Trends in Walking and Cycling Safety: Recent Evidence From High-Income Countries, With a Focus on the United States and Germany

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Objectives. To examine changes in pedestrian and cyclist fatalities per capita (1990–2014) and per kilometer (2000–2010) in selected high-income countries, and in fatalities and serious injuries per kilometer by age in the United States and Germany (2001–2009).

Methods. We used Organisation for Economic Cooperation and Development data to estimate 5-year annual averages of per-capita fatalities relative to the 1990–1994 average. To control for exposure, we divided fatalities and serious injuries by kilometers of walking or cycling per year for countries with comparable data from national household travel surveys.

Results. Most countries have reduced pedestrian and cyclist fatality rates per capita and per kilometer. The serious injuries data show smaller declines or even increases in rates per kilometer. There are large differences by age group in fatality and serious injury rates per kilometer, with seniors having the highest rates. The United States has much higher fatality and serious injury rates per kilometer than the other countries examined, and has made the least progress in reducing per-capita fatality rates.

Conclusions. The United States must greatly improve walking and cycling conditions. All countries should focus safety programs on seniors and children. (*Am J Public Health.* Published online ahead of print December 20, 2016: e1–e7. doi:10.2105/AJPH.2016.303546)

Improved traffic safety for pedestrians and cyclists is an important goal of public health policies in countries throughout the world.[1–3] The World Health Organization (WHO) has identified traffic injuries and fatalities as among the world's 5 most important causes of unnatural death, with predictions that they will become the leading cause by 2030.[2] As of 2015, they were already the leading cause of unnatural death among persons in the group aged 15 to 29 years. Reducing pedestrian and cyclist deaths and injuries is obviously a benefit in itself. In addition, however, safer walking and cycling conditions have been shown to increase levels of walking and cycling, especially among vulnerable or risk-averse groups such as children, seniors, and women.[4–9] Increasing walking and cycling rates would help raise the low physical activity levels in most developed countries, thus contributing to improved public health.[3,5,10]

The Organisation for Economic Cooperation and Development (OECD) issues annual reports with international comparisons of traffic safety over recent decades.[1] The OECD reports falling rates of total traffic fatalities per capita in most developed countries, including the United States, where traffic fatalities per capita fell by 46% from 1990 to 2014.[1] There are large differences among countries, however, and the United States has suffered for many years from a much higher traffic fatality rate per capita than most other OECD countries. In 2014, for example, the per-capita fatality rate in the United States was 2 to 3 times higher than that in most Western European countries.[1] The OECD's published reports do not include separate fatality rates for walking and cycling over time. Nor do they control for exposure rates such as the number of trips, distance, or hours walked and cycled, which are crucial in measuring the safety of these 2 nonmotorized modes.[1] Yet another gap in the OECD reports is the variation in walking and cycling safety by age group. Several studies suggest that children and seniors are especially vulnerable to walking and cycling injuries and fatalities.[4,11]

We first show trends in pedestrian and cyclist fatalities per capita from 1990 to 2014 for 11 major OECD countries on 4 continents to provide a broader context for the narrower analysis of the United States and Germany that follows. Most of the article is devoted to a detailed analysis of changes between 2001–2002 and 2008–2009 in pedestrian and cyclist fatalities and serious injuries per kilometer in the United States and Germany, disaggregated by the same 4 age groups used in both countries' national travel surveys: 5 to 14, 15 to 24, 25 to 64, and 65 years and older. We focused on the United States and Germany because their 2 most recent national travel surveys are almost identical in methodology and timing, and because their data on fatalities and serious injuries are comparably defined.[12] The 2 countries are similar in other respects as well: high per-capita incomes, high rates of car ownership, nearly identical rates of driver licensing, extensive high-quality road networks, and similarly advanced systems of emergency medical care, both at the crash site

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and in hospitals.[12–14] As noted in the Discussion section, however, there are large differences in government policies toward walking and cycling, thus highlighting the importance of public policies in improving pedestrian and cyclist safety.

METHODS

For annual data on pedestrian and cyclist fatalities, we used the official national traffic fatality data reported by each member country to OECD, which expresses them as annual totals as well as per-capita rates to enable comparison among countries of different sizes.[1] For almost all countries, the fatalities include deaths occurring within 30 days of the injury. The OECD's fatality statistics are based on police reports, which underestimate pedestrian and cyclist fatalities, as noted in our discussion of data limitations later in this article.[1,15] Because only a few countries have alternative sources of fatality data, we used the OECD data to ensure the same definition of traffic fatalities and the same reporting method for all countries. Upon special request by the authors, OECD provided fatality data disaggregated by mode of travel (e.g., pedestrian vs cyclist) and by age group (5 to 14, 15 to 24, 25 to 64, and ≥65 y).[16] For per-capita comparisons, we used the OECD's estimates of fatalities per 100 000 population, based on fatality and population data provided by countries to the OECD.

