The coefficient estimate for lanes is larger than for paths in Model 7, but as in Models 1 through 6, the two coefficients are not significantly different from each other at the 95% confidence level.

The last column of Table 4 presents elasticities for the Binary Logit Proportions Model, setting all other variables at their means. Estimated elasticities from the linear OLS log–log regression model and elasticities (at the mean) from the non-linear Binary Logit Proportions model are not comparable because of differences in functional form, estimation technique, and dependent variables. The significance, direction, and magnitude of coefficients from Models 1 through 7 are similar. In particular, both estimation techniques yield statistically significant positive coefficients for the two main variables of interest: bike paths and bike lanes.

Limitations of the analysis

The cross-sectional analysis in our study aims at explaining differences in cycling rates among cities but cannot be used to predict changes over time. Moreover, as in any cross-sectional regression analysis, none of our models can prove causality, although the significant associations we measured are consistent with the hypothesis that bike paths and lanes encourage more cycling. Our analysis is also limited by its reliance on aggregate, city-level data, which mask variations within cities, among neighborhoods, and individuals. The results suggest a statistically significant relationship between bike paths and lanes and cycling at the city level, but results do not permit conclusions about individual travel behavior.

In addition to the inherent limitations of cross-sectional regression analysis and aggregate data, there is a problem of endogeneity among some of the variables in our models. Cycling levels and the extent of the bikeway network almost certainly affect each other, so that causation is probably in both directions. In this paper, we have focused on the role of bike paths and lanes in explaining variation among cities in cycling levels. Conversely, however, high cycling levels might help explain the provision of a large supply of bike paths and lanes. Endogeneity and simultaneous equations bias are potentially serious problems in our regression analysis because the key explanatory variables—bike paths and bike lanes—are also a function of cycling levels, the dependent variable.

Three of the control variables may cause additional endogeneity problems. For example, cycling safety and car ownership may be influenced by cycling levels, just as cycling levels may be influenced by these two control variables. Land use might also be a function of cycling rates, but only in the long run, if cyclists move to compact, mixed-use neighborhoods. To explore the potential bias introduced by such endogeneity, Models 3, 4, and 5 in Table 4 remove cycling fatality rate, car ownership, and land use from the model—one at a time. Coefficients for the other variables and goodness of fit measures do not change significantly, suggesting that inclusion of the control variables does not cause serious endogeneity problems in the models. At any rate, exclusion of the variables would be theoretically incorrect and would cause underspecification bias.[7]

[7] In an attempt to model the simultaneous dependencies among the variables, we experimented with several alternative instrumental variables to estimate a simultaneous equation system using two-stage regressions. Unfortunately, none of the available variables in the dataset were sufficiently exogenous or strong enough to serve as instrumental variables. They failed on one or more criteria required for statistically robust and valid instrumental variables: (1) underidentification (Anderson LM statistic), (2) weak identification (Cragg–Donald Wald *F* statistic), (3) overidentification (Sargan statistic), (4) or robust instrument inference

Aside from methodological limitations, there are problems with the available data on bike paths and lanes. As noted earlier, the centerline measure of bike lanes does not distinguish between streets with bike lanes on only one side, in only one direction, and streets with bike lanes on both sides, serving both directions of travel. Clearly, bike lanes on both sides of a street provide more supply than a bike lane on only one side of the street. In addition, the data do not distinguish between the specific nature and quality of different types of lanes. For example, bike lanes have varying widths, markings, signage, coloring, and intersection treatments. They can be on the right or left side of the street, or even between traffic lanes. Some bike lanes have buffers or barriers of various sorts to separate them from motor vehicle traffic. Moreover, cities have different policies about maintaining bike lanes and keeping them clear of snow, debris, and motor vehicles.

Similar to bike lanes, bike paths vary in their width, pavement, design, and especially in the extent to which they are shared with other users such as pedestrians. Indeed the term 'bike path' is a bit of a misnomer in the USA. Most bike paths included in U.S. statistics are simply multi-use paths shared with pedestrians (Alliance for Biking and Walking 2010; Pucher et al. 1999). In contrast, bike paths in most northern European cities are completely separate facilities for the exclusive use of cyclists (Fietsberaad 2006, 2010; Pucher and Buehler 2008; Pucher et al. 2010). Thus, bike paths in the USA might have less impact on cycling levels than the higher-quality, fully separate bike paths in the Netherlands, Germany, and Denmark. Some mixed-use paths in the USA provide suggestive markings to help separate cyclists from pedestrians, but most do not. Some bike paths require cyclists to dismount when crossing a road, while others stop motor vehicles at crossings and give cyclists the right of way. None of the 90 cities in our dataset provided detailed information on those sorts of variations in the types of bike paths, although these differences may be important for cyclists.

Another limitation of our analysis is that the measure of cycling levels used as the dependent variable only includes daily bike commuters and thus excludes bike trips for all other trip purposes. According to the 2009 NHTS, the journey to work only accounts for 12% of all bike trips (Pucher et al. 2011a; USDOT 2010b). The lack of city-level data on cycling for all trip purposes restricts the inferences that can be drawn from our analysis. It seems likely that regular bike commuters have different characteristics and preferences than recreational cyclists. Thus, the coefficients estimated in our models for the various

Footnote 7 continued
(Anderson–Rubin Wald test). The best instrumental variable in the dataset was city land area—since area is fully exogenous and correlated with the total number of bike commuters and the extent of bike paths and lanes. The technical estimation procedure of two-stage least squares (2SLS) required combining the length of bike paths and lanes into one variable, because there was only one instrumental variable available. Moreover, the model was re-specified with the log of total number of bike commuters as dependent variable and the log of total length of bike paths and lanes as regressor. This model satisfied most of the statistical tests for appropriateness of the instrument, but failed to reject the null hypothesis of the Sargan test for overidentification—which casts some doubt on the validity of the instrument.

