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Spinning the wheels and rolling the dice: Life-cycle risks and benefits of bicycle commuting in the U.S.

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ABSTRACT

Objective. To assess the net impact on U.S. longevity of the decision to commute by bicycle rather than automobile.

Methods. We construct fatality rates per distance traveled using official statistics and denominators from the 2009 National Household Travel Survey. We model the life-table impact of switching from auto to bicycle commuting. Key factors are increased risks from road accidents and reduced risks from enhanced cardiovascular health.

Results. Bicycling fatality rates in the U.S. are an order of magnitude higher than in Western Europe. Risks punish both young and old, while the health benefits guard against causes of mortality that rise rapidly with age. Although the protective effects of bicycling appear significant, it may be optimal to wait until later ages to initiate regular bicycle commuting in the current U.S. risk environment, especially if individuals discount future life years.

Conclusions. The lifetime health benefits of bicycle commuting appear to outweigh the risks in the U.S., but individuals who sufficiently discount or disbelieve the health benefits may delay or avoid bicycling. Bicycling in middle age avoids much fatality risk while capturing health benefits. Significant cross-state variations in bicycling mortality suggest that improvements in the built environment might spur changes in transit mode.

Introduction

Many studies suggest that physical activity improves cardiovascular and other dimensions of health and thus longevity (Berlin and Colditz, 1990; Blair et al., 1995; Lee and Paffenbarger, 2000; Lee et al., 1995; Paffenbarger et al., 1993; Warburton et al., 2006); and there is interest in encouraging health through active transport (de Hartog et al., 2010; Dill et al., 2013; Edwards, 2008; Fraser and Lock, 2011; Oja et al., 2011; Rabl and de Nazelle, 2012; Rutter et al., 2013; Stipdonk and Reurings, 2012). Two prospective cohort studies show that bicycling is associated with significantly reduced mortality (Andersen et al., 2000; Matthews et al., 2007); two others are inconclusive (Besson et al., 2008; Tanasescu et al., 2002). The World Health Organization has embedded the estimates of Andersen et al. (2000) in its Health Economic Assessment Tool (HEAT), and recent years have brought bicycle sharing plans to several world cities (Rojas-Rueda et al., 2011), including most recently New York City, where the plan was partially motivated by the health benefits (NYC Dept. City Planning, 2009).

Bicycling involves greater exposure to traffic fatalities, and how these risks compare to the benefits is unclear. An earlier study quantified the net effect of bicycling on longevity using Dutch statistics, and it found that the benefits significantly outweighed the risks (de Hartog et al., 2010). But traffic fatality rates vary with geography. Here we compare risks versus benefits of bicycle commuting in the U.S., and we reassess the decision-making framework that is standard in this literature. Behaviors that maximize period life expectancy may be optimal for public health or well-being, but individuals might maximize the present discounted value of their future well-being. Because bicyclists must accept an elevated risk of early death via traffic fatality in exchange for the promise of improved health and reduced mortality in later years, young commuters especially may decide that the risks are not worth it. A secondary goal is to present and examine geographic patterns in the U.S. bicycle fatality rates to provide additional context.

Other studies tend to focus on the aggregate impacts of bicycling on public health, such as deaths averted and reductions in air pollution and carbon emissions (Lindsay et al., 2011; Rojas-Rueda et al., 2012; Woodcock et al., 2009). By contrast, we focus on the individual decision to commute by bicycle rather than automobile, and we omit explicit treatment of exposure to air pollution due to a lack of data. Based on

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the importance of air pollution exposure reported by de Hartog et al. (2010), we suspect that this omission may inject a small amount of bias favoring bicycle commuting.

Methods

Traffic fatalities

Our numerators are 2009 traffic fatalities by type, age, and state drawn from microdata from the National Highway Traffic Safety Administration (NHTSA). We focus on occupants of motor vehicles, not including motorcycles, buses, or taxis, and on bicyclists. Statistics from a single year can be noisy for a mode as rare as bicycling, but we found few meaningful differences when averaging multiple years.

Person miles traveled

Our denominators are annual person miles traveled either by bicycle or by motor vehicle as defined above, drawn from the 2009 National Household Travel Survey (NHTS) of 26,000 U.S. households. Defining exposure as a person trip produced similar results. Distinguishing between urban and rural locations is preferable but hampered by stark differences between these datasets. In our state-level analysis we weight by population. In our national analysis, we smooth the data on miles bicycled by age with a kernel density estimator, holding the total miles ridden constant. Smoothing did not substantially affect the results.

Reduced mortality through improved health

Much research associates physical activity with improved health and reduced mortality (Berlin and Colditz, 1990; Kahn et al., 2002; Lee and Paffenbarger, 2000; Lee et al., 1995; Warburton et al., 2006). Four longitudinal cohort studies considered bicycling: (Andersen et al., 2000), (Tanasescu et al., 2002), (Matthews et al., 2007), and (Besson et al., 2008). Of these, the first and third find statistically significant protective effects. All are observational in nature.

