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Supplementary appendix

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WEB APPENDIX

Glossary of terms

Megatrends: major forces in societal development that are likely to shape people lives over the next 10-15 years. For the modeling we included Information and communication technologies, the Internet and mobile-phone access and car ownership.

Standardized mean effect (SME)[1]: corresponds to the effect size of an intervention standardized to a uniform scale. For obtaining SME, the standardized mean differences method is used. This method expresses the size of the treatment effect in each trial relative to the variability observed in that trial. The method assumes that the differences in standard deviations between trials reflect differences in measurement scales and not real differences in variability between trial populations.

The formulations used for calculating SME are Cohen´s d given by $d_i = \frac{m_{1i} - m_{2i}}{\sqrt{\frac{(n_{1i}-1)SD_{1i}^2 + (n_{2i}-1)SD_{2i}^2}{N_i - 2}}}$ and

Hedges´ adjusted g defined as $g_i = \frac{m_{1i} - m_{2i}}{\sqrt{\frac{(n_{1i}-1)SD_{1i}^2 + (n_{2i}-1)SD_{2i}^2}{N_i - 2}}}\left(1 - \frac{3}{4N_i - 9}\right)$

Pooled effect estimate[1]: corresponds to a weighted average of the treatment effects from the individual trials. The weights are the reciprocals of the squared standard errors of the treatment effects from each individual trial.

Potential effect of an intervention via megatrend: is the expected effect of an intervention assuming that population with access to the megatrend is exposed to the intervention.

Population weighted potential effect size (WPE): corresponds to the potential effect of an intervention via megatrend weighted by the percentage of world population represented by each country income level according to the World Bank income level classification.

World Bank income level classification[2]: The World Bank's main criterion for classifying economies is gross national income (GNI) per capita. Based on its GNI per capita, every economy is classified as low income (USD$1,005 or less), middle income (subdivided into lower middle (USD$1,006 - USD$3,975) and upper middle (USD$3,976 - USD$12,275)), or high income (USD$12,276 or more).

Monte Carlo method[3]: corresponds to a technique used to approximate the probability of certain outcomes by running multiple trial runs, called simulations, using random variables. The error of the approximation is measured using the standard deviation of the output and usually decreases with the number of trial runs.

Anderson-Darling (A-D) goodness of fit test[4]: is a statistical test of whether there is evidence that a given sample of data did not arise from a given probability distribution.

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Section 1: Potential effect of interventions delivered using information and communication technologies (ICT).

1.1. Methods for estimating the potential effect for physical activity interventions.

The potential effect $\delta_{c,j,t}$ of intervention j via ICT t by country income level c was calculated as:

$$\delta_{c,j,t} = \frac{\sum_{i=1}^{N} E_{i,j} * A_{i,c,t}}{N}, \forall c \in C, \forall j \in J, \forall t \in T$$

Where:
C is the set of country income levels: low, lower-middle, middle, upper-middle and high.
T is the set of information and communication technologies (ICT): internet and mobile phone.
J is the set of interventions modeled: overall, web-based, telephone, community and clinical.
$A_{i,c,t}$ corresponds to megatrend t access i simulated using Monte-Carlo method, based on the distribution of the megatrend t access by country income level c. The access distributions of the ICT megatrends are detailed in 1.3.
$E_{i,j}$ corresponds to a simulated random effect i of the intervention j using the Monte-Carlo method. Estimation of the effects is detailed in 1.4.
N is the number of Monte-Carlo simulations (N = 10000).

1.2. Potential effect weighted by the percentage of world population represented by country income level.

We calculated a potential effect weighted by the percentage of world population represented by country income level c (WPE):

$$WPE_{j,c,t} = \delta_{j,c,t} * \frac{Pop_c}{\sum_{i \in C} Pop_i}, \forall c \in C, \forall j \in J, \forall t \in T$$

Where
C is the set of country income levels: low, lower-middle, middle, upper-middle and high.
T is the set of information and communication technologies (ICT): internet and mobile phone.
J is the set of interventions modeled: overall, web-based, telephone, community and clinical.
Pop_c represents population of country income level c.
$\delta_{j,c,t}$ represents the potential effect of intervention j via megatrend t per country income level c.

