich, UK

[2] UKCRC Centre for Diet and Activity Research (CEDAR), Institute of Public Health, Cambridge, UK

[3] MRC Epidemiology Unit, Cambridge, UK

Corresponding author information:

Adam Martin, Health Economics Group, Norwich Medical School, University of East Anglia, Norwich, NR4 7TJ, UK. +44 (0) 7712274638. adam.martin@uea.ac.uk

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[Appendix: An additional 1,481 words and 2 tables]

Conflict of interest statement:

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Abstract

Context: Financial incentives, including taxes and subsidies, can be used to encourage behaviour change. They are common in transport policy for tackling externalities associated with use of motor vehicles, and in public health for influencing alcohol consumption and smoking behaviours. Financial incentives also offer policymakers a compromise between 'nudging', which may be insufficient for changing habitual behaviour, and regulations that restrict individual choice.

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48 **Text**

49

50

51 **Introduction**

52

53 During the past century most developed countries have witnessed a considerable rise in the
54 prevalence of obesity.[1] A dominant view among economists is that this trend is largely
55 attributable to a utility-maximising response of individuals to technological progress which
56 has decreased the price of energy intake (via reduced food prices) and increased the price of
57 energy expenditure (via growing opportunity costs of physical activity).[2] Table 1 shows the
58 impact of these changes on the costs people face when making decisions about physical
59 activity and food consumption during their daily leisure, work, travel and home-based
60 activities. For example, technological innovation in agriculture, food production and retail
61 has contributed to reduced costs (including time costs) of energy-dense meals, while working
62 environments have typically become more office-based and sedentary.

63

64 INSERT TABLE 1 ABOUT HERE

65

66 This paper is primarily concerned with the impact on decision making of changes in the cost
67 of travel. Travel is a hitherto relatively under-exploited area for promoting health behaviour
68 change, but is potentially important in the "small changes approach" to tackling obesity,
69 which focuses on small but achievable improvements in physical activity rather than more

substantial lifestyle changes which have sometimes proved unrealistic.[3] Since cycling and walking can be more readily integrated into people's busy schedules than, for example, leisure-time exercise,[4, 5] these could represent low-cost, acceptable and accessible ways to achieve 30 minutes of daily, moderate intensity physical activity as recommended in international guidelines to help prevent obesity and over 20 other chronic conditions.[6-10]

More specifically, this paper explores the potential for financial incentives to encourage physical activity through active travel and influence related health outcomes. Financial incentives are policies involving a targeted payment to, or withdrawal of monetary resources from, an individual's budget. They encompass interventions at the macroenvironmental (e.g. government) and microenvironmental (e.g. worksite) levels,[11] including positive financial incentives rewarding active travel,[12] and negative financial incentives penalising sedentary travel.

Evidence Acquisition

Identification of Relevant Studies

The review identified studies of financial incentives relating to any mode of travel in which the impact on active travel, physical activity or obesity levels were reported. The ECONLIT, Google Scholar, National Bureau of Economic Research (NBER) and PUBMED electronic databases were searched between May 2011 and January 2012 with terms relating to "physical activity", "transport", "built environment" and "prices". Non-English language

papers, and studies published before 1997, were excluded. Five relevant reviews and 20 primary studies (of which 9 were not included in the reviews) were identified (Table 2).

Data Extraction and Quality Assessment

Information was extracted on: study place and year; study design; intervention and population characteristics; and results. Quality assessment focused on the likelihood that causal inferences may be drawn,[13] based on a method originally devised for use in criminology reviews.[14]

INSERT TABLE 2 ABOUT HERE

Evidence Synthesis

Description of Studies

The majority of studies (70%) presented evidence for a particular microenvironmental scheme. Together, only a small range of schemes were represented, predominantly involving free bicycles or local road pricing at specific locations and generally within particular population subgroups.

The majority (67%) of intervention studies used uncontrolled cross sectional analysis of population-level data which cannot support robust causal inference. Furthermore, most considered only changes in travel behaviour or physical activity (87%), so improvements in health or reductions in obesity can only be estimated. Higher quality study designs used included randomised controlled trials (RCT) (20%), although like other intervention studies these often had short follow-up periods (average 7 months).

Positive Financial Incentives

One US survey of employers suggested that 26% used financial incentives to boost employee engagement with worksite health promotion programs.[15] However, five recent reviews which included microenvironmental interventions to promote active travel identified just three examples of positive financial incentives,[16-20] all involving free bicycles. One RCT involving Swedish women with abdominal obesity reported a statistically significant increase in the proportion of women cycling more than 2km per day after 18 months.[21] Two uncontrolled studies found that the Danish "Bikebusters" and the Australian "Cycle100" schemes led to significant increases in the proportion of trips made by bicycle (from 9% to 28% in "Bikebusters"), although both involved selected participants.[22, 23]

Additional evidence, not captured in the five reviews, included an RCT involving 51 older Americans in which significant differences in average daily "aerobic minutes" were identified between a group receiving fixed weekly payments of $75 and a comparison group receiving $50 plus $10 (or $25) contingent on averaging at least 15 (or 40) aerobic minutes per day each week.[24] "Aerobic minutes" were measured using pedometers and defined as

continuous walking (not necessarily for transport), jogging, or running at a rate above 60 steps per minute for at least 10 minutes. Two further studies reported stated preference data.[25, 26] One showed that a £2 daily payment to cyclists could increase cycling by 88%,[26] although these studies relied on individuals choosing between hypothetical alternatives.