Estimating a 2SLS equation with this imperfect instrumental variable yields results for the bikeway variable that are similar to those for an OLS regression. In the 2SLS model, bike paths and lanes are statistically significant predictors of cycling levels—even after accounting for endogeneity bias. Another instrumental variable we examined—measuring city population per bicycling advocacy group member—yielded similar results: statistical tests point to weak instrumentation, but bike paths and lanes retain their significant and positive coefficient.

explanatory variables might differ if the dependent variable had included bike trips for all purposes.

Finally, the analysis was hampered by the unavailability or poor quality of data for control variables. For example, we had to use a very rough proxy for cycling fatality rates based on the available state data, and we could only measure exposure in terms of bike commuting levels. Perhaps the most important control variable we could not include was topography, since all studies show that it influences cycling levels. The model is under-specified in this respect.

Many limitations of our study could be overcome with more and better data, which would also facilitate more advanced modeling techniques and better measurement of control variables. A crucial first step is a larger dataset reporting on cycling for all trip purposes that could be disaggregated to the city level. However, that would require a large new national survey or a vast increase in the sample size of the NHTS, currently the only national travel survey in the USA reporting on travel for all trip purposes. Both of those options seem unrealistic, however, given the difficulty in funding the latest 2009 NHTS (AASHTO 2007). In addition, questions on the proximity to bike paths and lanes might be added to future NHTS surveys, since the 2001 and 2009 NHTS surveys already included questions about car ownership and access to public transport. More detailed information about city-level supply of cycling facilities might be collected by a separate survey, similar to the National Transit Database, which would provide an inventory of bike paths, lanes, and parking. Better statistics on cycling facilities would enable more precision in the analysis of their relationship to cycling levels. Moreover, better local data on cyclist fatality rates in cities and a comparable GIS-based measure of urban topography would also enhance the accuracy of the analysis of cycling levels.

Collecting comparable time-series data on cycling levels as well as bike path and lane supply would facilitate pooled cross-section and time-series regression analysis, which would permit stronger inferences from the models than in our cross-section analysis for only one year. Larger sample size and time series data could also help mitigate some of the endogeneity problems discussed above. For example, more advanced statistical techniques, such as Structural Equation Modeling (SEM), can help control for the simultaneous influence of independent and dependent variables, as well as for correlation among independent variables.

Discussion and conclusion

Over the past two decades, many American cities have focused on building bike paths and lanes to increase cycling (Alliance for Biking and Walking 2010; League of American Bicyclists 2010; Pucher and Buehler 2011; Pucher et al. 2011b; USDOT 2010d). Our analysis of newly collected data on cycling facilities in 90 large U.S. cities shows that cities with a greater supply of bike paths and lanes have higher bike commute levels—even after controlling for other factors that may affect cycling levels. That result is consistent with other studies that confirm the important role of separate facilities (Dill and Gliebe 2008; Dill and Voros 2007; Krizek et al. 2007; Moudon et al. 2005; Nelson and Allen 1997). Most disaggregate, individual-level studies of the relationship between bikeway supply and cycling levels focus on only one city or a few cities. Our study is most similar to two earlier studies, which also used aggregate, city-level data to explore the relationship of bikeways and cycling commute levels (Dill and Carr 2003; Nelson and Allen 1997). We expand on those two studies in several ways.

Our sample of 90 U.S. cities was much larger: more than four times as many cities as Nelson and Allen (18 cities) and more than twice as many cities as Dill and Carr (42 cities). Moreover, our regressions distinguish between paths and lanes, while the multiple regressions in the other two studies either combined the two types of facility (Nelson and Allen) or only included bike lanes (Dill and Carr). Similar to these two previous city-level studies, we find that the supply of bikeways per capita is a statistically significant predictor of bike commuting. By including separate variables for paths and lanes, however, our analysis is able to examine each type of facility separately and finds that they do not have significantly different associations with levels of bike commuting among cities.

Although the main focus of our study was on bike paths and lanes, the models yielded new results about the influence of the control variables on cycling levels. The much larger sample size and data availability for more variables allowed us to include nine control variables in the regression equations, compared to five for Dill and Carr (2003) and four for Nelson and Allen (1997). Our control variables include some of those suggested by Nelson and Allen (1997), such as gasoline price and public transport supply. Similar to the other two city-level studies, our results show that the percentage of college students in the city population is a significant predictor of bike commuting. In contrast to these earlier studies, however, we did not find a significant relationship between bike commuting and precipitation. Although the precipitation variable was estimated to be statistically significant in the regression analysis of Dill and Carr (2003), the authors themselves doubted the actual importance of precipitation as a predictor of cycling, since three of the top ten cycling cities in their sample had very high levels of precipitation. In our own analysis of climate, we included two additional climate control variables—the number of extremely hot and cold days per year—but their estimated coefficients were not statistically significant, either. Thus, none of our three measures of climate were strong predictors of bike commuting.