1.3. Probability distributions of internet and mobile phone access per country income-level.

For each country, we divided the number of internet and mobile phone users by the total population obtaining the internet and mobile phone access per country. Then we classified the data obtained per country income-level. Finally we used the Anderson-Darling (A-D) goodness of fit test in order to obtain the internet access ($A_{c,internet}$) and mobile phone access ($A_{c,mobile}$) probability distributions by country income-level (table 1). The test for fitting the potential effects of physical activity interventions as random distributed variables considered the existing distributions: Normal, Uniform, Gamma, Log-Normal, Weibull, Beta, Erlang, and Exponential.

Table 1: Internet and mobile phone access distribution by country income level using the Anderson-Darling goodness of fit test.

Country Income Level	Probability distribution of megatrend access	Test p-value
Internet access		
Low Income	Gamma (shape=0.45, scale=0.09)	0.806
Middle income	0.01 + Gamma (shape=1.26, scale=0.25)	0.004
Lower middle income	0.01 + Weibull (shape=1.07, scale=0.12)	0.651
Upper middle income	-0.38+ Gamma (shape=17.49, scale=0.04)	0.237
High income	-0.69+Weibull (shape=7.48, scale=1.38)	0.538
Mobile phone access		
Low income	-0.02 + Weibull (shape=1.51, scale=0.35)	0.492
Middle income	$\begin{cases} 1, & 0 \le x \le 0.27 \\ \text{Beta}(\alpha = 2.13, \beta = 1.10), & 0.27 < x \le 1 \end{cases}$	0.736
Lower middle income	-0.48+Weibull (shape=4.40, scale=1.14)	0.697
Upper middle income	$\begin{cases} 1, & 0 \le x \le 0.61 \\ -121.78 + \text{Weibull}(shape = 999, scale = 122.67), & 0.61 < x \le 1 \end{cases}$	0.117
High income	$\begin{cases} 1, & 0 \le x \le 0.67 \\ -8.72 + \text{Weibull}(shape = 120.15, scale = 9.67), & 0.67 < x \le 1 \end{cases}$	0.018

1.4. Effect estimates of physical activity interventions (table 2).

Effect estimates were obtained from the following meta-analyses: (1) the overall mean effect size and the mean effect (min/wk) from a meta-analysis of interventions among healthy adults;[5] (2) the mean effect size from a systematic review of web-based interventions;[6] (3) the mean effect size from a systematic review of telephone interventions;[7] (4) the mean effect (min/wk) from a randomised controlled trial of a mobile phone intervention; (5) the pooled random mean effect size for community interventions;[8, 9] and (6) the pooled random mean effect size of clinical interventions[8, 9]. Effect estimates of clinical interventions were adjusted by a population-wide impact that was assumed to range from 2.6% to 40%, based on elements of the Re-AIM framework.[10]

Table 2: Effect estimates used for simulation models.

Intervention	**Systematic review/study year/search period**	**Standardised mean effect**	**Effect estimate in minutes**
Overall: Intervention to increase physical activity among healthy adults	Conn VS et al, 2011 (search year 1960-2007) [5]	0.19, 95% CI (-0.14-0.53)	14.7 min/wk; range (-11 - 40.3)
Telephone interventions	Eakin EG et al, 2007 (search year 1965-2006) [7]	0.50; range (0.24-1.19)	
Website	Vandelanotte C et al, 2007 (search year up to 2006) [6]	0.44; range (0.13-0.67)	
Community	Michie S et al, 2009 (search year 1990-2008) [9]	0.31, 95% CI (0.26-0.38)	
	Hillsdon M et al, 2005 (search year up to 2005) [8]	0.28, 95% CI (0.15-0.41); 0.52, 95% CI (0.14-0.90)	
	Effect estimate for simulation	0.34, 95% CI (0.26-0.41)	
Clinical	Hillsdon M et al, 2005 (search year up to 2005) [8]	0.28, 95% CI (0.15-0.41); 0.52, 95% CI (0.14-0.90)	
	Lin JS et al, 2010 (search year 2001-2009) [11]	0.16, 95% CI (0.10-0.22)	
	Michie S et al, 2009 (search year 1990-2008) [9]	0.31, 95% CI (0.26-0.38)	
	Effect estimate for simulation	0.33, 95% CI (0.25-0.40)	
Car ownership	Adams J 2010 (cross-sectional study) [12]		Beta= -6 min/day; 95% CI (-12.04 - -0.32)

CI = Confidence interval

Section 2: Potential effect of car-ownership on physical activity level.

