



Health Impacts of Non-motorized Travel Behavior and Built Environment

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Background



Travel Behavior Data

- **National Household Travel Survey (NHTS)**
 - national level data collection
 - provides information on daily trips (count, mode, duration, etc.)
 - no questions about health (previously)

Health Data

- **Behavioral Risk Factor Surveillance System (BRFSS)**
 - national level data collection
 - questions about health and participation in physical activities (combines running, gardening, walking for exercise, biking, etc.)
 - does not provide specific and separate information on levels of walking and biking

Background



Inconsistency in Data

- Lack of a national database that provides travel behavior and health data collected from the same respondents
- Researchers probing the health impacts of travel choices
 - a) conduct private surveys to collect concurrent data on both travel behavior and health outcomes (**costly**); or
 - b) fuse travel and health survey data to create a combined dataset (**does not provide consistent data on travel behavior and health status collected simultaneously from one survey sample**)
- Research on the link between travel behavior and health can greatly benefit from a database that provides data on both trends

Research Motivation



2017 National Household Travel Survey

- Includes new questions about non-motorized trips for exercise, physical activity levels and overall health status
- Provides concurrent and consistent person-level data on travel behavior, health behavior and health status
- Offers a tremendous opportunity for resolving data limitation and data inconsistency issues in research on the health impacts of travel behavior

Research Objective



The main objectives of this study are to

- Examine the relationship between the health status of 2017 NHTS respondents and their:
 - levels of non-motorized travel (walking and biking)
 - levels of physical activity
 - neighborhood's built and social environment
- Identify factors that are linked with overall health status
- Understand the extent and direction of the effects of these factors

Literature Review



Health outcomes are correlated with

- **Non-motorized travel (walking and biking)**
(Frank et al. 2004¹; Smith et al. 2008²; Schauder and Foley 2015³)
- **Health-related behavior such as physical activity**
(HHS 2008⁴; CDC 2018⁵; WHO 2018⁶)
- **Built environment characteristics**
(Samimi et al. 2009⁷; Timperio et al. 2010⁸; Zick et al. 2013⁹)

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4. U.S. Department of Health and Human Services. Physical Activity Guidelines for Americans: <https://health.gov/paguidelines/pdf/paguide.pdf>
5. Centers for Disease Control and Prevention. Physical Activity: <https://www.cdc.gov/physicalactivity/>
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8. Timperio, A., Jeffery, R.W., Crawford, D., Roberts, R., Giles-Corti, B. and Ball, K., 2010. Neighbourhood physical activity environments and adiposity in children and mothers: a three-year longitudinal study. *International journal of behavioral nutrition and physical activity*, 7(1), p.1.
9. Zick, C.D., Hanson, H., Fan, J.X., Smith, K.R., Kowaleski-Jones, L., Brown, B.B. and Yamada, I., 2013. Re-visiting the relationship between neighbourhood environment and BMI: an instrumental variables approach to correcting for residential selection bias. *International journal of behavioral nutrition and physical activity*, 10(1), p.1.

Data Overview



| Data Field (2017 NHTS Person File) | Observations | Missing Data (prefer not to answer, not ascertained, etc.) | Total | Response Rate |
|---|--------------|--|---------|------------------|
| Count of Walk Trips (in the past 7 days) | 263,410 | 824 | 264,234 | 99.7% |
| Count of Bike Trips (in the past 7 days) | 264,019 | 215 | 264,234 | 99.9% |
| Physical Activity Level (in a typical week) | 263,746 | 488 | 264,234 | 99.8% |
| Count of Times of Light or Moderate Physical Activity (in a typical week) | 162,728 | 101,506 | 264,234 | 61.6% |
| Count of Times of Vigorous Physical Activity (in a typical week) | 70,570 | 193,664 | 264,234 | 26.7% |
| Overall Health | 263,973 | 261 | 264,234 | 99.9% |

Data Overview



Socio-economics, Travel Behavior and Health Data

(2017 NHTS Person File)

Person Attributes

Age
Gender
Race
Education
Employment Status
Non-motorized Travel
Physical Activity

Household Attributes

Household Size
Household Vehicle Ownership
Household Income



Land Use and Environmental Data

(Smart Location Database)

Built Environment

Density
Diversity
Design
Distance to Transit
Destination Accessibility
Regional Diversity
Urban vs. Rural Area