Similar to Dill and Carr (2003), our study shows that cities with higher car ownership have lower cycling levels. Inclusion of additional control variables in our study revealed that cities with safer cycling, less sprawl, and higher gasoline prices have more cycling. Regional public transport supply per capita was not a statistically significant predictor of bike commuting. Thus, we cannot confirm the speculations by Nelson and Allen (1997) and Schwanen (2002) that public transport supply affects levels of bike commuting.

Most American cities build both bike lanes and bike paths with the expectation that offering both kinds of facilities provides cyclists with more route options and choice of facility type. Prior research finds that some cyclists prefer bike lanes, while others favor bike paths. Some studies find that commuters prefer on-street bike lanes over paths because lanes follow the road network and provide more direct routes (Aultman-Hall et al. 1998). The multiple regression coefficients in our models, however, do not suggest a statistically significant difference between paths and lanes in their relationship to bike commuting. Furthermore, our coefficient estimates for paths and lanes suggest inelastic cycling demand with respect to the supply of cycling facilities. A one percent difference between cities in the supply of bike paths and lanes is associated with less than a one percent difference in cycling levels.

Similar to all previous studies, our estimates of the role of bike paths and lanes do not control for the many other differences among cities in their approaches to encourage cycling. For example, most cities offer suggested bike routes on streets without any separate facilities and consider them an integral part of their overall cycling network. But cities vary greatly in the quality of such routes and do not report statistics consistently, so we did not include bike routes on roads without any dedicated space for cyclists. Similarly, many other infrastructure measures and programs could not be integrated into the model.

Intersection improvements and priority traffic signals for cyclists, bike parking, coordination with public transport, traffic education and training, and bike promotion and public awareness campaigns all influence cycling levels to some extent, and should be controlled for in models examining the determinants of cycling. The lack of reliable, comparable data for these other measures prevents their inclusion in the regression models, which are thus inevitably underspecified to some unknown extent. We share this drawback with all other studies.

Whatever the shortcomings of our data and regression models, our estimated equations are consistent with the hypothesis that bike lanes and paths encourage cycling. They reveal a positive relationship even when controlling for a range of other factors expected to affect cycling levels. Although not always statistically significant, the coefficients of explanatory variables in our equations suggest a direction of influence similar to that found in most other studies.

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References

AASHTO: About the National Household Travel Survey. American Association of State Highway and Transportation Officials, Washington, DC (2007)

Abraham, J.E., McMillan, S., Brownlee, A.T., Hunt, J.D.: Investigation of cycling sensitivities. Paper presented at the 81st transportation research board annual meeting, Washington, DC (2002)

Akar, G., Clifon, K.J.: The influence of individual perceptions and bicycle infrastructure on the decision to bike. Transp. Res. Rec. **2140**, 165–172 (2009)

Alliance for Biking and Walking: Bicycling and Walking in the United States: 2010 Benchmarking Report. Alliance for Biking and Walking, Washington, DC (2010)

APBP: Bicycle Parking Guidelines. Assocition of Pedestrian and Bicycle Professionals, Washington, DC (2002)

Aultman-Hall, L., Hall, F.L., Baetz, B.B.: Analysis of bicycle commuter routes using geographic information systems: Implications for bicycle planning. Transp. Res. Rec. **1578**, 102–110 (1998)

Baltes, M.: Factors influencing nondiscretionary work trips by bicycle determined from 1990 us census metropolitan area statistical area data. Transp. Res. Rec. **1538**, 96–101 (1997)

Barnes, G., Thompson, K., Krizek, K.J.: A longitudional analysis of the effect of bicycle facilities on the commute share. Paper presented at the 85th transportation research board annual meeting, Washington, DC (2006)

Bergström, A., Magnusson, R.: Potential of transferring car trips to bicycle during winter. Transp. Res. A **37**(8), 649–666 (2003)

British Medical Association: Cycling: Towards Health and Safety. Oxford University Press, Oxford (1992)

Broach, J., Gliebe, J., Dill, J.: Bicycle route choice model developed using revealed preference GPS data. Paper presented at the 90th annual meeting of the transportation research board, Washington, DC (2011)

Brons, M., Givoni, M., Rietvield, P.: Access to railway stations and its potential in increasing rail use. Transp. Res. A **43**, 136–149 (2009)

Buehler, R.: Transport policies, automobile use, and sustainable transport: a comparison of Germany and the United States. J. Plan. Educ. Res. **30**, 76–93 (2010)

Buehler, R., Pucher, J., Merom, D., Bauman, A.: Active travel in Germany and the USA: contributions of daily walking and cycling to physical activity. Am. J. Prev. Med. **41**, September (2011, forthcoming)

Cavill, N., Kahlmeier, S., Racioppi, F. (eds.): Physical Activity and Health in Europe: Evidence for Action. WHO Regional Office for Europe, Copenhagen (2006)

CEMT: National Policies to Promote Cycling. European Conference of Ministers of Transport, Paris (2004)