Many studies in transport economics showed a negative price elasticity of demand for public transport,[27] indicating that price reductions would lead to increased demand. If, as three studies show,[28-30] this displaces car journeys (rather than active travel), then increased physical activity would be expected since public transport use is typically accompanied by some walking.[31-34] At the microenvironmental level, in the first study, an RCT reported statistically significant increases in the proportion of people using public transport (from 18% to 47%) and reductions in car use (from 50% to 33%) in an intervention group that received free public transport passes in Stuttgart, Germany. Respective changes in the control group were not statistically significant and there were no statistically significant changes in cycling or walking trips.[28] In the second study, higher employee physical activity levels were shown in US workplaces that provided subsidised public transport passes compared to those that did not.[29] However, the effect may have been over estimated since work places were more likely to provide a subsidy if public transport facilities were within walking distance. At the macroenvironmental level, the impact of free bus passes, available to older people in England since 2006, was examined using a logistic regression analysis of the English Longitudinal Study of Ageing (ELSA).[30] Eligibility for the free pass was associated with a 51% increase in the odds of using public transport, while public transport use in old age was associated with 21% lower odds of being obese, even after adjustment for previous weight status. A fourth study, of free bus passes available to young people in London since 2008, showed that

158 although increased public transport demand displaced some active travel journeys, physical
159 activity increased because the pass generated more journeys overall.[35]

160

161 ***Negative Financial Incentives***

162 At the microenvironmental level, one review identified limited evidence from two
163 intervention studies about the impact of road user charging on physical activity. [36] In
164 Durham, a 10% increase in pedestrian activity was reported one year after the scheme started,
165 and in London, distances cycled increased by 30% in London over a three year period.[37, 38]

166

167 In Zoetermeer, Holland, a study showed that 14% of car drivers switched to alternative travel
168 modes after daily financial incentives of €3 to €7 were given to regular commuters in return
169 for avoiding specific road sections.[39, 40] In Stockholm, Sweden, another found a 25%
170 reduction in the number of car journeys in response to a temporary $2 congestion charge.[41]
171 Small increases in public transport use and self-reported physical activity levels were also
172 identified. In Trondheim, Norway, one study attributed an increase in car journeys and
173 decreases in public transport use, cycling, walking and car occupancy, to the withdrawal of
174 road pricing.[42]

175

176 Other microenvironmental evidence includes a study reporting a three-fold increase in
177 cycling amongst employees at Manchester Airport, attributed to a Workplace Travel Plan that
178 included increased car parking charges,[43] and other reports that those Workplace Travel Plans
179 which included car-sharing financial incentives had the greatest chance of reducing car use.[44]

A further study of eight Californian workplaces reported a 39% increase in active commuting attributable to "cashing out", in which individuals receive payment for not using their free workplace car parking space.[45] However, these three studies were poorly controlled and the changes were small in absolute terms.

At the macroenvironmental level, two studies identified a statistically significant inverse relationship between gasoline prices and obesity prevalence (defined as the proportion of individuals with a BMI $\geq$ 30 kg/m^2). The first drew cross-national comparisons of 24 European countries.[46] Using US data, the second suggested that 8% of the rise in obesity prevalence between 1979 and 2004 was attributable to declining gasoline prices (via reduced walking and increased restaurant visits). It implied that a $1/gallon gasoline tax would reduce obesity prevalence by 10%, with some evidence that women, ethnic minorities and lower income groups were most responsive to price changes (although this may have been due to their living in urban areas with public transport facilities).[47] One further study involving 20 years' worth of cohort data from 5,115 US individuals demonstrated a positive association between gasoline prices and physical activity equating to roughly 17 minutes of additional walking each week after a 25c/gallon increase.[48] The study also suggested that the price change might encourage individuals to replace physical activity away from home (e.g. bowling) with activities in the immediate area (e.g. jogging).

Econometric analysis has also been used to show an inverse relationship between gasoline taxation and gasoline consumption.[49] One review estimated that a 10% rise in gasoline prices was associated with reductions of 3% in road traffic and 2.5% in car ownership.[50] Although more active travel cannot be inferred, since car trips are less responsive to gasoline prices

than fuel consumption and distance travelled,[51] some studies did report a positive relationship between gasoline prices and demand for other travel modes. For example, one study used self-reported data from a national survey to claim that cycling increased by 4.7% for men and 3.5% for women after a $1/gallon increase.[52]

Summary

This review identified only a limited amount of evidence on financial incentives for active travel. Although the identified studies provide useful insights into specific interventions for particular populations, a more general understanding about how people might be expected to respond has yet to emerge.

Discussion

One partial explanation for the shortage of empirical evidence, particularly at the macroenvironmental level, may be the potential political risks generally associated with financial incentives.[16, 53, 54] Negative financial incentives typically require strong justification since they penalise individuals who happen to have made particular choices, while positive financial incentives require significant financial investment.[55, 56]

However, as Figure 1 shows, financial incentives for active travel could be viewed somewhat more favourably as they fall neatly between regulating (or 'nannying'), which is sometimes regarded as overly restricting choice, and interventions that provide feedback (or 'nudging'), which might not be highly effective when used in isolation.[57] They could also reinforce

existing Government priorities such as environmental sustainability, tackling health inequalities, and economic growth (via reduced congestion and absenteeism). Furthermore, implementation may prove relatively straightforward if integrated somehow with existing transport schemes designed to internalise externalities including congestion, injuries, pollution,[58] and even risky driving.[59] Relevant lessons might also be drawn from financial incentives used in healthcare to reduce smoking, alcohol and obesity,[60] improve patient compliance,[61] and encourage Chlamydia screening.[62]