Especially in countries with low cycling levels, cyclist fatalities can fluctuate widely from year to year because of small numbers. To smooth out fluctuations and provide more reliable estimates, we calculated 5-year annual averages of fatalities per 100 000 population for both cyclists and pedestrians: 1990–1994, 1995–1999, 2000–2004, 2005–2009, 2010–2014. We only used the OECD data since 1990 to include Germany, which was reunified in 1990.

To focus on trends since 1990, we showed all per-capita fatality rates relative to the base period of 1990–1994. This also controlled indirectly (albeit imperfectly) for the very different levels of walking and cycling in the various countries. Expressing per capita rates relative to 1990 avoids the unfair comparison of countries with different walking and cycling levels and focuses instead on the degree of improvement in each country since 1990. It is only possible to calculate per-kilometer fatality rates for a few countries with reliable exposure data from comparable travel surveys, which explains the widespread use of per-capita rates by international organizations (such as OECD) to compare traffic safety among many countries.

Whereas the per-capita data are based on population-level numbers, the per-kilometer rates require sample estimates from national travel surveys to calculate exposure levels. The samples from such surveys are scaled up to the population level by using representative weights. In our analysis, we calculated total kilometers walked and cycled—by age group and in total—over roughly the decade of 2000 to 2010 (slightly different survey years) for the United States, Germany, the United Kingdom, the Netherlands, and Denmark.[17–21] We divided those exposure levels into the 5- or 6-year annual average pedestrian or cyclist fatalities for the period bracketing each country's survey years: the 2 years before, during, and after the US and German surveys (which were both conducted over a 2-year period), and the 2 years before, during, and after the UK, Dutch, and Danish surveys (1-year survey period).

It was only possible to calculate confidence intervals for the United States and Germany. The authors had access to the micro data sets for both of their travel surveys, thus enabling calculation of confidence intervals and a *t* test of the statistical significance of differences between the countries and over time. As shown in Table A in Appendix A (available as a supplement to the online version of this article at http://www.ajph.org), the US and German travel surveys are highly comparable, using the same methodology and timing (2001–2002 and 2008–2009). Access to the micro data sets for the United Kingdom, the Netherlands, and Denmark was denied to the authors, and the agencies that conducted the surveys were not willing to calculate the standard deviations of estimates necessary for our analysis.

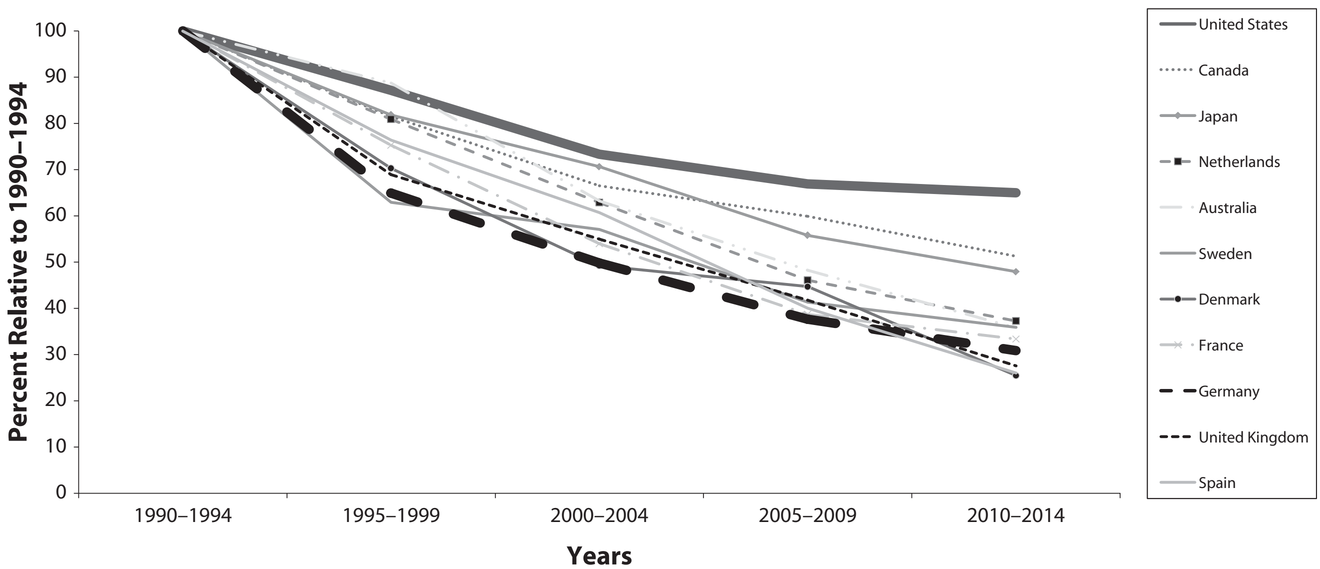
Moreover, the British, Dutch, and Danish surveys used slightly different age categories and survey years than those of the US and German surveys. Thus, the remainder of this article focuses on the United States and Germany. Nevertheless, we include Figures A and B in Appendix B, available as a supplement to the online version of this article at http://www.ajph.org, for readers who are interested in the 5-country comparison of fatality rates per kilometer, even though data for the United Kingdom, the Netherlands, and Denmark do not permit calculation of confidence intervals, and thus do not enable firm conclusions about statistical significance.