40

Cervero, R.: The built environment and travel: evidence from the United States. Eur. J. Transp. Infrastruct. Res. **3**(2), 119–137 (2003)
Cervero, R., Sarmiento, O., Jacoby, E., Gomez, L., Neiman, A.: Influences of built environment on walking and cycling: lessons from bogota. Int. J. Sustain. Transp. **3**(4), 203–226 (2009)
City of Toronto: City of Toronto Bike Plan: Shifting Gears. City of Toronto, Toronto, Canada (2001)
City of Vancouver: 1999 Bicycle Plan: Reviewing the Past and Planning the Future. City of Vancouver, Vancouver, Canada (1999)
Cleaveland, F., Douma, F.: The impact of bicycling facilities on commute mode share. In: 88th Transportation Research Board Annual Meeting, Washington, DC (2009)
Cohen, D., Sehgal, A., Williamson, S.: Impact of new bicycle path on physical activity. Prev. Med. **46**, 80–81 (2008)
de Geus, B., de Bourdeaudhuij, I., Jannes, C., Meeusen, R.: Psychosocial and environmental factors associated with cycling for transport among a working population. Health Educ. Res. **23**, 697–708 (2008)
DeJong, G., Gunn, H.: Recent evidence on car cost and time elasticities of travel demand in Europe. J. Transp. Econ. Policy **35**(2), 137–160 (2001)
Dill, J.: Bicycling for transportation and health: the role of infrastructure. J. Public Health Policy **30**, S95–S110 (2009)
Dill, J., Carr, T.: Bicycle commuting and facilities in major US cities: if you build them, commuters will use them-another look. Transp. Res. Rec. **1828**, 116–123 (2003)
Dill, J., Gliebe, J.: Understanding and Measuring Bicycle Behavior: A Focus on Travel Time and Route Choice. Oregon Transportation Research and Education Consortium, Portland, OR (2008)
Dill, J., Voros, K.: Factors affecting bicycling demand: Initial survey findings from the Portland, Oregon region. Transp. Res. Rec. **2031**, 9–17 (2007)
Dora, C., Phillips, M.: Transport, Environment and Health. WHO Regional Office for Europe, Copenhagen (2000)
Elvik, R.: The non-linearity of risk and the promotion of environmentally sustainable transport. Accid. Anal. Prev. **41**, 849–855 (2009)
Epsey M (1998) Gasoline demand revisited: an international meta-analysis of elasticities. Energy Econ. **20**, 273–295
Evenson, K.R., Herring, A.H., Houston, S.L.: Evaluating change in physical activity with the building of a multi-use trail. Am. J. Prev. Med. **28**, 177–185 (2005)
Ewing, R., Cervero, R.: Travel and the built environment. A synthesis. Transp. Res. Rec. **1780**, 87–114 (2001)
Ewing, R., Cervero, R.: Travel and the built environment: a meta analysis. J. Am. Plan. Assoc. **76**(3), 265–294 (2010)
Ewing, R., Pendall, R., Chen, D.: Measuring Sprawl and Its Impact. Smart Growth America, Washington, DC (2002)
Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., Chen, D.: Growing cooler. The evidence on urban development and climate change. Urban Land Institute, Washington, DC (2008)
Fietsberaad: Continuous and Integral: The Cycling Policies of Groningen and Other European Cities. Fietsberaad, Amsterdam, NL (2006)
Fietsberaad: Bicycle Policies of the European Principals: Continuous and Integral. Fietsberaad, Amsterdam, NL (2010)
Gatersleben, B., Appleton, K.M.: Contemplating cycling to work: attitudes and perceptions in different stages of change. Transp. Res. A **41**(4), 302–312 (2007)
Givoni, M., Rietveld, P.: The access journal to the railway station and its role in passengers' satisfaction with rail travel. Transp. Policy **14**, 357–365 (2007)
Guo, J.Y., Bhat, C.R., Copperman, R.B.: Effect of the built environment on motorized and non-motorized trip making: substitutive, complementary, or synergistic? Paper presented at the transportation research board annual meeting, Washington, DC (2007)
Handy, S.L.: Understanding the link between urban form and nonwork travel behavior. J. Plan. Educ. Res. **15**(3), 183–198 (1996)
Hanly, M., Dargay, J., Goodwin, P.: Review of income and price elasticities in the demand for road traffic. Department for Transport, London (2002)
Hegger, R.: Public transport and cycling: living apart or together? Public Transp. Int. **2**, 38–41 (2007)
Heinen, E., Van Wee, B., Maat, K.: Bicycle use for commuting: a literature review. Transp. Rev. **30**(1), 105–132 (2010)
Howard, C., Burns, E.K.: Cycling to work in Phoenix: route choice, travel behavior, and commuter characteristics. Transp. Res. Rec. **1773**, 39–46 (2001)
Hunt, J.D., Abraham, J.E.: Influences on bicycle use. Transportation **34**, 453–470 (2007)

411

IOTF: Obesity in Europe: The Case for Action. International Obesity Task Force and European Association for the Study of Obesity, London, UK (2010)

Jacobsen, P.: Safety in numbers: more walkers and bicyclists, safer walking and bicycling. Inj. Prev. **9**, 205–209 (2003)

Jacobsen, P.L., Racioppi, F., Rutter, H.: Who owns the roads? How motorised traffic discourages walking and bicycling. Inj. Prev. **15**, 369–373 (2009a)

Jacobsen, P.L., Racioppi, F., Rutter, H.: Who owns the roads? How motorised traffic discourages walking and bicycling. Inj. Prev. **15**(6), 369–373 (2009b). doi:10.1136/ip.2009.022566

Krizek, K.J., Johnson, P.J.: Proximity to trails and retail: effects on urban cycling and walking. J. Am. Plan. Assoc. **72**(1), 33–42 (2006)

Krizek, K.J., El-Geneidy, A., Thompson, K.: A detailed analysis of how an urban trail system affects cyclists' travel. Transportation **34**, 611–624 (2007)

Krizek, K.J., Forsyth, A., Baum, L.: Walking and cycling international literature review. Victoria Department of Transport, Melbourne, Australia (2009)