INSERT FIGURE 1 ABOUT HERE[63, 64]

In order to gain a more comprehensive understanding of the complex individual-level impact of financial incentives on travel behaviour and health, higher quality studies that support more robust causal inference are required. Reliance on uncontrolled cross sectional studies with short follow-up periods particularly limits the potential for understanding downstream changes, such as body size, or how to prevent people from returning to old habits after financial incentives are withdrawn.[12, 16, 65] Such studies may also have limited external validity if they include only small population subsets, such as ethnic minority, low income groups in high density urban areas (one study shows that walking to public transport is especially common in these groups),[31] or people who have recently moved house.[28, 66] Furthermore, biased effect estimates can occur if the quality of the built environment, which may support or hinder active travel,[67, 68] or other factors such as climate or the supportiveness of employers are not controlled for.

Although RCTs may sometimes be unrealistic or politically untenable,[69] 'natural experiment' designs, in which a "natural or predetermined variation of allocation occurs",[70, 71] provide a promising alternative. These include intervention studies with large individual-level datasets, such as those proposed for the evaluation of various UK policy and infrastructure projects,[35, 72, 73] and non-intervention studies relating particularly to negative financial incentives, which rely mainly on observed relationships between population-level behaviour and price changes over time. Although the latter provide a weaker basis for causal inference, similar econometric evidence supported the initial case for tobacco taxation.[74] With appropriate data, these methods can also contribute to a deeper understanding of the distribution of health benefits across different population groups and provide important insights into the types of financial incentives most likely to deliver long term behaviour change.

Other insights from economic rational-choice frameworks

The Appendix to this paper describes how an economic rational-choice framework might be developed to draw some broader insights into people's likely responses to financial incentives for active travel. It incorporates elements of the SLOTH time-budget model,[75-77] and Lakdawalla-Philipson's utility maximisation model,[78] developed elsewhere for analysing the multitude of decisions people make when allocating scarce resources of time and money to competing demands. This analysis provides a useful illustration of two broad points that were not established in the literature review and are in some contrast to existing SLOTH-based analyses which suggest that "leisure becomes the most likely area for increasing

physical activity"[77] because (for simplicity) the trade-offs associated with leisure and travel decisions had been treated as though identical.

Firstly, the framework suggests that individuals are likely to be at least as responsive to financial incentives for active travel as those for active leisure, a view reflected in recent panel data analysis that shows active leisure "comes and goes" and "exercise as part of travel and work must be emphasised".[79] Secondly, active travel allows people to access work and leisure activities but, unlike sedentary travel, is also 'productive' in the sense of enabling energy expenditure. Yet established methods for transport appraisal place large monetary values on travel time savings to justify investment in transport infrastructure on the basis that (for travel in work hours) savings in travel time convert non-productive time to productive use.[80-82] In contrast to car travel, others have argued that this overlooks the potential to use rail travel productively for work activities.[83, 84] Similarly, these methods probably favour faster sedentary travel (cars and trains) over active travel, despite active travel being suitable for most journeys.[85] These methods may also have encouraged decline in the availability of local services that are particularly accessible by active travel. In the UK, where travel time savings have accounted for around 80% of the claimed monetary benefits of major road schemes, the average time that people spend travelling has remained constant since the 1960s.[86] This suggests that motorway (freeway) expansion has encouraged long distance travel for access to work and leisure opportunities much further from home. People who choose active travel may then experience mobility-related social exclusion,[83] where they are disadvantaged in terms of access to services.

In the absence of more empirical evidence, further development of a modelling approach to active travel decisions may prove advantageous; however psychological theories of behaviour and recent empirical work in behavioural economics should be incorporated alongside standard rational behaviour assumptions.[87-89] For example, overly self focused behaviour,[90] strong habitual behaviour, optimism bias and ingrained social norms may all favour motorised transport and discourage individuals from giving rational consideration to active travel modes.[91] The resulting 'car dependency' may be reinforced by car manufacturers through marketing and political lobbying.[92] These factors, and policies for moderating them, are explored in Figure 2 in the context of the theory that individual behaviour is determined by a deliberative system, which assesses options with a broad, goal-based perspective, and an affective system that encompasses emotions and motivational drives.[93] The deliberative system is described in Ajzen's Theory of Planned Behaviour as comprising attitudes, subjective norms and perceived behavioural control.[94] For example, the Cycling Demonstration Towns programme in England, in which per capita investment in schemes to promote cycling was increased in six urban areas to ten times the national average,[95] might be viewed as a method of influencing habitual behaviour ("changing the default") and "status quo bias", where people tend to maintain established behaviours unless incentives to change are significant. However, studies specifically examining the impact of financial incentives on habitual travel behaviour have produced inconclusive results.[28, 96]

INSERT FIGURE 2 ABOUT HERE

In addition to habitual behaviour, excessive driving might also occur because people feel they ought to drive more often in order to justify the high sunk (i.e. retrospective and non-recoverable) costs they incurred when buying a car. Like rail commuters with annual season tickets,[97] they find additional journeys incur low marginal costs. Yet, when encouraged to consider only the (smaller) average cost of each journey, the utility maximising allocation of resources would involve more active travel. Though the evidence is limited, 'car clubs', in which car drivers hire cars for short periods rather than owning them outright, are reported to have reduced car mileage (by 33% in Holland),[98] increased cycling,[99] and reduced motor vehicle ownership.[100] Bicycle hire schemes might have a similar impact in the sense that car drivers are not deterred by the monetary and other costs (e.g. those arising from unfamiliarity) of bike purchase. In the Netherlands, a before-and-after study has attributed reductions in car use and increases in cycling to such schemes.[101] Public transport 'clubs', which encourage passengers to consider marginal (rather than average) costs by making a large upfront payment for future discounted public transport tickets, have also encouraged higher tram and bus use in some Swiss cities,[102] although any association with fewer car journeys is unknown.