Social Environment

Working-aged Population
Levels of Vehicle Ownership
Low-Income Employment

Sample Data – Descriptive Statistics



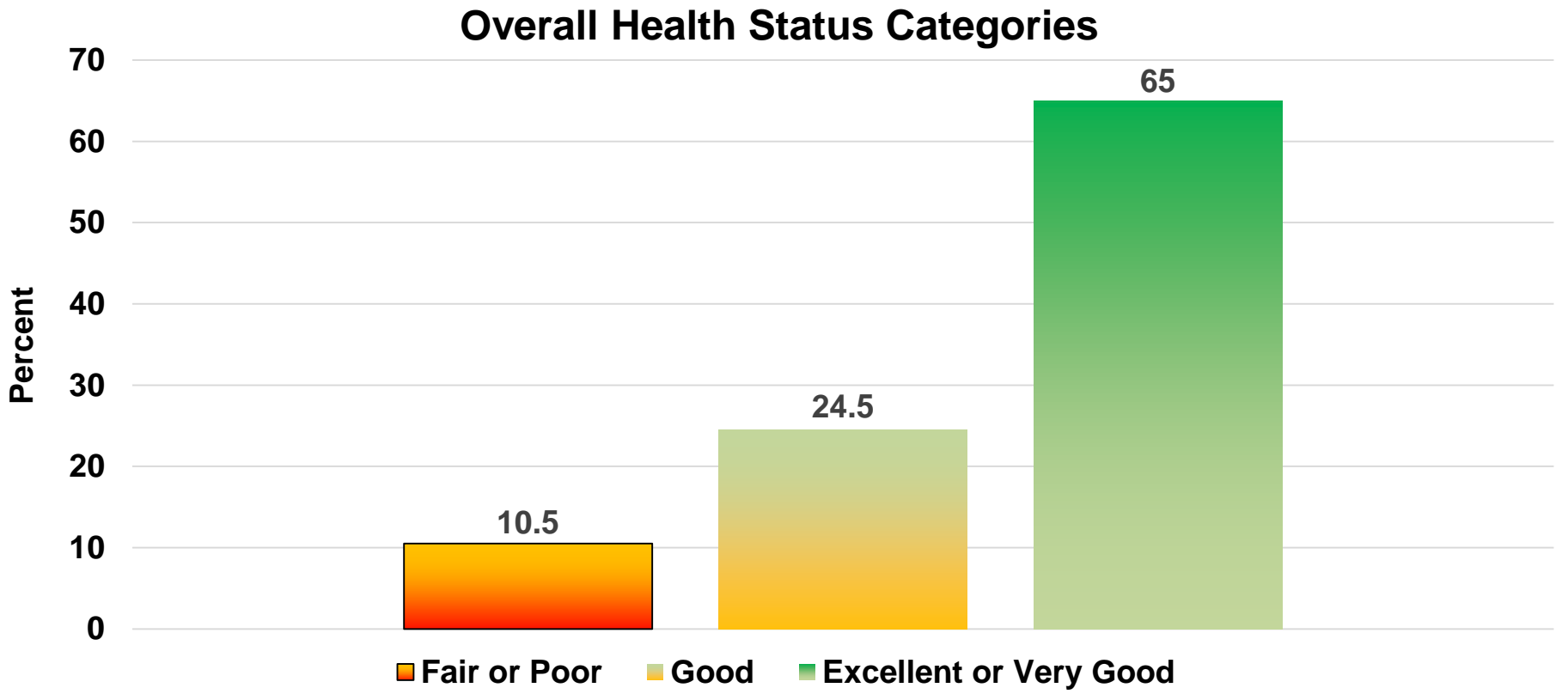
| Independent Variable | Description | Mean | SD |
|-----------------------------|---|-------------------------------------|-------|
| Person Attributes | | | |
| Age | Age (years) | 48.75 | 21.85 |
| Gender | Gender (1: male/ 0: female) | 0.47 | 0.49 |
| Race | Race (1: White/ 2-6,97: NHTS race) | — | — |
| Education | Educational level (1: less than high school/ 2-5: NHTS educ) | 3.28 (Some college or AA degree) | 1.22 |
| Employment Status | Worker status (1: yes/ 0: no) | 0.54 | 0.50 |
| Non-motorized Trips | Number of (walking + biking) trips (in the past 7 days) | 5.79 | 8.79 |
| Physical Activity Level | Never; light or moderate; vigorous (in a typical week) | 2.15 (light or mod.) | 0.60 |
| Household Attributes | | | |
| Household Size | Count of household members | 2.70 | 1.40 |
| Household Vehicles | Count of household vehicles | 2.24 | 1.22 |
| Household Income | Household income level (1= less than \$10,000/ 2-11 NHTS income) | 6.35 (\$50 to \$75 K) | 2.60 |
| Household Location | (1: urban / 0: rural) | 0.77 | 0.42 |