League of American Bicyclists: Bicycling Friendly Community Program. League of American Bicyclists, Washington, DC (2010)

LeClerc, M.: Bicycle Planning in the City of Portland: Evaluation of the City's Bicycle Master Plan and Statistical Analysis of Relationship Between the City's Bicyle Network and Bicycle Commute. Portland State University, Portland, OR (2002)

Litman, T.: Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior. Victoria Transport Institute, Victoria, Canada (2007a)

Litman, T.: Transportation elasticities. Victoria Transport Policy Institute. http://www.vtpi.org/tdm/tdm11.htm#_Toc161022580 (2007b). Accessed 23 June 2011

Lusk, A.C., Furth, P.G., Morency, P., Miranda-Moreno, L.F., Willett, W.C., Dennerlein, J.T.: Risk of injury for bicycling on cycle tracks versus in the street. Inj. Prev. Brief Report http://injuryprevention.bmj.com/content/early/2011/02/02/ip.2010.028696.full (2011). Accessed 23 June 2011

Martens, K.: The bicycle as a feedering mode: experiences from three European countries. Transp. Res. D **9**, 281–294 (2004)

Martens, K.: Promoting bike and ride: the Dutch experience. Transp. Res. A **41**, 326–338 (2007)

Menghini, G., Carrasco, N., Schüssler, N., Axhausen, K.: Route choice of cyclists in Zurich. Transp. Res. A **9**, 754–765 (2010)

Moudon, A.V., Lee, C., Cheadle, A.D., Collier, C.W., Johnson, D., Schmid, T.L., Weather, R.D.: Cycling and the built environment, a US perspective. Transp. Res. D **10**, 245–261 (2005)

NACTO: Cities for Cycling. National Association of City Transportation Officials, Washington, DC (2010)

Nankervis, M.: The effect of weather and climate on bicycle commuting. Transp. Res. A **33**(6), 417–431 (1999)

National Climatic Data Center: Mean Number of Days with Maximum Temperature 90 Degrees for Higher. U.S. Department of Commerce, Washington, DC (2010)

Nelson, A., Allen, D.: If you build them, commuters will use them. Transp. Res. Rec. **1578**, 79–83 (1997)

Netherlands Ministry of Transport: Cycling in the chain: the combination with public transport. In: Cycling in the Netherlands. Netherlands Ministry of Transport, The Hague, pp. 48–51 (2009)

Noland, R., Kunreuther, H.: Short-run and long-run policies for increasing bicycle transportation for daily commuter trips. Transp. Policy **2**(1), 67–79 (1995)

Papke, L.E., Wooldridge, J.M.: Econometric methods for fractional response variables with an application to 401(k) plan participation rates. J. Appl. Econ. **11**(6), 619–632 (1996)

Parkin, J., Wardman, M., Page, M.: Estimation of the determinants of bicycle mode share for the journey to work using census data. Transportation **35**, 93–109 (2008)

Pucher, J., Buehler, R.: Why Canadians cycle more than Americans: a comparative analysis of bicycling trends and policies. Transp. Policy **13**(1), 265–279 (2006)

Pucher, J., Buehler, R.: At the frontiers of cycling: policy innovations in the Netherlands, Denmark, and Germany. World Transp. Policy Pract. **13**(3), 8–57 (2007)

Pucher, J., Buehler, R.: Making cycling irresistible: lessons from the Netherlands, Denmark, and Germany. Transp. Rev. **28**(1), 495–528 (2008)

Pucher, J., Buehler, R.: Analysis of Cycling Policies and Trends in Large American and Canadian Cities. U. S. Department of Transportation, Research and Innovative Technology Administration, Washington, DC (2011)

Pucher, J., Komanoff, C., Schimek, P.: Bicycling renaissance in North America? Recent trends and alternative policies to promote bicycling. Transp. Res. A **33**(7/8), 625–654 (1999)

Pucher, J., Dill, J., Handy, S.L.: Infrastructure, programs and policies to increase bicycling: an international review. Prev Med **50**(S1), S106–S125 (2010)