Conclusion

Recent empirical evidence, complemented by a simple economic rational-choice framework, suggests that financial incentives for active travel may represent an underused but potentially promising method for encouraging healthier behaviours. However, higher quality studies,

particularly at the macroenvironmental level, are required if policy makers are to use evidence of effectiveness to make confident decisions about allocating scarce resources to such schemes.

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612 **Figure titles**

613

614

615 Figure 1: A hierarchy of policy interventions to support active travel

616

617 Figure 2: Alternative theoretical perspectives on travel mode choices and active travel

618 policies[103]

Table

Table 1: Examples of the impact of technological progress on the costs of energy intake and energy expenditure

Activity domain	**Costs of energy expenditure**		**Costs of energy intake**
	Increasing opportunity costs of energy expenditure	**Increasing monetary costs of energy expenditure**	**Decreasing costs of food consumption**
Sleep	N/A (The time spent sleeping has remained broadly constant)		
Leisure	Greater opportunity for sedentary leisure activities, e.g. television, computers and the internet	Greater availability of active leisure facilities away from home which incur a financial cost, e.g. swimming and gyms	Increased availability of restaurants (including fast food)
Occupation	Greater availability of, and higher wages associated with, sedentary work	The change from an agricultural or industrial society means that, in a sense, people are no longer paid to exercise at work	Greater availability of mass produced, energy-dense, packaged, snack foods which can be consumed "on-the-go" (and are often heavily marketed, perhaps appealing to a lack of self control and hyperbolic discounting which apparently characterises food consumption)
Transport	Availability of motorised transport and investment in road networks has provided greater opportunities for faster and longer distance journeys which are not well suited to active travel modes	N/A	Expansion of "Drive-Thru" takeaway services which allow consumption of fast food while travelling
Home	Modern technology (e.g. tools for gardening and kitchen appliances) allows household chores to be done more quickly with less physical effort	N/A	Transfer of labour-intensive food preparation to intensive farming, supermarkets and factories has dramatically reduced the time costs associated with food preparation at home. The availability and quality of kitchen appliances such as microwaves, fridges and freezers has also improved

Table 2: Summary of review-level evidence relating to financial incentives identified in the review

REVIEWS

Reference	Review details: Author, (Year)	Title
A	Mackett et al (2011)[1]	Transport, Physical Activity and Health: Present knowledge and the way ahead
B	Ogilvie et al (2004)[2]	Promoting walking and cycling as an alternative to using cars: systematic review
C	Ogilvie et al (2007)[3]	Interventions to promote walking: systematic review
D	Pucher et al (2010)[4]	Infrastructure, programs, and policies to increase bicycling: An international review
E	Yang et al (2010)[5]	Interventions to promote cycling: systematic review

STUDIES

Listed in order of appearance in the paper

Study details: First author, (Year) [Review Ref.]	Study design		Study description			Results						
	Study design description (checklist score*)	Intervention study	Country	Population	Description of intervention	Outcome	Comparator	Follow-up (months)	Reported outcomes			Individual (I) or Population (P) level data
									Travel mode	Active travel or Physical activity	Obesity, BMI or weight	
Positive financial incentives												
Walking and cycling												
Hemmingson (2009)[6] [D,E]	RCT (7)	X	Sweden	Middle aged women with abdominal obesity	A moderate intensity programme including free bicycles	Statistically significant increase in women cycling more than 2km per day	Control group involving a low intensity programme (excluding free bicycles)	18	X	X	X	I
Bunde (1997)[7] [B,D]	Uncontrolled before and after study (0)	X	Denmark	Adults	Free bicycles (‘Bikebusters’)	Increase in proportion of trips made by bike (from 9% to 28%)	Proportion of trips made by bike before the intervention	11	X	X		P
Bauman (2008)[8] [A]	Uncontrolled, before and after study (0)	X	Australia	Adults	Free bicycles (‘Cycle 100’)	Increase in proportion of trips made by bike	Proportion of trips made by bike before the intervention	Not reported	X	X		P

Finkelstein (2008)[9] [NONE]	RCT (7)	X	USA	Older adults	Payments contingent on exercise levels (number of "aerobic minutes")	Significant differences in exercise levels	Individuals who receive a fixed payment irrespective of exercise levels	1	X	X		I
Ryley (2006)[10] & Wardman (2007)[11] [NONE]	Stated Preference Data (N/A)		UK	Adults	Hypothetical payment to individuals in return for cycling more often	In one case, an increase in proportion of trips made by bike of 88%	Hypothetical case where payments are not made to individuals	N/A	X	X		I
Public transport												
Lachapelle (2009)[12] [A]	Observational study (0)	X	USA	Workplace employees	Subsidised public transport passes	Statistically significant increases in physical activity levels	Workplaces that do not offer subsidised public transport passes	N/A (Cross section)	X	X		P

