Can municipalities positively influence health via active travel? Results from a path model

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Abstract

Active travel (walking and cycling) is increasingly being recognised as a potentially effective means of increasing physical activity levels and thereby contribute to physical and mental health. Research related to active travel typically either focuses on the (policy-related) determinants of active travel or the health effects. As far as the author is aware, no studies have tried to include both in a single empirical model. The goal of this study is to address this gap by developing and estimating a path model including both determinants of active travel and relevant health outcomes. To estimate the model aggregated data are used from Dutch municipalities, 355 in total. The results provide insights as to which built environment and/or infrastructure characteristics municipalities should on, if their aim is to increase health via active travel. In the respect, the model shows that decreasing the (mean) distances to primary schools will sort the most effect. Another policy-relevant finding is that the built environment also directly impacts health and (mostly) in a negative way; the level of density in particular has a negative effect on several health outcomes. It is important to recognise these effects as they seem to operate in the opposite direction than the positive pathway through active travel.

1. Introduction

There is strong evidence that physical activity positively influences health; regular physical activity reduces the risk of cardiovascular disease, diabetes, cancer, hypertension, depression, osteoporosis and premature death (Warburton et al., 2006). Worldwide, around a third of all adults do not reach public health guidelines for recommended levels of physical activity (Hallal et al., 2012). Based on such prevalence rates, it has been estimated that inactivity causes 9% of premature mortality globally (Lee et al., 2012), making physical inactivity the fourth leading health risk factor in Western countries (Lim et al., 2013).

Active travel (walking and cycling) is increasingly being recognised as a potentially effective means of increasing physical activity levels and thereby contribute to physical and mental health (Sallis, 2004). Active travel can typically easily be incorporated in the daily routine and there is generally much potential for active travel to help people meet recommended physical activity levels. Even in a country like the Netherlands, which can be considered a country oriented towards active travel, as much as 30% of the trips with a distance shorter than 5 kilometer are made by car, which are trips that can potentially be made by foot or bicycle.

Research related to the active travel is largely driven by two questions: (1) what are the health benefits of active travel? and (2) what are the determinants of active travel? Multiple disciplines are involved in answering these two questions and the resulting literatures are vast. Regarding the health effects, relevant potential outcomes include increased total physical activity, reduced obesity, increased fitness and increased psychological well-being (see Oja et al. (2011), Wanner et al. (2012) and Saunders et al. (2013) for relevant reviews). With respect to the determinants of active travel much research has focused on role of the built environment (e.g.

residential density, connectivity) and available bicycle and pedestrian infrastructure (a review of reviews is provided by Ding & Gebel (2012)). Also psychological factors (perceived environmental characteristics or attitudes and preference) have been considered, albeit to a lesser extent (Panter & Jones, 2010; Heinen et al., 2011).

Up till now empirical studies either focus on the health benefits or the (policy-related) determinants of active travel. As far as the author is aware, no studies have tried to include both in a single empirical model. Such a model could reveal to what extent policy efforts would influence relevant health outcomes via active travel, yielding knowledge that could be used to assess the cost-effectiveness of measures to stimulate the uptake of active travel. In addition, an integrated model can reveal whether active travel is indeed the most relevant mediating factor between the considered determinants of active travel and its health outcomes and/or whether other forms of (less active) travel and/or behavioural risk factors mainly (or additionally) function as such. Obviously such insights are highly relevant from a policy perspective.

The goal of this study is to address this gap by developing and estimating a path model including both determinants of active travel and relevant health outcomes. The levels of active travel in terms of walking and cycling are considered as relevant mediating factors. In addition, other behavioural variables are also taken into account as mediating factors, namely the use of other travel modes (car and public transport) and behavioural health risk factors (e.g. smoking and leisure physical activity). To estimate the model aggregated data are used from Dutch municipalities, 355 in total. As shown by the study of Rietveld and Daniel (2004) this unit of analysis is well suited to assess the influences of policy efforts (by municipalities) to stimulate active travel, in particular the use of the bicycle.

2. Conceptual model

A straightforward conceptual model -shown in Figure 1- is developed to serve as the basis for the path model. The model consists of three layers; the first captures structural characteristics of the municipalities, relating to the demographic and economic composition of the population and to spatial determinants of active mode use (cycling infrastructure and accessibility), which can potentially be influenced by planning policies of municipalities. The second layer captures behavioural characteristics, relating to the use of active modes (walking and cycling), the use of other modes (car and public transport) and other behavioural factors that influence health, specifically, leisure psychical activity and smoking behaviour. Finally, the third layer captures relevant health outcomes, relating to both physical and mental health.

The model is based on the assumption that the structural factors influence the behavioural characteristics, which, in turn, are assumed to influence the health outcomes. In addition, the structural factors are also allowed to directly influence the considered health outcomes. If such direct effects are found to be significant, this would suggest the existence of other (behavioural) factors that function are relevant mediating variables.