This article's comparison of severe pedestrian and cyclist injury rates per kilometer is limited to the United States and Germany for the same reason. In addition, the United Kingdom, the Netherlands, and Denmark had definitions of severe injuries that were not exactly comparable to those used in the United States and Germany (overnight hospitalization), but instead included lists of specific kinds of injuries categorized as serious, often in combination with the hospitalization criterion.[1] For both the United States and Germany, we calculated 2-year annual averages of serious injuries because both of their travel surveys were over the same 2-year periods.

There is one difference in the severe injury data in the United States and Germany. The German data are population-level numbers, based on comprehensive, nationwide collection of police reports combined with hospital reports on the status of patients.[22] The US data are sample estimates from the Centers for Disease Control and Prevention's (CDC's) WISQARS injury database derived from hospital reports and not police reports.[23] The CDC uses representative weights to scale up the sample results to population levels. Thus, the US ratios of serious injuries to kilometers walked or cycled are sample estimates of injuries divided by sample estimates of kilometers traveled. The German ratio is the population-level number of injuries divided by a sample estimate of kilometers traveled. Appendix C (available as a supplement to the online version of this article at http://www.ajph.org) provides details of the methodology used to calculate fatality and injury rates, confidence intervals, and a *t* test of statistical significance.

RESULTS

Figures 1 and 2 show trends in pedestrian and cyclist fatality rates per 100 000

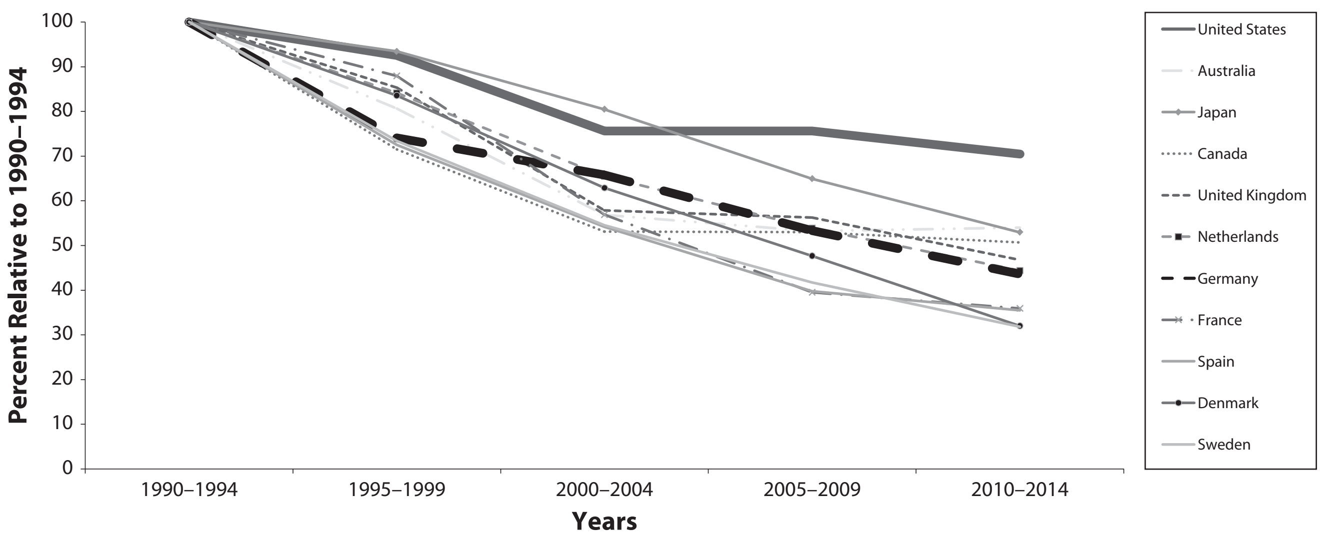


Note. For comparison, the 1990–1994 average was set at 100%.
Source. Calculated by the authors on the basis of data from the Organisation for Economic Cooperation and Development.[16]

FIGURE 1—Trend in Pedestrian Fatality Rate per 100 000 Population 1990–2014, 5-Year Annual Averages Relative to 1990–1994 Average

population in the United States, Canada, Australia, Japan, the United Kingdom, the Netherlands, Sweden, Denmark, Germany, France, and Spain. Both the fatality and population data on which the rates are based are population-level numbers and not sample estimates. Rates are shown as 5-year annual averages for 5 periods, with those average rates expressed relative to the average for the base period of 1990–1994.