Bamberg (2006)[13] [A]	RCT (7)	X	Germany, Stuttgart	People who have recently (within 6 months) moved to the city	Subsidised public transport passes	Statistically significant increases in the proportion of people using public transport and reductions in car use	Before and after the intervention (in the intervention group) and compared to respective analysis in the control group	1.5	X	X		I
Webb (2011)[14] [NONE]	Controlled study with analysis of change at individual level (4)	X	England	Older people	Subsidised public transport passes	Free pass was associated with increased public transport use. Public transport use was associated with lower obesity	Logistic regression analysis using panel data	24	X	X	X	I
Jones (2012)[15] [NONE]	Qualitative observational study (0)	X	England, London	Young People	Subsidised public transport passes	Physical activity increased since young people reported an increase in journeys made	Young people's own accounts of bus travel arising from interviews and focus groups	N/A	X	X		I
Negative financial incentives												
Walking and cycling												

Durham Council (2006)[16] [A]	Uncontrolled, before and after study (0)	X	England, Durham	Drivers	Road pricing	A 10% increase in pedestrian activity	Before the road pricing was introduced	9	X	X		P
Transport for London (2006)[17] [A]	Uncontrolled, before and after study (0)	X	England, London	Drivers	Road pricing	Distances cycled increased by 30%	Before the road pricing was introduced	36	X	X		P
Ben-Elia (2011)[18] and Bliemer (2010)[19] [NONE]	Uncontrolled, before and after study (0)	X	The Netherlands, Zoetermeer	Car drivers	Financial incentives of $3 to $7	14% of drivers switched to alternative travel modes	Individual behaviour before the financial incentive introduced	3	X			I
Bergman (2010)[20] [A]	Uncontrolled, before and after study (0)	X	Sweden, Stockholm	Car drivers	$2 congestion charge	25% reduction in number of car journeys	Before the road pricing was introduced (and comparisons with similar cities to suggest a real effect attributable to the policy)	30	X	X		P
Meland (2010)[21] [A,B]	Uncontrolled, before and after study (0)	X	Norway, Trondheim	Car drivers	Removal of a road pricing system	Increased car journeys and decreases in public transport and active travel	Before the withdrawal of road pricing	Up to 12	X	X		P

Shoup (1997)[22] [B,D,E]	Uncontrolled, before and after study (0)	X	USA, California	Car drivers (commuters)	Payment for not using a car park	39% increase in active commuting	Before the scheme	Up to 36	X	X		P
Rye (2002)[23] [D]	Uncontrolled, before and after study (0)	X	UK, Manchester Airport	Car drivers (commuters)	Car park charging (as part of a Work Place Travel Plan)	A threefold increase in cycling	Before the scheme	Not reported	X	X		P
Gasoline prices												
Rabin (2007)[24] [NONE]	Cross sectional, observational study using linear regression (0)		24 European countries	Country level data	None	Statistically significant inverse relationship between obesity levels and obesity prevalence	Cross-national comparisons are made	N/A (Cross section)	X		X	P
Courtemarche (2011)[25] [NONE]	Individual level repeated cross sectional study (0)		USA	Adults	None	Statistically significant inverse relationship between obesity levels and obesity prevalence	Changes in gas prices over time	20 years	X	X	X	I

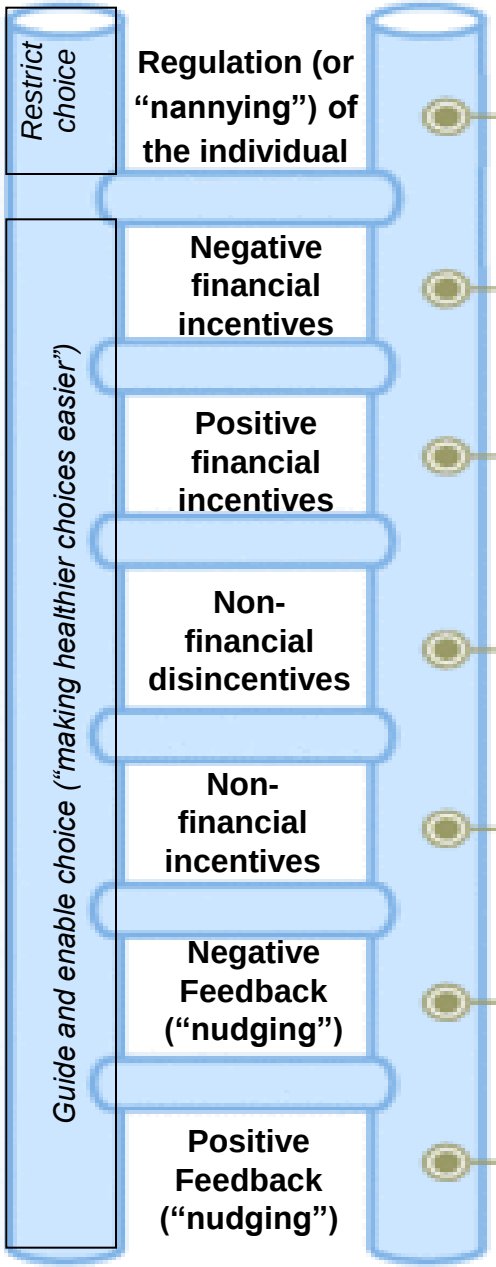
Hou (2011) [26] [NONE]	Random-effect longitudinal regression using individual level data (3)		USA, four cities	Young adults (18-30 at baseline)	None	Statistically significant relationship between gas prices and physical activity	Changes in gas prices over time (the individuals act as their own controls)	15 years	X	X	X	I
Rashad (2009) [27] [NONE]	Cross sectional multivariate regression analysis (0)		USA	Adults	None	Statistically significant relationship between gas prices and self-reported cycling	Comparison of individuals in different areas with different gas prices	N/A (Cross section)	X	X		I

* A higher score on the checklist represents increasing likelihood that causal inferences may be drawn. 0 = study designs from which causal inferences cannot be drawn; 1-4 = study designs from which some causal inferences may be drawn depending on the extent to which there is analysis of change over time and whether (observable and unobservable) characteristics are controlled for; 5-7 = study designs most likely to support robust causal inferences (5-6 = randomisation in a natural experiment setting; 7 = randomisation in an controlled experiment setting).