Sample Data – Descriptive Statistics



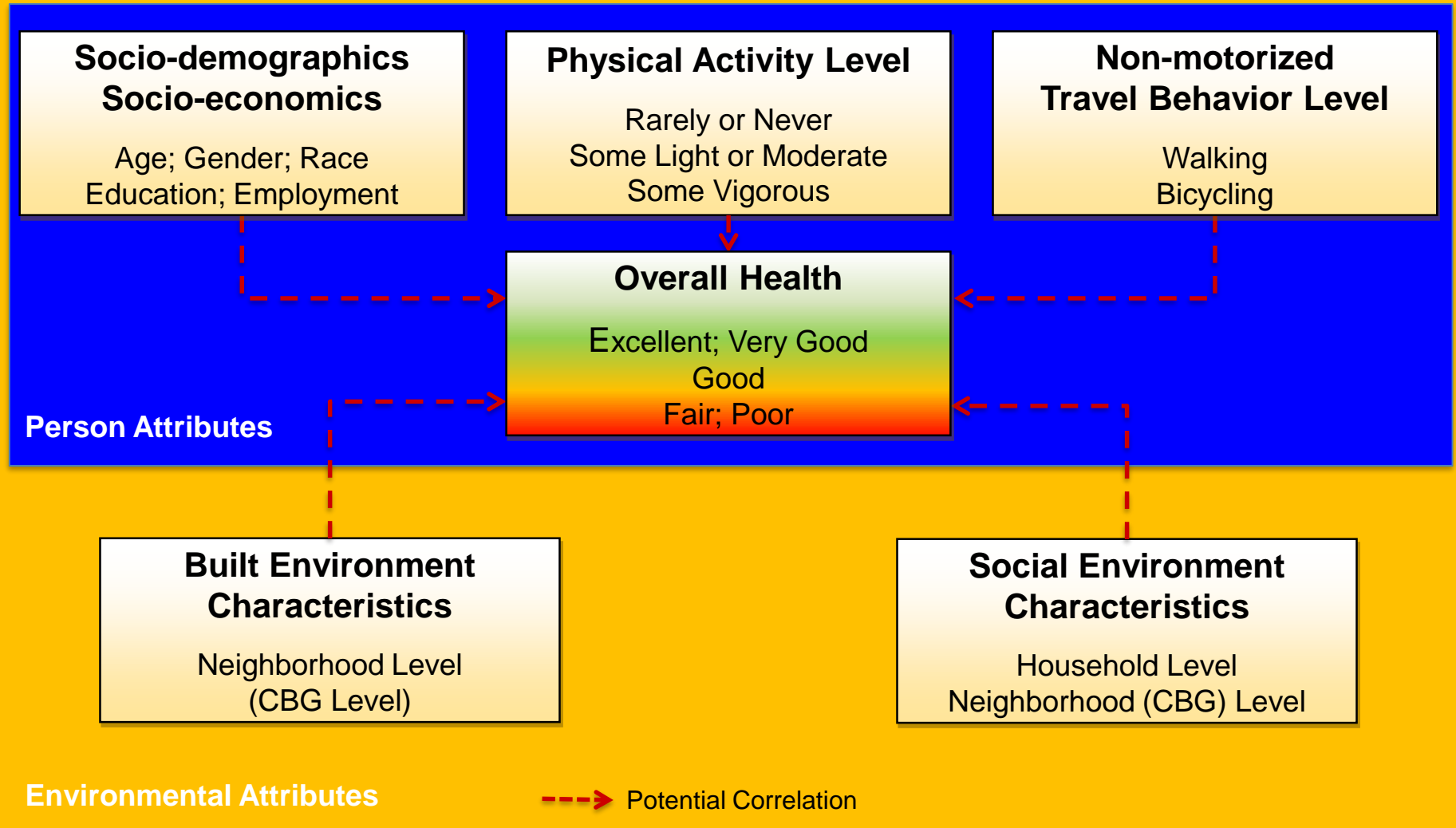
| Independent Variable | Description | Mean | SD |
|--|---|--------|---------|
| Built Environment Attributes (CBG Level) | | | |
| Activity Density | [(Employment + housing units)/acre] | 5.05 | 21.43 |
| Diversity (mixed land use) | 5-tier employment entropy | 0.56 | 0.31 |
| Pedestrian-friendly Network Design | Facility miles of pedestrian-oriented links/mi ² | 9.36 | 7.09 |
| Intersection Density | Automobile-oriented intersections/mi ² | 1.01 | 3.06 |
| Destination Accessibility | Jobs within 45 minutes auto travel time | 85,126 | 122,199 |
| Regional Diversity | Deviation of jobs/population ratio from regional ratio | 0.17 | 0.22 |
| Transit Accessibility (in terms of distance) | Proportion of jobs within ¼ mile of transit stops | 0.01 | 0.09 |
| Transit Service | Frequency of transit service during weekday evening peak period/mi ² | 274 | 1,521 |
| Social Environment Attributes (CBG Level) | | | |
| Working-aged Population | % population that is working aged | 76% | 7% |
| Vehicle Ownership | % households with no cars | 6% | 9.4% |
| Low-wage Income | % workers earning ≤ \$1,250/month | 25% | 5.8% |