Without exception, all 11 countries succeeded in reducing pedestrian and cyclist fatality rates per capita between the periods of 1990–1994 and 2010–2014. By far, the least progress has been made in the United States. Its pedestrian fatality rate per capita fell by 35% compared with 49% in Canada, 52% in Japan, and 63% to 75% in Australia and the 7 Western European countries. Similarly, the cyclist fatality rate in the United States fell by 30% compared with 46% in Australia, 47% in Japan, 49% in Canada, and by 53% to 68% in Western Europe. These per-capita rates do not adjust for changes in walking and cycling



Note. For comparison, the 1990–1994 average was set at 100%.
Source. Calculated by the authors on the basis of data from the Organisation for Economic Cooperation and Development.[16]

FIGURE 2—Trend in Cyclist Fatality Rate per 100 000 Population 1990–2014, 5-Year Annual Averages Relative to 1990–1994 Average

levels over time, but the large percentage reductions suggest improvement in walking and cycling safety.

Table 1 shows pedestrian and cyclist fatality rates per 100 million kilometers walked and biked in the United States and Germany for 2001–2002 and 2008–2009, disaggregated by the same 4 age groups in each country: 5 to 14, 15 to 24, 25 to 64, and 65 years and older. In both survey periods, fatality rates in the United States were significantly higher than in Germany for all age groups ($P < .05$). In 2008–2009, for the population as a whole, pedestrian fatality rates in the United States were about 5 times higher than in Germany (9.7 vs 1.9) and more than 3 times higher for cyclists (4.7 vs 1.3).

There is, however, much variation among age groups. The fatality rate for senior pedestrians is roughly twice as high as for the population as a whole in both the United States (21.5 vs 9.7) and Germany (3.8 vs 1.9). Similarly, the fatality rate for senior cyclists is much higher than average in both the United States (7.6 vs 4.7) and Germany (4.2 vs 1.3). By comparison, children have much lower fatality rates per kilometer walked than the population as a whole in both countries: 2.9 versus 9.7 (United States) and 0.9 versus 1.9 (Germany). Children have slightly lower fatality rates per 100 million kilometers cycled: 4.1 versus 4.7 (United States) and 0.9 versus 1.3 (Germany). In both the United States and Germany, fatality rates per 100 million kilometers declined for both pedestrians and cyclists and among all age groups from 2001–2002 to 2008–2009. The declines were statistically significant except for German pedestrians aged 15 to 24 years and 25 to 64 years—for which rates fell only slightly—and for US pedestrians and cyclists aged 15 to 24 years and 65 years and older, 2 age groups with small sample sizes in the National Household Travel Survey.[18]

As already noted, we could not calculate confidence intervals for fatality rates per 100 million kilometers estimated for the Netherlands, Denmark, and the United Kingdom. For their populations as a whole, however, the fatality rates for the Netherlands and Denmark are so low, and their levels of walking and cycling are so high (yielding large sample sizes),[24] that the estimated rates are almost certainly statistically significantly lower than those for the United States. For example, for all age groups combined, the estimated pedestrian fatality rate per 100 million kilometers in 2010 was 1.2 in the Netherlands and 2.5 in Denmark, compared with 9.7 in the United States (Figure A in Appendix B). Similarly, the estimated cyclist fatality rate in 2010 was 1.0 in the Netherlands and 1.1 in Denmark, compared with 4.7 in the United States (Figure B in Appendix B). The corresponding rates for the United Kingdom in 2010 were 2.7 for walking and 2.5 for cycling, also much lower than in the United States. These estimates suggest that the United States has, by far, the most dangerous walking and cycling among the 5 countries. We can only report with 95% statistical confidence, however, that walking and cycling fatality rates per kilometer are much higher in the United States than in Germany.

Confirming the importance of injuries, the number of severe pedestrian and cyclist injuries (requiring overnight hospitalization) far exceeds the number of fatalities. In 2008–2009, the ratio of severe injuries to fatalities for pedestrians was 8 to 1 in the United States and 13 to 1 in Germany. The ratio is many times higher for cycling: 44 to 1 in the United States and 34 to 1 in Germany.

As shown in Table 2, the rate of serious pedestrian injuries per 100 million kilometers in the United States rose significantly from 70.4 in 2001–2002 to 72.9 in 2008–2009 ($P < .05$). In Germany, the rate fell from 29.4 to 24.4 ($P < .05$). The rate of serious cyclist injuries fell from 230.5 to 207.1 in the United States ($P < .05$), and from 47.2 to 44.2 in Germany (but not significantly at $P < .05$). For their populations as a whole, the rate of severe pedestrian injuries in 2008–2009 was 3.0 times higher in the United States than in Germany, and the rate of severe cyclist injuries was 4.7 times higher in the United States. As with fatalities, however, there is variation among the 4 age groups. Most striking for the United States is the high severe injury rate for senior pedestrians, almost twice the national average (131.4 vs 72.9). Moreover, that rate rose significantly from 2001–2002 to 2008–2009 ($P < .05$). Similarly, the