Figure

Figure 1: A hierarchy of policy interventions to encourage active travel

Higher rungs on the ladder represent decreasing acceptability and increasing intrusiveness (as suggested in the Nuffield Intervention Ladder).[59] Decision makers should only consider policies on higher rungs of the ladder if policies on lower rungs have been deemed to be ineffective.



Examples

Motor vehicle access restrictions e.g. in Athens, Greece, vehicles are banned from entering the city centre on alternate days and in Santiago, Chile, vehicles without catalytic converters are banned at certain times[66]

Congestion charging in towns and cities

Provision of free bicycles and accessories

Traffic calming measures to slow traffic and increase road traffic journey times (e.g. Home Zones which encourage road space sharing between pedestrians, cyclists and low-speed motor vehicles)[67]

Provision of personalised information about local bus and cycle routes for travel to work

Information provided to employees in a workplace detailing the carbon emissions arising from their daily commute to work

Information provided to employees in a workplace detailing the physical activity (and calorie expenditure) arising from different modes of travel for their daily commute to work

Broad theoretical framework			Impact on journey decision	Active Travel Policy (Example)	Behavioural economics insights (see key below)
Traditional economics	Rational utility maximisation theory		"I will consider active travel alongside other options for each individual journey by weighing up the relative costs and benefits"	Financial incentives to alter the utility maximising allocation of resources (e.g. congestion charging)	
Psychological behaviour theories	Deliberative system	Attitudes (how favourable the individual considers a behaviour)	"For my journey to work, active travel would be a bad choice"	Provide people with accurate personalised information about traffic congestion on their route to work, on the likelihood of poor weather conditions (e.g. rain – people overestimate the chances of bad things happening), or their impact on the environment.	**M,N,D,A,E**
		Subjective Norms (perceived social pressure to perform a behaviour)	"Most people who are important to me think that active travel is not well suited to my lifestyle"	Provide people with information about how other people make use of active travel (e.g. celebrities, or people outside the immediate community in similar locations and occupations)	**M,N**
		Perceived Behavioural Control (ease of performing a behaviour)	"For my journey to work, it would not be very easy to choose active travel"	Provide a substantial investment in cycling infrastructure to encourage people to reconsider their travel options (e.g. UK Cycling Demonstration Towns)[84]	**I,D,S**
	Affective system	Habitual behaviour	"I've always driven to work"	Ensure that new employees have to apply for a car parking permit at work rather than being allocated one automatically	**D**

Key:[77]

M	**M**essenger: We are heavily influenced by who communicates information
I	**I**ncentives: Our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses
N	**N**orms: We are strongly influenced by what others do
D	**D**efaults: We "go with the flow" of pre-set options
S	**S**alience: Our attention is drawn to what is novel and seems relevant to us
P	**P**riming: Our acts are often influenced by sub-conscious cues
A	**A**ffect: Our emotional associations can powerfully shape our actions
C	**C**ommitments: We seek to be consistent with our public promises, and reciprocate acts
E	**E**go: We act in ways that make us feel better about ourselves

Figure 2: Alternative theoretical perspectives on travel mode choices and active travel policies

Appendix

This appendix describes an economic rational-choice framework which incorporates elements of the SLOTH time-budget model,[1-3] and Lakdawalla-Philipson's utility maximisation model,[4] developed elsewhere for analysing decisions people make when allocating scarce resources of time and money to competing demands. A number of simplifying assumptions have been made (summarised in Table A1) and more detailed analysis might be possible using a full economic model similar to Yaniv's work on healthy eating financial incentives.[5] However, to complement the specific examples identified in the evidence review, the framework is designed to provide broader insights into people's likely responses to financial incentives for active travel in a way that contrasts with existing SLOTH-based analyses, which suggest that "leisure becomes the most likely area for increasing physical activity"[3] because the trade-offs associated with leisure and travel decisions are treated as though identical.

Resource constraints (Y and Z)

Individuals are subject to:

- a time constraint (Z hours in the current period) such that time is allocated to **S**leep, **L**eisure, w**O**rk, **T**ravel or **H**ome (SLOTH) activities and, within those domains, to sedentary or physically active behaviours:

$$\mathbf{S} + \mathbf{L} + \mathbf{O} + \mathbf{T} + \mathbf{H} = \mathbf{Ss} + \mathbf{Ls} + \mathbf{Lp} + \mathbf{Os} + \mathbf{Op} + \mathbf{Ts} + \mathbf{Tp} + \mathbf{Hs} + \mathbf{Hp} = \mathbf{Z} \qquad \textbf{(I)}$$

[where bold letters indicate time allocated to domain-based activities; lower-case s stands for sedentary activity; p stands for physically active behaviours]