2.1. Methods for estimating the average potential effect of car ownership on physical activity.

Using time spent in active travel (walking and cycling) as a proxy for physical activity, the average potential effect $\delta_{c,car}$ of trends in car ownership per group of countries c was calculated as:

$$\delta_{c,car} = \frac{\sum_{i=1}^{N} \beta_{i,car} * A_{i,c,car}}{N}, \forall c \in C$$

Where
N corresponds to the number of Monte-Carlo simulations.
C is the set of country income levels: low, lower-middle, middle, upper-middle, and high.
$\beta_{i,car}$ corresponds to the relationship between active travel time and private car ownership.[12]
$A_{i,c,car}$ corresponds to car access simulated using the Monte-Carlo method based on the distribution of car access per group of countries c (Figure 3).

2.2. Potential effect weighted by the percentage of world population represented by country income level.

We calculated a potential effect weighted by the percentage of world population represented by country income level c (WPE):

$$WPE_{c,car} = \delta_{c,car} * \frac{Pop_c}{\sum_{i \in C} Pop_i}, \forall c \in C$$

Where
C is the set of country income levels: low, lower-middle, middle, upper-middle and high.
T is the set of information and communication technologies (ICT): internet and mobile phone.
J is the set of interventions modeled: overall, web-based, telephone, community and clinical.
Pop_c represents population of country income level c.
$\delta_{c,car}$ represents the potential effect of car ownership on physical activity level per country income level c.

2.3. Probability distribution of car-ownership access per country income level.

For each country, we divided the number of car owners by the total population and we classified the country by income level according to the World Bank classification. To fit the distribution of $A_{c,car}$ for each group of countries, we used the Anderson-Darling (A-D) goodness of fit test considering the existing distributions: Normal, Uniform, Gamma, Log-Normal, Weibull, Beta, Erlang, and Exponential (table 3).

Table 3: Car ownership access probability distribution by country income level using the Anderson-Darling goodness of fit test.

Country Income Level	Probability distribution of car-ownership access	Test p-value
Low Income	Weibull (shape=1.12, scale=0.02)	0.815
Lower middle income	-0.03 + Weibull (shape=2.58, scale=0.12)	0.459
Upper middle income	Gamma (shape =3.28, scale=0.06)	0.529
Middle income	Gamma (shape=1.55, scale=0.08)	0.919
High income	Normal (μ=0.51, σ=0.22)	0.099

2.4. Effect of fuel price increase on physical activity.

The effect of fuel price increment on physical activity per country income level was calculated as:

$$\delta_{c,fuel} = \delta_{c,car} * \lambda_{fuel}, \forall c \in C$$

Where:
C is the set of country income levels: low, lower-middle, middle, upper-middle and high
$\delta_{c,car}$: is the potential effect of car ownership on PA at the population level by country income level

λ_{fuel}: corresponds to a reduction in car ownership with respect to an increase in fuel price according to a review of elasticities of road traffic and fuel consumption with respect to price and income.[13] The reduction in car ownership is 1% in the short term (one year) and 2·5% in the long term (5–10 years) as the fuel price increases 10% and stays at that level.

Section 3: Systematic review search methods

We conducted searches for systematic reviews in the following databases: DARE, HTA, Cochrane, TRIP, SIGLE (OpenGrey)

- **DARE and HTA** searched September 14 2011 (limited from January 2001 to July 2011)

Total of merged records 251
1. Physical activity
2. Interventions
3. 1 and 2
4. DARE
5. HTA
6. 4 and 5
7. (From January 2001 to July 2011)
8. 3 and 6 and 7

- **The Cochrane Library** searched September 14 2011 (limited from 2001 to 2011)

Total of merged records 89
1. Physical activity.ti,ab,kf
2. Iinterventions.ti,ab,kf
3. 1 and 2
4. Restrict Search by Record Status: All
5. Cochrane Database of Systematic Reviews
6. Date range: 2001 to 2011
7. 3 and 4 and 5 and 6

- **Trip** searched September 14 2011 (limited from 2001 to 2011)

Total merged records 28
1. (Physical activity interventions). ti
2. Date: Start year (inclusive): “2001” and End year (inclusive): “2011”
3. Systematic reviews
4. 1 and 2 and 3

- **SIGLE (OpenGrey)** searched September 14 2011 (limited from 2001 to 2011)

Total merged records 2
1. "physical activity"
2. "interventions"
3. 1 and 3

- **National Guidelines Clearinghouse** searched September 14 2011 (limited from 2001 to 2011)

Total merged records 83

1. "physical activity"
2. "interventions"
3. 1 and 3
4. Systematic reviews
5. 3 and 4