42

Pucher, J., Buehler, R., Merom, D., Bauman, A.: Walking and cycling in the United States, 2001–2009: Evidence from the NHTS. Am J Public Health **101** e1–e8 (2011a). doi:10.2105/AJPH.2010.300067
Pucher, J., Buehler, R., Seinen, M.: Bicycling renaissance in North America? An update and re-assessment of cycling trends and policies. Transp. Res. A **45**(6), 451–475 (2011b)
Pucher, J., Garrard, J., Greaves, S.: Cycling down under: a comparative analysis of bicycling trends and policies in Sydney and Melbourne. J. Transp. Geogr. **18**(2), 332–345 (2011c)
Rashad, I.: Associations of cycling with urban sprawl and the gasoline price. Am. J. Health Promot. **24**(1), 27–36 (2009)
Reynolds, C., Harris, M., Teschke, K., Cripton, P., Winters, M.: The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. Environ. Health **8**(47), 1–19 (2009)
Rietveld, P., Daniel, V.: Determinants of bicycle use: do municipal policies matter? Transp. Res. A **38**, 531–550 (2004)
Robinson, D.: Safety in numbers in Australia: more walkers and bicyclists, safer walking and cycling. Health Promot. J. Aust. **16**, 47–51 (2005)
Schwanen, T.: Urban form and commuting behavior a cross European comparison. Tijdschrift voor Economische en Sociale Geografie **93**(3), 336–343 (2002)
Shafizadeh, K., Niemeier, D.: Bicycle journey-to-work: travel behavior characteristics and spatial analysis. Transp. Res. Rec. **1578**, 84–90 (1997)
Stinson, M., Bhat, C.: Commuter bicycle route choice: analysis using a stated preference survey. Transp. Res. Rec. **1828**, 107–115 (2003)
Taylor, D., Mahmassani, H.: Analysis of state preferences for intermodal bicycle-transit interfaces. Transp. Res. Rec. **1556**, 86–95 (1996)
Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Baur, C., Crawford, D.: Personal, family, social, and environmental correlates of active commuting to school. Am. J. Prev. Med. **30**(1), 45–51 (2006)
TRB: Integration of Bicycles and Transit—TCRP Synthesis Report 62. Transportation Research Board, National Research Council, Washington, DC (2005)
USDHHS: Physical Activity and Health: A Report of the Surgeon General. U.S. Department of Health and Human Services, Atlanta, GA (1996)
USDHHS: Physical Activity Guidelines for Americans. U.S. Department of Health and Human Services, Atlanta, GA (2008)
USDOC: American Community Survey 2006–2008 Three Year Averages. U.S. Department of Commerce, U.S. Census Bureau, Washington, DC (2009a)
USDOC: United States Census 2000. U.S. Department of Commerce, U.S. Census Bureau, Washington, DC (2009b)
USDOC: American Community Survey 2009. U.S. Census Bureau, Washington, DC (2010)
USDOE: Average Gasoline Retail Prices in U.S. States 2006–2008. United States Department of Energy, Washignton, DC (2010a)
USDOE: Monthly Energy Review: Motor Gasoline Retail Prices. Energy Information Administration. United States Department of Energy, Washington, DC (2010b)
USDOT: The National Bicycling and Walking Study: Transportation Choices for a Changing America. U.S. Department of Transportation, Federal Highway Administration, Washington, DC (1994)
USDOT: Bicycles and Transit: A Partnership that Works. U.S. Department of Transportation, Federal Transit Administration, Washington, DC (1998)
USDOT: National Bicycling and Walking Study: A Ten-year Status Report. U.S. Department of Transportation. Federal Highway Administration, Washington, DC (2004)
USDOT: National Transit Database. U.S. Department of Transportation, Federal Transit Administration, Washington, DC (2008)
USDOT: Bicyclist Fatalities by State. National Highway Traffic Safety Administration (NHTSA), United States Department of Transportation, Washington, DC (2010a)
USDOT: National Household Travel Survey 2009. Version 2.0/2010. U.S. Department of Transportation, Federal Highway Administration, Washington, DC (2010b)
USDOT: National Household Travel Survey, Our Nation's Travel. U.S. Department of Transportation, Federal Highway Administration, Washington, DC (2010c)
USDOT: The National Walking and Bicycling Study: 15-Year Status Report. U.S. Department of Transportation, Federal Highway Administration, Washington, DC (2010d)
Vandenbulcke, G., Dujardin, C., Thomas, I., de Geus, B., Degraeuwe, B., Meeusen, R., Int Panis, L.: Cycle commuting in Belgium: spatial determinants and 're-cycling' strategies. Transp. Res. A **45**(2), 118–137 (2011)

Wardman, M., Tight, M., Page, M.: Factors influencing the propensity to cycle to work. Transp. Res. A **41**, 339–350 (2007)

Winters, M., Friesen, M., Koehoorn, M., Teschke, K.: Utilitarian bicycling: a multilevel analysis of climate and personal influences. Am. J. Prev. Med. **32**, 52–58 (2007)

Xing, Y., Handy, S., Mokhtarian, P.: Factors associated with proportions and miles of bicycling for transportation and recreation in six small us cities. Transp. Res. D **15**, 73–81 (2010)

Zahran, S., Brody, S.D., Maghelal, P., Prelog, A., Lacy, M.: Cycling and walking: explaining the spatial distribution of healthy modes of transportation in the United States. Transp. Res. D **13**(7), 462–470 (2008)

Author Biographies

Ralph Buehler is an assistant professor in Urban Affairs and Planning at Virginia Tech. Most of his research relies on international comparisons and falls into three areas: the influence of transport policy, land use, and socio-demographics on travel behavior; walking and cycling to improve public health; and regional planning for sustainable transport.

John Pucher is a professor in the Bloustein School of Planning and Public Policy at Rutgers University. For over two decades, his research has examined differences in travel behavior, transport systems, and policies in Europe, North America, and Australia, with a current focus on walking and cycling to improve public health.

Jack Witthaus - Fw: Research critical in making general plan work "Who owns the roads - Jacobsen 2009.pdf"

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Subject:	Fw: Research critical in making general plan work "Who owns the roads - Jacobsen 2009.pdf"
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Subject: Research critical in making general plan work "Who owns the roads - Jacobsen 2009.pdf"
Sent: Sat, Jun 9, 2012 3:22:07 PM

Hi,
Another key research paper detailing what needs to be done to support transporation element in general plan
Regards
Pat grant

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Who owns the roads? How motorised traffic discourages walking and bicycling

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See Commentary, p 362

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ABSTRACT

Objective: To examine the impact of traffic on levels of walking and bicycling.

Method: Review of the literature of medical, public health, city planning, public administration and traffic engineering.