- an income constraint such that expenditure ($ per unit of time) on leisure ($L, e.g. cost of a swimming ticket), transport ($T, e.g. cost of a rail ticket) and home ($H, e.g. cost of cooking ingredients) cannot exceed income (Y):

$$\$L + \$T + \$H = Y \quad \textbf{(II)}$$

Income (Y) is determined by time allocated to work and the wage rate (w, $ per unit of time):

$$Y = \mathbf{O} \times w \quad \textbf{(III)}$$

Utility maximisation

An individual's current period utility depends on consumption of Sleep, Leisure, Home and Transport activities (**S, L, T** and **H**), weight in the current period (W) and their own valuation of their expected weight in the next period (βv (W')):

$$U(W) = U(\mathbf{S}, \mathbf{L}(\$L, mL), \mathbf{T}(\$T), \mathbf{H}(\$H), W) + \beta v\,(W') \quad \textbf{(IV)}$$

41 [where U=utility; mL=distance (miles) travelled to leisure activity; $L/$H=leisure or
42 home-based expenditure; W=current weight; W'=expected weight in next period;
43 βv=discounted value of future weight]

44

45 $$W' = (1 - \delta)W + g(E,F) \quad \textbf{(V)}$$

46 [where δ <1; g is continuous, concave, increasing in food consumption (F) and
47 decreasing in energy expenditure (E)][4]

48

49 Utility increases or decreases in weight, depending on whether the individual is above or
50 below their (own notion of) "ideal weight" (W_0). They prefer weight gain when below W_0
51 and weight loss when above W_0. Future weight (W') is influenced by current period choices
52 about physical activity and food consumption (E and F). Energy expenditure (E) increases
53 with domain-based physical activity (e.g. **L**p) and is treated as a ratio of time allocated to
54 physical relative to sedentary activities:

55 $$E = \frac{(\mathbf{Lp} + \mathbf{Op} + \mathbf{Tp} + \mathbf{Hp})}{(\mathbf{Ss} + \mathbf{Ls} + \mathbf{Os} + \mathbf{Ts} + \mathbf{Hs})} \quad \textbf{(VI)}$$

56

57 Standard economic assumptions state that utility rises with consumption of **S, L** and **H** at
58 diminishing marginal rates and, for given **L** and **H**, increases with expenditure ($H and $L).
59 Distance from home to any specific work (mO) or leisure (mL) activity (e.g. a person's own
60 workplace, or their preferred gym) is fixed, since individuals cannot influence the locations of
61 those destinations in the short term. All else equal, people seek to minimise travel distances,
62 but will choose to travel further (higher mL) to access particular leisure activities which offer

higher marginal utility than those available locally or at home (e.g. a leisure park is only chosen over gardening if it provides higher utility). In the same way, individuals will only choose to spend more money on an activity (e.g. swimming) if it provides higher marginal utility than cheaper alternatives (e.g. gardening).

Choices about **S, L** and **H** are determined by the 'last hour' and 'last dollar' rules which state that if the last hour or dollar invested in one activity (e.g. swimming) provides greater utility than the last unit invested in another (e.g. home cooking), then each day individuals will reallocate resources in favour of activities that deliver higher returns (i.e. all else equal, reduce home cooking [d**H** < 0] and increase swimming [d**L**p > 0]).[1]

This implies that energy expenditure (E) increases only if the utility associated with additional investment in some physical activity (e.g. swimming, Lp) rises. Budget constraints mean that the investment necessary for overweight individuals to achieve their ideal weight (W_0) must compete with other (i.e. sedentary) activities that offer higher utility. This suggests that financial incentives ought to be targeted at activities where the opportunity cost of physical activity is the lowest.

People choose resource allocations that maximise their utility (U) subject to resource constraints (Y and Z) such that the opportunity cost of time allocated to Leisure (**L**), which increases utility directly, are:

- Sleep (**S**) and Home (**H**) activities which increase utility directly

- Work (**O**), which does not affect utility directly, but provides income (Y) for expenditure in other domains ($L, $T, $H)

- Travel (**T**), which increases with distance (mO, mL) travelled to Work and Leisure facilities, decreases with speed, and typically provides modest utility (e.g. car drivers may enjoy their in-car entertainment systems, while cyclists may enjoy being outside), or even disutility (e.g. the frustration arising from unpredictable traffic queues).

Impact of financial incentives

Financial incentives are interpreted as increasing or decreasing the cost of given activities. Sufficient reduction in the price of swimming ($d\$Lp < 0$), for example, alters the utility-maximising allocation of resources for some individuals and encourages more swimming. However, the impact in terms of overall energy expenditure (E) is complex and unpredictable unless more information about personal preferences (including their valuation of future weight βv (W')) and willingness to trade one activity for another is taken into account. Consider just two different types of people proposed by Yaniv.[5] First, the financial incentive might encourage non-swimmers ('non health-conscious people') to start swimming at the expense of sedentary leisure activities (a 'substitution effect'). But second, the financial incentive simply increases the income (Y) of existing swimmers ('health conscious people' who place a high value on βv (W')). If they also cycle to work, they might be inclined to respond by increasing travel expenditure ($T) in order to get to work faster by switching to sedentary travel modes (the 'income effect'). Although both types of people have benefited from the financial incentive (in terms of overall utility), energy expenditure (E) only increases in the first case. In the second, it might fall. These alternative scenarios are explored in Table A2.

Although their impact seems ambiguous, financial incentives may be most useful for encouraging physical activity in 'non health-conscious people' since (for them) the opportunity cost of additional physical activity is always sedentary activity (so E unambiguously increases). Of course this assumes they are actually persuaded to forgo their sedentary activities. So the remaining question is how large does the incentive need to be?