- **APA** (includes Psycinfo, Psycbooks, Psycarticles) searched September 14 2011 (limited from 2001 to 2011

Total emerged records 89

1. “physical activity”. Any field
2. “interventions”. Any field
3. 1 and 2
4. Humans
5. Systematic review
6. 4 and 5
7. Published From 2001 to 2011
8. 3 and 6 and 7

- **PUBMED (Medline)** searched until December 20, 2011

Total merged records 1005

1. “physical activity”
2. “interventions”
3. 1 and 2
4. Humans
5. Meta-Analysis
6. Review
7. 5 or 6
8. English
9. Spanish
10. 8 or 9
11. 3 and 4 and 7 and 10

Section 4: Additional Tables and Figures

Table 4: Percentage of world population by country income level.

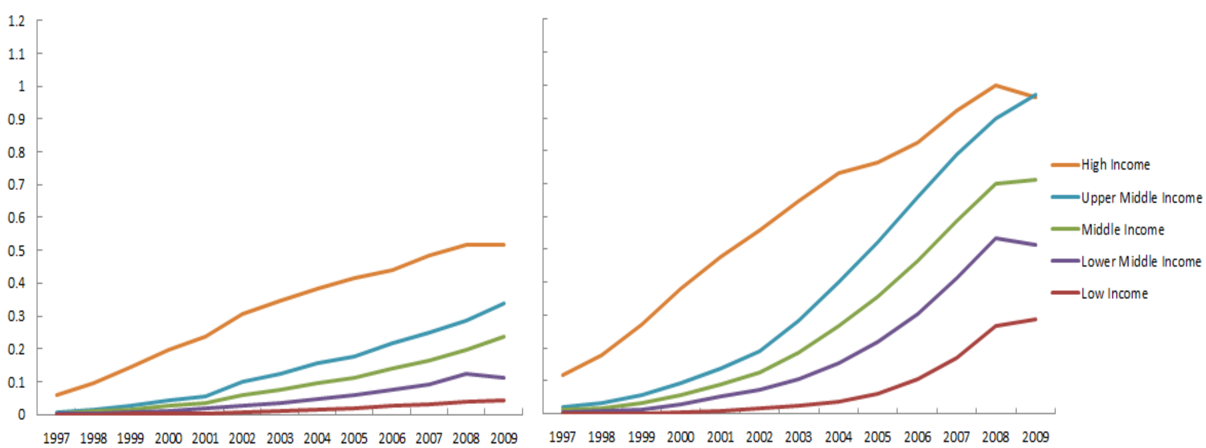
Country group	World population (%)	Gross National Income per capita (USD)
Low income	11.7	< 1,005
Middle income	72.2	1,006 - 12,275
Lower-middle income	36.2	1,006 - 3,975
Upper-middle income	36.0	3,976 - 12,275
High income	16.2	> 12,276

Table 5: Proportion of internet access, mobile phone access, and motorized car ownership stratified by country income level.

	Internet access*					Mobile phone access**					Motorized car ownership***				
Percentile	**5**	**25**	**50**	**75**	**95**	**5**	**25**	**50**	**75**	**95**	**5**	**25**	**50**	**75**	**95**
Low income	0.00	0.01	0.02	0.05	0.11	0.02	0.16	0.24	0.37	0.75	0.00	0.01	0.01	0.02	0.04
Middle income	0.02	0.07	0.23	0.35	0.58	0.13	0.53	0.80	1.00	1.00	0.02	0.05	0.11	0.17	0.31
Lower middle income	0.02	0.05	0.08	0.16	0.33	0.09	0.36	0.55	0.76	1.00	0.01	0.03	0.07	0.10	0.14
Upper middle income	0.06	0.26	0.34	0.45	0.68	0.40	0.86	0.94	1.00	1.00	0.06	0.14	0.17	0.25	0.46
High income	0.25	0.47	0.63	0.77	0.90	0.75	1.00	1.00	1.00	1.00	0.12	0.38	0.54	0.61	0.81

Country classifications by income level, according to World Development Indicators (WDI) 2011
*Internet access was calculated as the number of internet users in each country divided by total population.
**Mobile phone access was calculated as the number of mobile phone users in each country divided by total population.
***Motorized car ownership was calculated as the number of motorized car owners in each country divided by total population.

Figure 1: Access to information and communication technologies by country income level (1997-2009): a. Internet. b. Mobile phone.