TABLE 1—Pedestrian and Cyclist Fatality Rates per 100 Million Kilometers Walked or Cycled: United States and Germany, 2000–2001 and 2008–2009

	Pedestrian Fatality Rates per 100 Million km Walked (95% CI)		Cyclist Fatality Rates per 100 Million km Cycled (95% CI)	
Age Group	2001–2002	2008–2009	2001–2002	2008–2009
5–14 y				
United States	4.4[a] (4.1, 4.7)	2.9[a] (2.6, 3.2)	5.9[a] (5.3, 6.7)	4.1[a] (3.6, 4.8)
Germany	1.2[a] (1.1, 1.4)	0.9[a] (0.8, 1.0)	1.3[a] (1.1, 1.6)	0.9[a] (0.7, 1.0)
15–24 y				
United States	11.9 (8.8, 18.3)	9.6 (8.6, 10.8)	10.0 (4.2, 15.8)	4.2 (3.1, 6.6)
Germany	2.1 (1.8, 2.5)	2.0 (1.8, 2.2)	1.0[a] (0.9, 1.3)	0.6[a] (0.5, 0.7)
25–64 y				
United States	13.2[a] (13.1, 13.3)	9.6[a] (9.5, 9.7)	6.9[a] (6.7, 7.1)	4.7[a] (4.4, 5.0)
Germany	1.2 (1.1, 1.3)	1.1 (1.0, 1.2)	1.4[a] (1.2, 1.6)	0.9[a] (0.8, 0.9)
≥ 65 y				
United States	23.9 (23.2, 24.7)	21.5 (13.6, 51.2)	11.2 (10.1, 12.5)	7.6 (2.8, 12.4)
Germany	6.4[a] (5.8, 7.1)	3.8[a] (3.6, 4.0)	7.3[a] (6.1, 9.1)	4.2[a] (4.0, 4.4)
All				
United States	11.6[a] (11.5, 11.7)	9.7[a] (9.6, 9.8)	6.8[a] (6.8, 6.9)	4.7[a] (4.7, 4.7)
Germany	2.6[a] (2.4, 2.7)	1.9[a] (1.7, 2.0)	2.0[a] (1.8, 2.2)	1.3[a] (1.2, 1.5)

Note. CI = confidence interval. Differences in fatality rates between the United States and Germany were statistically significant ($P < .05$) for all age groups and both survey periods.

Source. Calculated by the authors on the basis of data from the Organisation for Economic Co-operation and Development, the US Department of Transportation, and the German Federal Ministry of Transport.[16–18]

[a]These estimates indicate a statistically significant ($P < .05$) change between 2001–2002 and 2008–2009.

TABLE 2—Pedestrian and Cyclist Serious Injury Rates per 100 Million Kilometers Walked or Cycled: United States and Germany, 2000–2001 and 2008–2009

	Pedestrian Injury Rates per 100 Million km Walked (95% CI)		Cyclist Injury Rates per 100 Million km Cycled (95% CI)	
Age Group	2001–2002	2008–2009	2001–2002	2008–2009
5–14 y				
United States	84.5[a] (82.3, 86.7)	66.5[a] (64.0, 69.0)	392.9[a] (387.2, 398.6)	415.7[a] (408.6, 422.8)
Germany	73.2 (64.9, 83.9)	74.8 (67.6, 83.7)	63.0 (53.6, 76.5)	55.9 (47.8, 67.3)
15–24 y				
United States	76.2 (72.3, 80.1)	79.1 (75.7, 82.4)	305.2[a] (285.9, 326.7)	176.0[a] (170.5, 181.6)
Germany	33.5 (28.7, 40.2)	32.5 (29.7, 35.7)	46.7[a] (39.7, 56.7)	36.4[a] (32.4, 41.7)
25–64 y				
United States	62.2 (59.6, 64.7)	61.8 (60.1, 63.5)	141.5[a] (137.0, 145.9)	156.5[a] (152.7, 160.2)
Germany	16.8[a] (15.2, 18.7)	14.3[a] (13.3, 15.6)	38.8 (33.6, 46.1)	38.2 (35.0, 42.1)
≥ 65 y				
United States	98.6[a] (91.9, 105.2)	131.4[a] (126.6, 136.2)	351.3[a] (312.3, 390.3)	337.3[a] (308.2, 368.4)
Germany	43.7[a] (39.8, 48.5)	30.4[a] (28.7, 32.1)	77.1 (64.5, 95.9)	68.5 (65.6, 71.7)
All				
United States	70.4[a] (69.0, 71.7)	72.9[a] (71.7, 74.1)	230.5[a] (228.1, 232.8)	207.1[a] (204.5, 209.6)
Germany	29.4[a] (27.8, 31.3)	24.4[a] (22.7, 26.4)	47.2 (43.0, 52.3)	44.2 (40.4, 48.8)

Note. CI = confidence interval. Differences in serious injury rates between the United States and Germany were statistically significant ($P < .05$) for all age groups and both survey periods, except for child pedestrians.