A financial incentive for active leisure (d$Lp) requires a payment that offsets the difference between utility losses from sedentary activities (e.g. watching less television, d**L**s<0) and utility gains arising from more physical activity (e.g. more swimming, d**L**p>0):

$$d\$Lp > \left[\frac{dU}{dLs}\ d\mathbf{L}s + \frac{dU}{dLp}\ d\mathbf{L}p\right] \qquad \textbf{(VII)}$$

Consider 'non health-conscious' people who may place little value on their future weight (βv (W')) and may gain very little direct utility from active leisure (e.g. swimming). The incentive payment (d$Lp) must reimburse forgone sedentary leisure activities (e.g. watching television, **L**s) which are of greater value than an equal allocation of time to active leisure (e.g. swimming, **L**p). According to the 'last hour rule', the opportunity cost of sedentary leisure activities is equal to utility associated with any other activity, including work. In order to change behaviour, the incentive might need to be relatively large, perhaps equivalent to the amount they are paid at work (i.e. the wage rate per unit of time, $O).

In contrast, an active travel financial incentive requires a payment that reimburses the difference in an individual's valuation of forgone sedentary travel (d**T**s < 0) and new active travel (d**T**p > 0):

$$d\$Tp > \left[\frac{dU}{dTs}\ d\mathbf{T}s + \frac{dU}{dTp}\ d\mathbf{T}p\right] \qquad \textbf{(VIII)}$$

This active travel incentive could be much smaller than the active leisure incentive (d$Tp < d$Lp) in some cases. First, consider a 'non health-conscious' individual who works reasonably near home so that active travel is viable in terms of distance, but who currently always drives. Noting that their drive to work provides minimal utility directly (compared to sedentary leisure) but access to work facilities, the opportunity cost of sedentary travel is relatively small since active travel also allows them equal accessibility. In this framework, the only losses arise if sedentary modes are slower, so that the time taken to travel increases (d**T** > 0) resulting in forgone **O, L** and **H**, or are less comfortable (although this may be negligible for short urban journeys). Individuals may also save money if active travel is cheaper than sedentary travel ($Ts - $Tp). Second, even if the financial incentive does not increase the energy expenditure in 'health conscious people' who are already very active in their leisure time, these individuals would gain utility if they substitute active travel for active leisure and use the additional time and income to enjoy more expensive (sedentary) leisure activities.

Table A1: Summary of simplifying assumptions

In the long term, all domains are variable (e.g. people can move home and change their working hours; and better leisure facilities might open locally) but, for the purposes of analysing the impact of financial incentives for active travel and active leisure, the discussion in Section 3 makes the following assumptions:

Domain	**Time allocated to domain (in the short term)**	**Physical activity (in the short term)**	**Rationale and other assumptions**
Sleep	Variable	Fixed - None	Hours of sleep are not affected by changes in other (time, money) resource allocations or physical activity.
Leisure	Variable	Variable	
Occupation	Fixed	Fixed	At least in the short term, job, wage, working hours, and work and home locations (and so distance travelled) are fixed (although in the longer term, people make choices about their job and work hours as with any other decision in the economic framework) Wages cannot be saved in one period for spending in another period
Transport	Variable (in terms of speed and therefore time), but distance travelled (mO and mL) is fixed for given activities	Variable	Distance travelled to leisure activities is determined by the quality of local facilities (which are fixed, at least in the short term) The time and expenditure investment required to travel a given distance varies by travel mode (sedentary travel is likely to be more expensive and, in many cases, faster) Time allocated to active travel has a similar impact on energy expenditure and weight as time allocated to active leisure
Home	Fixed	Variable	

Table A2: How the actual impact of financial incentives may deviate from the expected or desired impact

Financial incentive policy to promote:		**Active leisure**	**Active travel**	**Healthy eating (an example from[5])**
Example		Free swimming lessons	Free bikes	Thin subsidy
Desired impact	On relative prices	Reduction in relative price of physical leisure activities (d$Lp < 0)	Reduction in relative price of active travel (d$Tp < 0)	Reduction in relative price of healthy food
	On utility max position	U(last hour of active leisure) > U(last hour of other activities)	U(last hour of active travel) > U(last hour of other activities)	U(last hour of home cooking) > U(last hour of other activities)
	On W'	Increase in energy expenditure (E) and decrease in W'	Increase in energy expenditure (E) and decrease in W'	Decrease in food consumption (F) and decrease in W'
Example of actual impact on behaviour of 'health-conscious people' (i.e. people with low fast-food food consumption and high exercise consumption)	Income effect	If swim already, then more income to spend on other activities (perhaps sedentary, e.g. Ts) Decrease in E	If cycle (to work or leisure) already, then more income to spend on other activities (perhaps sedentary, e.g. Ls) Decrease in E	If home cook already, then more income to spend on other activities (perhaps sedentary, e.g. Ls) Decrease in E
	Substitution effect	If swim already, then may swim more often at the expense of other sedentary or physical activities No change or an increase in E	If cycle already, then may increase length of existing journeys at the expense of other sedentary travel or other activities No change or an increase in E	May cook more healthy food, which is time consuming and sedentary, at the expense of other physical activities Decrease in E and F
Example of actual impact on behaviour of 'non health-	Income	N/A	N/A	N/A
	Substitution effect	If not a swimmer, then may swim more often **at the expense of other**	If not a cyclist, then may cycle more often **at the expense of other**	If not a cook, then may eat more healthy food instead of junk food, using time at

conscious people' (i.e. people with high junk food consumption and low energy expenditure)		**sedentary leisure activities** **Increase in E**	**sedentary travel** **Increase in E**	the expense of other sedentary activities Decrease in F
Empirical Evidence		Limited[6]	See Section 2	More widely studied

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