Section 5: Case Study

London congestion charge

London is the capital city of a highly motorised country, with a population of around eight million living in the Greater London urban area. Despite an extensive and long-established public transport system, including bus and light, heavy and underground rail networks, traffic congestion in central London has long been regarded as a problem. To reduce congestion and raise revenue for other transport expenditure, the Mayor of London introduced a congestion charge in 2003. Drivers were required to pay a daily charge of £5 ($8 USD) to bring a car into central London between the hours of 0700 and 1800, Monday to Friday. The charging zone was later extended in 2007 and the daily charge has increased to its current level of £10 ($16 USD). The scheme was accompanied by an extensive monitoring programme that showed consistent evidence of changes in the flow of vehicles into the charging zone, including a 30% decrease in car traffic and a 20% increase in bicycle traffic. Even in the presence of other policy measures to promote cycling and the absence of an unexposed control group, these interrupted time series data strongly support an inference that charging car users to enter central London had an immediate and substantial effect on driver behaviour, which has decayed relatively slowly over time and has not been associated with an increase in the incidence of adverse events such as injuries to cyclists. It is not known, however, whether these changes are reflected in a change in the overall physical activity patterns of Londoners as the monitoring programme was not designed to answer that question.[14, 15] Observational data collected during a more recent trial of congestion charging in Stockholm suggest that residents with access to motor vehicles reported more physical activity under congestion charging, but this was a small study with small observed effect sizes.[16] The western extension of the charging zone in London was rescinded by the new Conservative mayoral administration in 2011, illustrating the importance of the political context in influencing the implementation of interventions of this kind. Proposals to introduce congestion charging in other UK cities such as Edinburgh and Manchester were defeated in public referenda and subsequently abandoned, whereas the scheme in Stockholm was introduced as a trial and subsequently supported by a majority of city residents.

References

1. Egger M, editor. Systematic Reviews in Health Care: Meta-analysis in context. 2nd ed. London: BMJ; 2001.
2. The World Bank. How We Classify Countries. [cited April 3, 2012]; Available from: http://data.worldbank.org/about/country-classifications
3. Metropolis N, Ulam S. The Monte Carlo method. Journal of the American Statistical Association. 1949; **44**(247): 335-41.
4. Anderson TW, Darling DA. Asymptotic theory of certain "goodness-of-fit" criteria based on stochastic processes. Annals of Mathematical Statistics 1952; **23**: 193–212.
5. Conn VS, Hafdahl AR, Mehr DR. Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. Am J Public Health. 2011; **101**(4): 751-8.
6. Vandelanotte C, Spathonis KM, Eakin EG, Owen N. Website-delivered physical activity interventions a review of the literature. Am J Prev Med. 2007; **33**(1): 54-64.
7. Eakin EG, Lawler SP, Vandelanotte C, Owen N. Telephone interventions for physical activity and dietary behavior change: a systematic review. Am J Prev Med. 2007; **32**(5): 419-34.
8. Hillsdon M, Foster C, Thorogood M. Interventions for promoting physical activity. Cochrane database of systematic reviews. 2005; (1): CD003180.
9. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. Health Psychol. 2009; **28**(6): 690-701.
10. Glasgow RE, Davidson KW, Dobkin PL, Ockene J, Spring B. Practical behavioral trials to advance evidence-based behavioral medicine. Ann Behav Med. 2006; **31**(1): 5-13.
11. Lin JS, O'Connor E, Whitlock EP, Beil TL. Behavioral counseling to promote physical activity and a healthful diet to prevent cardiovascular disease in adults: a systematic review for the U.S. Preventive Services Task Force. Annals of internal medicine. 2010; **153**(11): 736-50.
12. Adams J. Prevalence and socio-demographic correlates of "active transport" in the UK: analysis of the UK time use survey 2005. Prev Med. 2010; **50**(4): 199-203.
13. Goodwin P, Dargay J, Hanly M. Elasticities of road traffic and fuel consumption with respect to price and income: a review. Transport Rev 2004; **24**: 275-92.
14. Central London congestion charging impacts monitoring: second annual report, April 2004. London: Transport for London; 2004.
15. Maibach E, Steg L, Anable J. Promoting physical activity and reducing climate change: opportunities to replace short car trips with active transportation. Prev Med. 2009; **49**(4): 326-7.
16. Bergman P, Grjibovski AM, Hagstromer M, Patterson E, Sjostrom M. Congestion road tax and physical activity. Am J Prev Med. 2010; **38**(2): 171-7.