Sample Data – Descriptive Statistics



| Overall Health Status Category | Frequency | Percent |
|--------------------------------|----------------|------------|
| Fair or Poor | 27,706 | 10.5 |
| Good | 64,667 | 24.5 |
| Excellent or Very Good | 171,600 | 65.0 |
| Total | 263,973 | 100 |

Methodology



Conceptual Framework

Model Specification

- **Dependent variable: ordinal categories of overall health (i.e., Excellent or Very Good, Good, Fair or Poor)**
- **Ordered probit model**
 - Suitable for dependent variables measured in ordered categories
 - Relates observed response y to an unobserved latent variable y^*
 - Captures the probability of a certain category in the ordinal dependent variable
- **Probability of falling into each category of overall health status can be estimated**
- **Formulation:**
$$y_i^* = c + x_i \beta' + \mu_i$$
 - c = constant; x_i = vector of independent variables; β' = vector of model parameters; μ_i = error term with normal distribution

Results



| Independent Variable | Model 1 | | Model 2 | |
|---|------------------------|----------------------------------|------------------------|----------------------------------|
| | Coefficient | Marginal Effects (Better Health) | Coefficient | Marginal Effects (Better Health) |
| Person Attributes | | | | |
| Age | - 0.0142*** | - 0.0044*** | - 0.0149*** | - 0.0045*** |
| Gender = male | - 0.1309*** | - 0.0401*** | - 0.1265*** | - 0.0379*** |
| Race (base category: White) | | | | |
| <i>Black or African American</i> | - 0.1668*** | - 0.0519*** | - 0.1343*** | - 0.0408*** |
| <i>Asian</i> | - 0.0107 ^{NS} | -0.0033 ^{NS} | - 0.0231 ^{NS} | - 0.0069 ^{NS} |
| <i>American Indian or Alaska Native</i> | - 0.2951*** | - 0.0929*** | - 0.3379*** | - 0.1050*** |
| <i>Native Hawaiian or other Pacific Islander</i> | - 0.0682 ^{NS} | - 0.0210 ^{NS} | - 0.1584** | - 0.0483** |
| <i>Multiple responses selected</i> | - 0.2106*** | - 0.0658*** | - 0.1942*** | - 0.0594*** |
| <i>Some Other Race</i> | - 0.1564*** | - 0.0487*** | - 0.1584*** | - 0.0483*** |
| Educational Level (base: less than high school) | | | | |
| <i>High school graduate or GED</i> | 0.0281** | 0.0091** | 0.0146 ^{NS} | 0.0047 ^{NS} |
| <i>Some college or associate degree</i> | 0.1158*** | 0.0373*** | 0.1034*** | 0.0327*** |
| <i>Bachelor's degree</i> | 0.3060*** | 0.0965*** | 0.2805*** | 0.0866*** |
| <i>Graduate degree or professional degree</i> | 0.3460*** | 0.1085*** | 0.3252*** | 0.0997*** |
| Employment Status = employed | 0.2173*** | 0.0666*** | 0.1969*** | 0.0589*** |
| Number of Non-motorized Trips (in the past 7 days) | 0.0023*** | 0.0007*** | 0.0039*** | 0.0011*** |
| Physical Activity Level (base: rarely or never) | | | | |
| <i>some light or moderate physical activities</i> | 0.7326*** | 0.2549*** | 0.7152*** | 0.2520*** |
| <i>some vigorous physical activities</i> | 1.4874*** | 0.4777*** | 1.4917*** | 0.4712*** |