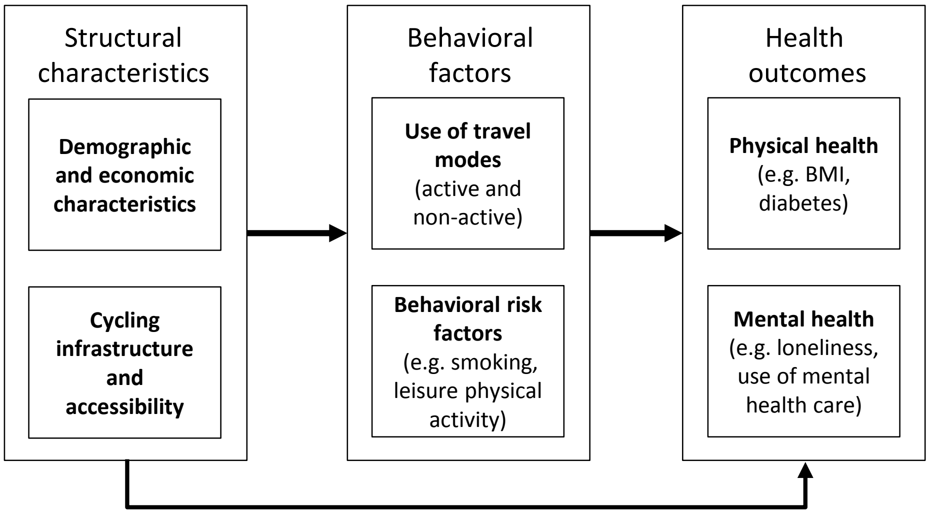

Figure 1. Conceptual model

3. Method

3.1 Data and operationalization

To operationalise and test the conceptual model aggregated data are used from all Dutch municipalities, 355 in total. On average, the municipalities have 48.6 thousand inhabitants, collectively covering the 17.3 million residents of the Netherlands. The data related to the behavioural and health outcomes originate from large-scale nation-wide surveys, in particular the national travel survey (2017) and the national health survey (2016), with 38,127 and 457,153 respondents, respectively. This allows the calculation of reliable estimates at the municipality level. Table 1 presents an overview of the variables used to operationalise the concepts in Figure 1, including their descriptive statistics and the sources from which the respective data originate.

In the analysis, the (average) age, immigrant background, household income and unemployment rate are used as relevant demographic and economic characteristics. As policy-related determinants of active travel (and cycling in particular) three variables related to the cycling infrastructure are considered, namely the directness of cycling routes, the right of way for cyclists at roundabouts and the relative amount of dedicated cycling lanes. These measured were calculated by the Dutch cycling association at the levels of municipalities. Next to the these variables, several accessibility measures were included, namely the density, the diversity and the (mean) distance to four relevant locations, namely primary school, high school, grocery stores and railway stations.

Mode use was measured by calculating the relative trip frequency that each mode is used. Regarding active travel it can be observed that levels are generally high, on average, 27.2% of all trips are made by bicycle and 17.0% on foot. Yet, there is also considerable variation across municipalities, especially regarding bicycle use which ranges from 8.1% to 54.4% in the dataset. Next to mode use, two additional behavioural (health risk) variables are considered, namely engagement in sports and smoking behaviour (tobacco use). Unfortunately, no data was available related to diet (e.g. fruit and vegetable intake).

Table 1. Descriptive statistics of the Dutch municipalities (N=355)

Factor group	Variables	Mean	SD	Source
Demographic and economic composition	Age (years)	43.2	2.3	a
	People with a non-Western immigrant background (%)	7.4	5.9	a
	Disposable household income (Keuro)	45.1	5.7	a
	Unemployment rate (%)	3.4	0.6	a
Cycling infrastructure, diversity and accessibility	Directness of cycling routes (compared to route by car) (normalised score on 1-5 scale)	2.4	0.7	b
	Right of way for cyclists on roundabouts (normalised score on 1-5 scale)	4.0	1.6	b
	Dedicated cycling lanes in urban areas (normalised score on 1-5 scale)	2.0	1.0	b
	Density (average address density per km^2) (normalised score on 1-5 scale)	2.6	1.1	a
	Diversity (relative amount of jobs compared to residences) (%)	49.2	6.9	c
	Distance to primary school (km)	0.8	0.2	a
	Distance to high school (km)	3.2	2.0	a
	Distance to grocery store (km)	0.9	0.3	a
	Distance to railway station (km)	7.0	7.1	a
Modal split	Cycling trips (%)	27.2	6.0	d
	Walking trips (%)	17.0	3.2	d
	Car trips (%)	35.2	5.2	d
	Train trips (%)	1.5	1.2	d
	Bus, tram or metro (BTM) trips (%)	1.4	1.5	d
Behavioral risk factors	People engaged in sports (%)	50.8	6.0	e
	People who smoke tobacco (%)	18.7	3.2	f
Physical health outcomes	People who satisfy physical activity norm of Dutch health council (%)	63.7	4.7	f
	People who are overweight (BMI>25) (%)	50.2	4.6	f
	People diagnosed with COPD or asthma (%)	4.3	0.7	g
	People diagnosed with heart failure (%)	3.7	0.7	g
	People diagnosed with diabetes (%)	2.3	0.5	g
	People diagnosed with cancer (%)	3.5	0.6	g
Mental health outcomes	People treated for mental health problems (%)	8.6	1.4	g
	People with high score on loneliness scale (%)	41.0	4.4	f