Source. Calculated by the authors on the basis of data from the Centers for Disease Control and Prevention, the German Federal Office of Statistics, the US Department of Transportation, and the German Federal Ministry of Transport.[17,18,22,23]

[a]These estimates indicate a statistically significant ($P < .05$) change between 2001–2002 and 2008–2009.

severe injury rate for cyclists in 2008–2009 in the United States was much higher for children (415.7) and seniors (337.3) than the national average (207.1). The rate for children rose significantly over the decade, from 392.9 to 415.7 ($P < .05$). The rate for seniors fell slightly (from 351.3 to 337.3), but not statistically significantly.

In Germany, child pedestrians in 2008–2009 had a walking injury rate 3 times as high as the national average (74.8 vs 24.4), even higher than the rate for children in the United States (66.5), the only instance in Table 2 in which the serious injury rate in Germany is higher than that in the United States. By comparison, the serious injury rate for senior pedestrians in Germany in 2008–2009 was only slightly higher than the national average (30.4 vs 24.4), and less than a fourth the rate for seniors in the United States (131.4). There is less variation among age groups in cycling injury rates in Germany than in the United States, but children (55.9) and senior (68.5) cyclists have higher rates than the national average (44.2). It is noteworthy that the injury rate for child cyclists in the United States in 2008–2009 was more than 7 times higher than in Germany (415.7 vs 55.9) and that the rate for senior cyclists was 5 times higher in the United States than in Germany (337.3 vs 68.5).

DISCUSSION

In all 11 countries shown in Figures 1 and 2, pedestrian and cyclist fatality rates per capita fell between 1990 and 2014, but the smallest reductions were in the United States. Moreover, fatality rates per kilometer in 2010 were much higher in the United States than in Germany, the Netherlands, Denmark, and the United Kingdom. Serious injury rates per kilometer were also much higher in the United States than in Germany, the 2 countries with comparable injury data.

One possible explanation for greater pedestrian and cycling safety in northern European countries is the far more extensive and better quality walking and cycling infrastructure in Europe.[12,25–30] In contrast with the United States, many northern European cities have extensive auto-free zones in much of their centers; most neighborhood streets traffic-calmed with speed limits of 30 kilometers per hour (20 miles per hour) or less; sidewalks on both sides of almost every street; pedestrian refuge islands for crossing wide streets; clearly marked crosswalks, often raised and with special lighting; and pedestrian signals at intersections and midblock crosswalks with ample crossing times. Facilitating safe and convenient cycling, many northern European cities have extensive systems of separate bikeways, both on-road and off-road, often including priority traffic signals and advance stop lines for cyclists at intersections.[25,31] US cities only began building separate bike facilities in the 1990s, and, even currently, they lag far behind northern European cities in the extent, quality, and integration of their bikeways.[8,13,14,24,31,32]

In addition to better infrastructure, some European countries provide mandatory traffic education in schools—to teach safe walking and cycling skills—and require far stricter motorist training and licensing than in the United States.[25] Further promoting traffic safety, police enforcement of traffic regulations is much stricter in northern Europe, both for motorists and nonmotorists.[25]

Although pedestrian and cyclist safety is much higher in Germany than in the United States, fatality rates per kilometer fell significantly in both countries for their populations as a whole between 2001–2002 and 2008–2009, the 2 periods of their most recent national travel surveys. By comparison, severe injury rates per kilometer fell significantly only for German pedestrians, while the severe injury rate for US pedestrians rose. Injury rates for both German and US cyclists fell slightly, but only statistically significantly in the United States. In short, there has been more improvement in reducing walking and bicycling fatalities than serious injuries, which greatly exceed the number of fatalities.

Moreover, there is important and statistically significant variation in both fatality and injury rates among the 4 age groups examined in the United States and Germany. Senior pedestrians and cyclists have 2 to 3 times as high a fatality rate per kilometer than the population as a whole. Seniors in the

United States also have much higher walking and cycling injury rates than the population as whole, but US children have an even higher cycling injury rate than seniors. In Germany, children have, by far, the highest walking injury rate—3 times the national average—and children and seniors both have cycling injury rates higher than the national average. Our analysis confirms the special vulnerability of seniors and children when walking and cycling.