Results



| Independent Variable | Model 1 | | Model 2 | |
|--|-----------------------------|----------------------------------|-----------------------------|----------------------------------|
| | Coefficient | Marginal Effects (Better Health) | Coefficient | Marginal Effects (Better Health) |
| Household Attributes | | | | |
| Household Size | - 0.0137*** | - 0.0042*** | - 0.0169** | - 0.0051*** |
| Number of Household Vehicles | 0.0193*** | 0.0059*** | 0.0209*** | 0.0063*** |
| Household Annual Income (base: < \$10,000) | +*** | +*** | +*** | +*** |
| Household Location = Urban | 0.0459*** | 0.0141*** | 0.0410** | 0.0123** |
| Neighborhood Social Environment Attributes | | | | |
| Working-aged Population (%) | 0.6054*** | 0.1855*** | 0.5226*** | 0.1563*** |
| Households with no cars (%) | - 0.3431*** | - 0.1051*** | - 0.2749*** | - 0.0822*** |
| Low-wage Workers (%) | - 0.3996*** | - 0.1224*** | - 0.5021*** | - 0.1502*** |
| Neighborhood Built Environment Attributes | | | | |
| Activity Density (logged) | 0.0035 ^{NS} | 0.0011 ^{NS} | - 0.0082 ^{NS} | - 0.0024 ^{NS} |
| Mixed Land Use (entropy) | 0.01947** | 0.0060** | 0.0081* | 0.0025* |
| Pedestrian-friendly Network Design (logged) | 0.0234*** | 0.0072*** | 0.0170** | 0.0051** |
| Intersection Density (logged) | - 0.0018*** | - 0.0006*** | - 0.0023*** | - 0.0007*** |
| Destination Accessibility – Automobile (logged) | 0.0009 ^{NS} | 0.0003 ^{NS} | 0.0080** | 0.0024** |
| Destination Accessibility – Transit (logged) | — | — | - 0.0014 ^{NS} | - 0.0004 ^{NS} |
| Regional Diversity (logged) | 0.0050** | 0.0015** | 0.0057 ^{NS} | 0.0017 ^{NS} |
| Transit Accessibility | 0.0906** | 0.0278** | 0.0980** | 0.0293** |
| Transit Service (logged) | — | — | 0.0003 ^{NS} | 0.0001 ^{NS} |
| Pseudo R ² ; Log Likelihood; Number of Observations | 0.1579; -171276.83; 226,818 | | 0.1576; -84233.931; 116,525 | |

Summary of Findings



Higher health rankings are associated with

- **Person and household attributes:**
 - younger age
 - being a female, being of the White race, being employed
 - higher education, higher income, higher vehicle ownership
 - higher levels of non-motorized trips and physical activity
- **Neighborhood attributes (including built environment factors):**
 - living in neighborhoods with higher working-aged population, more households with vehicles, and fewer low-income workers
 - higher mixed land use development
 - higher levels of pedestrian-oriented and lower levels of car-oriented network design
 - increased accessibility to local transit
 - increased destination accessibility to employment (by automobile)

Conclusions: Findings



Overall health status of 2017 NHTS respondents is associated with their

- **Socio-economic and socio-demographic characteristics**
(age, gender, race, education, income, vehicle ownership, etc.)
- **Levels of non-motorized travel**
(walking and biking)
- **Levels of physical activity**
- **Neighborhood built environment characteristics**
(mixed land use development, pedestrian-friendly network design, destination and transit accessibility, etc.)
- **Neighborhood social environment characteristics**
(working-aged population, vehicle ownership levels, income levels)

Conclusions: Policy Implications



Findings from this study can assist transportation and public health policy decision-makers to

- **Identify factors that are linked with health of individuals**
- **Strengthen arguments for interventions aiming at improving public health through changing travel behavior and the built environment**
- **Develop more effective policies and implementation strategies to promote public health**

Limitations and Future Research



Study Limitations

- Cross-sectional data; no inference about causality
- Self-reported rankings of health status
- Did not address endogeneity

Future Work

- More sophisticated statistical tools to check for
 - causal links between non-motorized travel behavior, built environment and health
 - potential endogeneity bias

Thank you!



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