a Municipality data (2017) - Statistics Netherlands (CBS)
b Election of cycling municipality (2018) - Cyclists' association (Fietersbond)
c Municipality data (2017) - Statistics Netherlands (CBS), measure developed by ABF Research
d National Travel Survey (2017) - Statistics Netherlands (CBS)
e Knowledge and Information System Sport (KISS) (2017) - Sport Unions and NOC*NSF
f National Health Monitor (2016) - National Institute for Public Health and the Environment (RIVM)
g Medical diagnoses based on medicine use (2017) - Vektis (private company handling health care data)

The physical health outcomes include the percentages of the population in the respective municipalities that satisfy the (Dutch health council's) physical activity norm (150 minutes moderate to vigorous physical activity per week), that are overweight (i.e. have a body-mass index over 25), and are diagnosed with COPD/asthma, heart failure, diabetes and cancer. The mental health outcomes include the percentages of the population that receives treatment for mental health problems and has a high score on (multi-item) scale measuring emotional/social loneliness.

3.2 Model specification and estimation

In line with the conceptual model the structural variables are specified as exogenous variables and assumed to influence both the behavioural variables and the health outcomes. The behavioural variables are hypothesized to operate as mediating variables and also assumed to influence the health outcomes. The error terms of the endogenous variables at the same level of the causal chain (so at the level of behavioural and health outcomes respectively) are allowed to freely correlate. This specification leads to a fully saturated model (with zero degrees of freedom). The model is estimated in MPlus 8.4 using the standard maximum likelihood estimator.

Next, to obtain a parsimonious model, insignificant direct effects are deleted in a stepwise fashion through a process of backward elimination. All correlations between error terms (even when insignificant) are retained to ensure proper statistical control. In the end, 153 direct paths are deleted. The resulting model yields a good model fit (χ^2=311.0, df=153, p=0.00, CFI=0.968, RMSEA=0.054).

4. Results

Table 2 presents the standardised estimates of the direct effects and the correlation between the error terms of the endogenous variables. In the following the most important findings are highlighted.

Turning first to the determinants of active mode use, the directness of the cycling routes was found to positively influence the cycling rate (0.096), yet, at the expense of walking trips (-0.167). This suggests that cycling and walking act as (partial) substitutes for one another, which is also confirmed by the significant negative correlation between (the error terms of) both behaviours (-0.123). A similar pattern was found for the level of diversity, which positively influences the share of cycling trips (0.161) but has a negative effect on walking (-0.179). Surprisingly, the other variables related to cycling infrastructure were not found to be significant. Regarding the accessibility variables, the distance to primary schools has a negative effect on both walking (-0.247) and cycling levels (-0.199).

Significant effects are also revealed between the built environment variables and engagement in sport. For example, the density positively influences engagement in sports (-0.148). This effect may be due to the fact that dense urban environments generally offer people more opportunities to engage in (a variety of) sport activities. Interestingly, engagement in sport is positively correlated with bicycle use (0.324), indicating that these different forms of physical activity complement (rather than substitute) each other.

Regarding the health effects of mode use, the first noticeable finding is that cycling strongly contributes to satisfying the physical activity norm (0.484), an effect which is similar in size as the effect of engagement in sport (0.478). Surprisingly, walking does not significantly contribute reaching the recommended physical activity norm. With respect to the other physical health outcomes, walking and cycling have expected negative effects, reducing the portions of the population that are overweight and are diagnosed with heart failure, diabetes and cancer. A notable exception is COPD/asthma, for which no significant effects are found. It may be speculated that the exposure to particular matter associated with walking and cycling outside (especially in urban environments) counters the positive health benefits. This interpretation fits with the finding that engagement in sport does have an expected negative effect on COPD/asthma.

Surprisingly, walking and cycling do not lead to benefits in terms of mental health, while this does seem to be the case for sport participation. Walking is even positively linked to levels of loneliness (0.142). It may be speculated that the effects of sport engagement are due to the (often) social nature of this activity, which obviously holds to a lesser extent for walking and cycling.