The falling per-capita fatality rates in the United States and Germany from 1990 to 2014 and falling per-kilometer fatality rates from 2001–2002 to 2008–2009 do not necessarily mean that walking and cycling conditions have been getting safer. The likelihood of fatal injury has fallen, but serious injury rates have fallen less (or increased). The difference in fatality and serious injury trends might be attributable to improved emergency medical technology, both at the site of the incident and at the hospital, thus reducing the percentage of serious injuries resulting in death. Our findings are consistent with those of the annual OECD reports on overall traffic safety trends, which find that traffic fatalities per capita have declined more than serious injuries from 2000 to 2014 in member countries for which both fatality and serious injury data are available.[1]

The unknown degree of reliability and comparability of the fatality and injury data fundamentally limit the conclusions that can be drawn from the analysis. Police reports understate total pedestrian and cyclist fatalities because they only include traffic crashes on public roadways.[1,15] For example, the CDC's hospital-based statistics on pedestrian and cyclist fatalities in the United States from 1999 to 2014 averaged 16% higher for cyclists and 21% higher for pedestrians than police-reported fatalities.[1,23,33] Similarly, in the Netherlands, hospital fatality data from 1996 to 2014 were 11% higher than police data for pedestrians and 18% higher for cyclists.[1] In short, it is likely that the calculated fatality rates are underestimates for all countries. In addition, the serious injury data for the United States and Germany are only partly comparable. They both rely on the same criterion of an overnight hospital stay, but the US injury data (from CDC) are derived from a representative sample of hospital reports, whereas the German data are collected through a comprehensive national canvassing of coordinated police and hospital reports.[22,23]

There is yet another reason to interpret the fatality and injury statistics with caution. They do not control for differences in where and how walking and cycling take place. Because the vast majority of pedestrian and cyclist fatalities are attributable to collisions with motor vehicles, roadways are the most lethal environment for walking and cycling.[1,2,7,26] Walking and cycling are safer on completely separate off-road facilities, such as mixed-use recreational paths, or in car-free zones, traffic-calmed residential streets (with slower speeds and less traffic), and physically separated on-street facilities (such as cycle tracks).[11,28,30,32,34,35] Thus, the provision of more and better separate facilities is a key to improving overall walking and cycling safety. Such facilities are especially important for children and seniors, who are most likely to be killed or seriously injured if hit by a motor vehicle.[1,2,4,7,26] AJPH

CONTRIBUTORS

J. Pucher initiated the research and led the writing of the article. R. Buehler had primary responsibility for the data analysis and created the tables and figures. Both authors conceptualized the analysis and guided the study design and data analysis. Both authors participated in interpreting the findings and reviewing successive drafts of the article.

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HUMAN PARTICIPANT PROTECTION

The analysis was based on statistical data sets and did not require human participants.

REFERENCES

1. *Road Safety Annual Report 2016*. Organisation for Economic Cooperation and Development, International Transport Forum, International Traffic Safety, Datam and Analysis Division. 2016. Available at: http://dx.doi.org/10.1787/irtad-2016-en. Accessed November 9, 2016.

2. *Global Status Report on Road Safety 2015*. Geneva, Switzerland: World Health Organization; 2015.

3. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services; 1996.

4. McDonald N. Children and cycling. In: Pucher J, Buehler R, eds. *City Cycling*. Cambridge, MA: MIT Press; 2012: 235–255.

5. Buehler R, Götschi T, Winters M. Moving toward active transportation: how policies can encourage walking and bicycling. *Active Living Research: Research Brief and Synthesis*. 2016. Available at: http://activelivingresearch.org/sites/default/files/ALR_Review_ActiveTransport_January2016.pdf. Accessed September 12, 2016.

6. Pucher J, Dill J, Handy S. Infrastructure, programs, and policies to increase bicycling: an international review. *Prev Med*. 2010;50(suppl 1):S106–S125.

7. *Pedestrian Safety: A Road Safety Manual for Decision-Makers and Practitioners*. World Health Organization. 2013. Available at: http://www.who.int/roadsafety/projects/manuals/pedestrian/en. Accessed November 9, 2016.

8. *Bicycling and Walking in the United States: 2016 Benchmarking Report*. Alliance for Biking and Walking. 2016. Available at: http://www.bikewalkalliance.org/resources/benchmarking. Accessed November 9, 2016.

9. Jacobsen PL, Ragland DR, Komanoff C. Safety in numbers for walkers and bicyclists: exploring the mechanisms. *Inj Prev*. 2015;21(4):217–220.

10. Bassett DR Jr, Pucher J, Buehler R, Thompson DL, Crouter SE. Walking, cycling, and obesity rates in Europe, North America and Australia. *J Phys Act Health*. 2008;5(6):795–814.

11. Sanford T, McCulloch CE, Callcut RA, Carroll PR, Breyer BN. Bicycle trauma injuries and hospital admissions in the United States, 1998–2013. *JAMA*. 2015;314(9):947–949.

12. Buehler R, Pucher J, Merom D, Bauman A. Active travel in Germany and the US: contributions of daily walking and cycling to physical activity. *Am J Prev Med*. 2011;41(3):241–250.

13. Pucher J, Dijkstra L. Making walking and cycling safer: lessons from Europe. *Transp Q*. 2000;54(3):25–50.

14. Pucher J, Dijkstra L. Promoting safe walking and cycling to improve public health: lessons from The Netherlands and Germany. *Am J Public Health*. 2003;93(9):1509–1516.