Andersen et al. (2000) estimate the relative risk for all-cause mortality among commuting bicyclists at 0.72, and that is the most widely cited result. We view the evidence as supportive of such an effect only on mortality at older ages, and not at younger ages when external causes are far more important. In the Andersen et al. (2000) study, the empirical relationship was not statistically significant for women aged 20–44, and it was not robust among men of those ages. Physical activity is protective against cardiovascular disease, ischemic stroke, type-2 diabetes, colon cancer, osteoporosis, depression, and fall-related injuries (Kahn et al., 2002), and few to none of these are major causes of death at younger ages. Table 1 lists shares of deaths by major underlying causes between ages 20 and 64 in the U.S. in 2009. More than half of young deaths are attributable to accidents or homicides, which exercise cannot plausibly reduce. There is an abrupt shift in causes at age 45 when cancer and heart disease begin to account for the majority of deaths. Thus we believe that any protective effects of bicycling on mortality under age 45 are negligible, and in our preferred scenario we model reductions in all-cause mortality by 28% starting at age 45.

Life-table analysis

We take as our baseline the 2009 U.S. life table for both sexes combined as provided by the Human Mortality Database (2013). Switching from auto to bicycle commuting adds to age-specific mortality rates through increased fatality risk, and it reduces them proportionally through protective effects on health. We assume that the relative risk estimate of Andersen et al. (2000) based on a Copenhagen study does not already include the effect of transportation mode on traffic fatalities, which is consistent with the approach of de Hartog et al. (2010) and probably reasonable given how much more hazardous the U.S. is.

Table 1
Major causes of death in the U.S. in 2009.

Age	Percent of deaths due to:					
	Accidents	Homicides	Suicides	Cancer	Heart disease	Other
20–24	40.5	15.6	14.3	5.2	3.7	20.7
25–34	33.1	9.9	12.5	8.6	7.5	28.4
35–44	20.2	3.7	8.9	16.8	14.8	35.5
45–54	10.6	1.1	4.6	27.0	19.7	37.0
55–64	4.3	0.3	1.9	35.2	22.2	36.1

Notes: Data are deaths by underlying cause for both sexes combined reported by Heron (2012) and augmented with the CDC WONDER online database.

Time discounting

Health economists believe that individuals discount future health and longevity. Because switching from auto commuting to bicycle commuting reduces life years at younger ages while increasing them at older ages, we assess the effect of the switch on the sum of discounted life years. We allow the discount rate to vary between 0% and 15%.

Scenarios

We model bicycle commuting as the substitution of a 6-mile (10 km) daily round-trip bicycle commute for 5 days each week over 50 workweeks for an equivalent set of commutes by auto, starting at age 20 and ending at age 65. While 6 miles (10 km) is a relatively short commute by American standards, 25% of commutes (all modes included) in the 2009 NHTS were shorter. Modeling separately by sex did not produce substantially different results, so we present results for both sexes combined. In our baseline scenario, bicycling imparts an all-mortality relative risk (RR) of 0.72 starting at age 45. In alternative scenarios, the protective effect starts at age 20, or the RR is only 0.85 starting from age 45, or it is nonexistent (RR = 1).

Results

Fatality rates by age

Table 2, which we present for comparison to de Hartog et al. (2010) Table 4, lists fatality rates by age and travel mode per billion passenger kilometer traveled in the U.S. in 2009 and their ratios. Traffic fatalities are more prevalent in the U.S. overall, and the added risk associated with bicycling rather than driving is much higher in the U.S., especially at ages under 50. The ratio of the bicycling fatality rate to the driving fatality rate never dips below 3.3 at ages 20–29, when auto fatalities are near their peak. At older working ages, that ratio rises

Table 2
Rates of traffic deaths per billion person kilometer in the U.S., 2009.

Age	Bicycle	Auto	Ratio
5–9	18.4	1.3	14.3
10–14	45.9	1.4	33.3
15–19	39.7	7.5	5.3
20–24	32.4	9.7	3.3
25–29	31.1	9.3	3.3
30–34	24.2	4.3	5.6
35–39	31.6	3.0	10.5
40–44	42.0	2.3	18.0
45–49	53.1	3.9	13.8
50–54	51.1	3.4	15.1
55–59	58.4	2.9	19.9
60–64	74.0	3.3	22.5
65–69	94.0	4.4	21.4
70–74	78.0	6.1	12.7
75–79	160.0	8.0	20.0
80–84	345.2	15.7	22.0
Ages 5+	43.2	4.5	9.6
Ages 20–64	41.5	4.2	9.9

Notes: Statistics are for both sexes combined. Numerators are drawn from the NHTSA fatality statistics for 2009. Denominators are converted from annual million person miles traveled by mode in the 2009 NHTS, smoothed over single years of age as described in the text. Rates are for all areas, urban and rural combined. Autos include cars, vans, SUVs, pickup trucks, other trucks, and RVs.