Results: The real and perceived danger and discomfort imposed by traffic discourage walking and bicycling. Accurately or not, pedestrians and bicyclists judge injury risk and respond accordingly. Although it can be difficult to measure these effects, observed behaviour provides good evidence for these effects, with the strongest association being an inverse correlation between volumes and speeds of traffic and levels of walking and cycling.

Conclusion: Interventions to reduce traffic speed and volume are likely to promote walking and bicycling and thus result in public health gains.

Over the past two decades, the health consequences of physical inactivity have become increasingly apparent. Non-communicable diseases and related conditions, such as overweight and obesity, have increased steadily in Europe and the USA. European health ministries have acknowledged that physical inactivity, along with unhealthy diets, plays a key role in the obesity epidemic, and poses one of the most serious challenges to public health in Europe. Many have endorsed the promotion of physical activity, including stimulating cycling and walking, by better urban design and transport policies.[1]

During the mid-1990s, an international scientific consensus developed over the value of moderate physical activity—at least 30 min of physical activity on most, preferably all, days of the week for adults—in reducing risks of a number of non-communicable diseases.[2] Children and young people should participate in physical activity of at least moderate intensity for 60 min per day. At a frequency of at least twice a week, some of these activities should help to enhance and maintain muscular strength, flexibility and bone health.[3 4] However, an analysis of a survey of European Union countries showed that two-thirds of the adult population did not reach recommended levels of physical activity, and another survey showed similar results among young people aged 11, 13 and 15 across Europe.[5 6]

Integrating physical activity into daily life is an important factor in increasing population levels of activity; bicycling and walking are major potential contributors to this.[7 3] Many journeys are short, yet many of them are taken using cars. It has been estimated that some 50% of these short trips could be walked or bicycled easily, thereby providing the recommended amount of daily physical activity.[7–9]

In addition, switching from driving to walking and cycling is important for reducing CO_2 emissions.[10] For example, it has been estimated that, if the US population aged 10–64 bicycled for 60 min a day and therefore reduced their car use by that distance bicycled, it could reduce US CO_2 emissions by almost 11%.[11]

How people perceive traffic is an important but poorly understood determinant of travel choices and consequent levels of physical activity through cycling and walking. In 2000, a report by the World Health Organization (WHO) noted that the impact of motorised traffic on people walking and bicycling remained unquantified, but speculated that it might be the greatest health impact of motorised traffic.[12] This paper describes these links and identifies possible entry points for corrective interventions and areas for further study.

Five recent review articles examine some reasons why people do not walk or bicycle. These articles examine attitudes towards walking and bicycling,[13] the relationship between the way neighbourhoods are built and the amount of walking and bicycling,[14] and what interventions encourage people to walk and bicycle.[15–17] However, there is important additional evidence that needs to be considered, which is that people actually avoid walking and bicycling near traffic.

METHOD

We searched for papers that reported observed evidence that traffic discouraged walking and cycling in medical, public health, city planning, public administration and traffic engineering literature. This is an inchoate and poorly organised area of research, with very few publications identified through formal literature review, so the majority of the papers were identified through our professional networks. In these publications and reports, specific evidence relating to the question was often only presented incidentally.

RESULTS

Our literature search found that negative traffic perceptions are associated with decreases in walking and bicycling. This finding was consistently found across several types of studies.

A number of studies have observed people avoiding dangerous and unpleasant traffic. Where pedestrians and bicyclists are safer, levels of walking and cycling tend to be higher, and vice versa. Figure 1 shows the relationship between the safety of cycling and the amount of cycling in 14

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What is already known on the subject

- People do not walk and bicycle for a variety of reasons.
- Most of the research on barriers to cycling and walking to date focuses on attitudes and the built environment.

What this study adds

- Traffic, because it is dangerous and unpleasant, discourages walking and bicycling.
- Increasing traffic volume or speed discourages walking and bicycling and therefore harms health.

Policy implications

- Compared with rebuilding streets and neighbourhoods, traffic can be made less dangerous and more pleasant quickly and relatively inexpensively—for example, through traffic calming interventions, congestion charging, enforcement of speed limits and prioritisation of the rights of pedestrians and cyclists over motorised traffic.
- Society can encourage physical activity and counteract non-communicable diseases and obesity by making traffic less dangerous and more pleasant.

space to parking and roads than to the needs of pedestrians and cyclists. They thus have greater distances between destinations, which discourages walking and bicycling.[41] Many communities built before motor vehicles have yielded public spaces to parking, and their roads have filled with traffic.

The evidence on the relationship between perceptions of the traffic environment and walking and cycling is consistent in showing an inverse association between traffic danger (or perceived danger) and levels of walking and cycling. However, the majority of the evidence is observational, and is confounded by hard-to-isolate issues such as cultural attitudes to driving and perceptions of convenience.[13] This review is not systematic, and thus may suffer from biases and oversights. Although this does not diminish the significance of the identified effects, it highlights the need for well-structured research to address these important public health issues.

Results in relation to other studies

The evidence on determinants of walking and cycling describes a wide range of factors, from environmental to personal.[13 14 41–43] Much of this research has focused on the built environment, which is relatively easy to measure. Some neighbourhoods deter walking and bicycling by segregating land use, low residential density and infrequent street intersections.[14 41 42]

Perceptions of risk of being injured by motorised traffic affect decisions to drive, walk, bicycle or use public transport.[44] Perceptions differ from true risk because of cultural influences and the individual characteristics of the people experiencing the fear.[44] Fear may suppress walking and bicycling in several ways. Fear of crime is known to discourage physical activity.[38] Air pollution and vehicular exhaust and noise probably discourage walking and bicycling. In addition, neighbourhood conditions such as poor walking surfaces and loose dogs reduce walking and bicycling.[38]

Meaning of the results for policy

Changing land use and reshaping population density take a long time and have high costs. On the other hand, traffic can be made less dangerous and more pleasant relatively quickly and inexpensively—for example, through traffic calming, 30 km/h zones, congestion charging, providing cycle tracks on major streets, and giving priority to the rights and safety of vulnerable road users as opposed to motorised transport. This provides an important opportunity to develop a health-improving environment that supports physical activity and contributes to reductions in risks for non-communicable diseases, obesity and related health problems.