Finally, the results are informative as to whether the considered behavioural variables are indeed the most relevant mediating variables in the relation between the built environment and health. In this regard, it can be observed that several direct effects remain, of which the strongest are linked to density. In particular, density has a direct negative effect on the percentage that satisfies the physical activity norm (-0.205), and positive effects on COPD/asthma prevalence (0.241) and mental health care use (0.233). Regarding COPD/asthma, (again) a plausible explanation is that exposure to particulate matter is higher in dense urban regions compared to rural ones. The other two effects are more difficult to explain.

5. Conclusion

In this paper a path model is estimated including both determinants and (health) effects of active and non-active mode use. The model is estimated using data from an aggregated unit of analysis, namely Dutch municipalities. The results provide insights as to which built environment and/or infrastructure characteristics municipalities should on, if their aim is to increase health via active travel. In the respect, the model shows that decreasing the (mean) distances to primary schools will sort the most effect. This finding actually goes against the current trend in the Netherlands to merge smaller primary schools into larger ones, which generally results in lower accessibility.

Another policy-relevant finding is that the built environment also directly impacts health and (mostly) in a negative way. Density in particular has a negative effect on several health outcomes. Although this is not the case in the present study, density is typically found to increase active mode use, supporting policy recommendations to increase densities to stimulate active mode use. As shown by this study, however, such recommendations should be made with care, as density may also negatively influence health via other pathways. From a scientific perspective, it is important to better understand these pathways and try and identify the variables that act as relevant mediators here.

Table 2. Standardized direct effects and correlations between error terms of endogenous variables

	Endogenous variables														
	Mode use					Behavioral risk factors		Physical health						Mental health	
Exogenous variables	**Cycling**	**Walking**	**Car**	**Train**	**BTM**	**Sport**	**Smoking**	**PA norm**	**Over-weight**	**COPD/ Asthma**	**Heart failure**	**Diabetes**	**Cancer**	**Mental health care**	**Loneli-ness**
Age (years)	-0.371		0.358								0.282	0.482	0.291		0.288
People with a non-Western immigrant background	-0.431	0.249		0.474	0.834					-0.304		-0.172		-0.362	0.438
Disposable household income		-0.193			0.120	0.469	-0.306		-0.384	-0.257	-0.251	-0.257	-0.360	-0.110	-0.105
Unemployment rate					0.117	-0.117	0.436			0.138	0.291		0.197	0.410	0.165
Directness of cycling routes	0.096	-0.167				0.087	-0.098							-0.104	
Right of way for cyclists on roundabouts				0.070							-0.087				
Dedicated cycling lanes in urban areas												-0.076		0.086	
Density					-0.161	0.148		-0.205		0.241				0.233	
Diversity	0.161	-0.179				0.138		-0.104	-0.089						
Distance to primary school	-0.247	-0.199	0.147							-0.180			-0.081		
Distance to high school			0.214			-0.118							-0.055		
Distance to grocery store		-0.146				-0.126	-0.091						0.092		
Distance to railway station		0.188	-0.121	-0.346	0.343		0.117							-0.084	
Endogenous variables	**Correlations between error terms**														
Cycling trips								0.484	-0.214		-0.130	-0.321	-0.139		
Walking trips	**-0.123**								-0.194		-0.147	-0.122	-0.125		0.142
Car trips	**-0.760**	**-0.351**										-0.206			
Train trips	**0.161**	0.039	**-0.293**						-0.272	0.143				0.235	
Bus, tram or metro (BTM) trips	**-0.183**	**0.153**	**-0.108**	-0.087							-0.111			0.114	
People engaged in sports	**0.324**	0.069	**-0.268**	**0.168**	0.027			0.478	-0.298	-0.313	-0.243	-0.275	-0.296	-0.160	-0.280
People who smoke tobacco	-0.015	0.003	-0.041	-0.043	0.014	**-0.337**		0.131					0.123		
								Correlations between error terms							
People who are overweight (BMI>25)								-0.029							
People diagnosed with COPD or Asthma								-0.065	0.067						
People diagnosed with heart failure								**-0.161**	**0.329**	0.300					
People diagnosed with diabetes								**-0.176**	0.095	0.090	**0.205**				
People diagnosed with cancer								**-0.262**	**0.366**	0.066	**0.504**	**0.408**			
People treated for mental health problems								-0.076	0.071	**0.568**	**0.294**	0.101	0.082		
People with high score on loneliness scale								0.089	**-0.120**	**0.213**	0.036	0.023	-0.101	0.030	
R-square	0.288	0.338	0.278	0.465	0.555	0.383	0.464	0.531	0.580	0.372	0.543	0.690	0.735	0.445	0.550

Note: All direct effects as well as correlations in bold are significant at 5% level

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