15. Lusk AC, Asgarzadeh M, Farvid MS. Database improvements for motor vehicle/bicycle crash analysis. *Inj Prev*. 2015;21(4):221–230.

16. International comparison of cyclist and pedestrian traffic fatalities and fatality rates per 100,000 population by age group. In: *IRTAD Road Safety Database*. Paris, France: Organisation for Economic Cooperation and Development, International Transport Forum, International Traffic Safety Data and Analysis Division; 2016.

17. *German National Household Travel Survey (MID), 2001–2002 & 2008–2009*. German Federal Ministry of Transport. 2010. Available at: http://www.mobilitaet-in-deutschland.de. Accessed November 9, 2016.

18. *National Household Travel Survey (NHTS), 2001–2002 & 2008–2009*. US Department of Transportation. 2010. Available at: http://nhts.ornl.gov/index.shtml. Accessed November 9, 2016.

19. *Dutch National Travel Survey*. Institute for Road Safety Research. 2016. Available at: https://www.swov.nl/UK/Research/cijfers/Toelichting-gegevensbronnen/Personenmobiliteit-UK.html. Accessed November 9, 2016.

20. Average distance travelled and average number of trips by age, and mode: 2002, 2003, 2010, and 2014. In: *National Travel Survey*. Department for Transport. 2016. Table NTS0605. Available at: https://www.gov.uk/government/collections/national-travel-survey-statistics. Accessed November 9, 2016.

21. Hansen AS, Jensen C. Traffic safety 2007–2010. In: *DTU Transport Report*. 4. Technical University of Denmark. 2012;4. Available at: http://www.dtu.dk/nyheder/2012/04/webnyhed_ny-rapport-om-risiko-i-trafikken?id=5f4912c7-dd9a-4aba-a23d-cfe540746bbc. Accessed November 9, 2016.

22. Severe traffic injuries in Germany 1991–2014. In: *Traffic Safety in Germany*. German Federal Statistical Office. 2015. Table 5.6.3. Available at: https://www.destatis.de/DE/Publikationen/Thematisch/TransportVerkehr/Verkehrsunfaelle/VerkehrsunfaelleZeitreihen.html. Accessed November 9, 2016.

23. Web-based Injury Statistics Query and Reporting System (WISQARS). Centers for Disease Control and Prevention, Injury Data and Statistics Division. 2016. Available at: https://www.cdc.gov/injury/wisqars. Accessed November 9, 2016.

24. Buehler R, Pucher J, Gerike R, Goetschi T. Reducing car dependence in the heart of Europe: lessons from Germany, Austria, and Switzerland. *Transp Rev*. 2017;37(1):4–28.

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

26. *Achieving Traffic Safety Goals in the United States: Lessons From Other Nations*. Transportation Research Board. 2011. TRB Special Report 300. Available at: http://onlinepubs.trb.org/onlinepubs/sr/sr300.pdf. Accessed November 9, 2016.

27. Making urban mobility greener and safer. In: *State of European Cities in 2016*. UN Habitat and European Union. 2016: 112–137. Available at: http://ec.europa.eu/regional_policy/en/information/publications/reports/2016/state-of-european-cities-report-2016. Accessed November 9, 2016.

28. Hass-Klau C. *The Pedestrian and the City*. New York, NY: Routledge; 2015.

29. Newman P, Kenworthy J. *The End of Automobile Dependence: How Cities Are Moving Beyond Car-Based Planning*. Washington, DC: Island Press; 2015.

30. Teschke K, Harris MA, Reynolds CC, et al. Route infrastructure and the risk of injuries to bicyclists: a case-crossover study. *Am J Public Health*. 2012;102(12):2336–2343.

31. Lanzendorf M, Busch-Geertsema A. The cycling boom in large German cities—empirical evidence for successful cycling campaigns. *Transp Policy*. 2014;36(C):26–33.

32. Furth PG. Bicycling infrastructure for mass cycling: a trans-Atlantic comparison. In: Pucher J, Buehler R, eds. *City Cycling*. Cambridge, MA: MIT Press; 2012: 105–140.

33. *Traffic Safety Facts 2013: A Compilation of Motor Vehicle Crash Data From the Fatality Analysis Reporting System and the General Estimates System*. US Department of Transportation, National Highway Traffic Safety Administration. 2013. Available at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812139. Accessed November 9, 2016.

34. Lusk AC, Furth PG, Morency P, Miranda-Moreno LF, Willett WC, Dennerlein JT. Risk of injury for bicycling on cycle tracks versus in the street. *Inj Prev*. 2011;17(2):131–135.

35. Lusk AC, Morency P, Miranda-Moreno LF, Willett WC, Dennerlein JT. Bicycle guidelines and crash rates on cycle tracks in the United States. *Am J Public Health*. 2013;103(7):1240–1248.