Cooperation and coordination is needed between health promotion efforts to reduce injuries and increase walking and bicycling.

The British injury prevention campaign of the early 1990s, "One False Move and You're Dead" (fig 3) was criticised for using fear,[26] which, as shown, discourages walking and bicycling. Nonetheless, many injury prevention efforts continue to use fear. Figure 4 shows an injury prevention campaign poster produced by the US Government in 2007, which uses the outline of a corpse to remind people that motorists can kill them while they walk in their own neighbourhoods.[45]

Society has often placed the responsibility for preventing injuries on the person walking or bicycling. Soon after the automobile's creation, its proponents worked to reconstruct the meaning of safety, removing the connection between speed and danger. Car proponents crafted "safety" campaigns that placed the burden for preventing injury on the person walking, generating the term "jaywalker" for the person who failed to show deference to the motorist by walking where and how they always had. Car proponents had the major control in writing traffic laws and developing traffic engineering policies, and these favour the motorist over other road users.[27] Pedestrians—even children—are often blamed for their injuries.[46] Injury prevention research often reflects this perspective. For example, a study of seriously injured bicyclists found that motor vehicle involvement was overwhelmingly the greatest risk factor.[47] However, the authors considered helmets, separation of cyclists from motor vehicles and delaying cycling until children are developmentally ready as part of the recommendations to prevent injuries, which contribute to reinforcing the fear of cycling, and did not consider effective measures such as lowering traffic speeds to make roads safer for bicyclists. Society often still terms traffic crashes "accidents", a term that excuses the perpetrator, diminishes the concerns of the victim, and perpetuates the myth of inevitability.[48] Although motorists with a history of traffic citations are known to be at increased risk of colliding with child pedestrians, society allows them to continue to drive, implicitly valuing their mobility above the safety of others.[49]

Unanswered questions and future research

The role of fear-based road safety efforts in reducing physical activity, and hence health, deserves further investigation. It seems likely that traffic safety efforts that evoke fear in the potential victims discourage walking and cycling. If fewer people walk or bicycle, then each remaining walker or bicyclist is in greater danger.[18]

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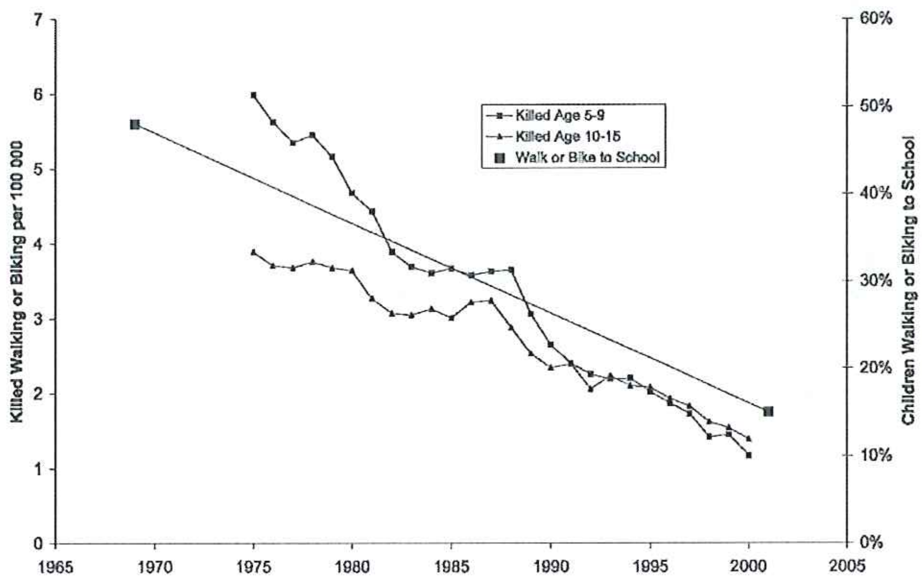

Figure 2 School age children in USA: safer streets or less walking and bicycling?

70% decrease in fatalities matches their 67% decrease in walking to school (fig 2),[32 37] while among middle-aged pedestrians, the decrease in their fatality rate (10%) was less than their decrease in walking (30% decrease in walk-to-work rate).[37 38] So the decline in injuries may reflect to a significant extent lower levels of exposure to danger among the population, rather than any true reduction in road danger. This has also been observed in the UK.[39]

It is also important to note that improved medical care has increased the likelihood of survival in the event of a motor vehicle crash.[40] For these two reasons, fatality statistics, in isolation from other information, are an inadequate measure of the traffic danger faced by people walking and bicycling.

Traffic can also discourage physical activity by making walking and bicycling unpleasant. Streets in new neighbourhoods are often designed primarily around the needs of motorists and are thus unattractive for pedestrians. Many newer neighbourhoods separate land uses and devote more

Figure 3 British injury prevention campaign.

Figure 4 US injury prevention campaign.

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