American Journal of
Preventive Medicine

RESEARCH ARTICLE

Disparities in Activity and Traffic Fatalities by Race/Ethnicity

Matthew A. Raifman, MPP,[1] Ernani F. Choma, PhD[2]

Introduction: Traffic fatalities remain a major public health challenge despite progress made during recent decades. This study develops exposure-based estimates of fatalities per mile traveled for pedestrians, cyclists, and light-duty vehicle occupants and describes disparities by race/ethnicity, including a subanalysis of fatality rates during darkness and in urban areas.

Methods: Estimates of person-miles traveled by mode and race/ethnicity group were derived from the 2017 National Household Travel Survey using replicate weights. Three-year average (2016–2018) traffic fatalities were measured by mode and race/ethnicity group with the U.S. Fatality Analysis Reporting System. Fatality rates per mile traveled and CIs were calculated for each subgroup as well as separately for trips occurring during darkness and in urban areas. Analysis was conducted in 2021–2022.

Results: Exposure to traffic fatality differs by race/ethnicity group and by mode, indicating that adjustment for differential exposure is needed when estimating disparities. The authors find that fatality rates per 100 million miles traveled are systematically higher for Black and Hispanic Americans for all modes and notably higher for vulnerable modes (e.g., Black Americans died at more than 4 times the rate for White Americans while cycling, 33.71 [95% CI: 21.84, 73.83] compared with 7.53 [95% CI: 6.64, 8.69], and more than 2 times the rate while walking, 40.92 [95% CI: 36.58, 46.44] compared with 18.77 [95% CI: 17.30, 20.51]). Previous estimates that do not adjust for differential exposure may underestimate disparities by race/ethnicity. Observed disparities remained when considering only urban areas and appear to be exacerbated during darkness.

Conclusions: Traffic fatalities are a substantial and preventable public health challenge in America. Black and Hispanic Americans have higher traffic fatality rates per mile traveled than White Americans across the transportation system, requiring urgent attention.

INTRODUCTION

Reducing the rate of deaths attributable to vehicle crashes in the U.S. in the 20th century has been heralded as one of the top achievements in public health.[1] Although the fatality rate per vehicle miles traveled has fallen over the past 20 years for vehicle occupants (although notably elevated in 2020 and 2021[2]), a troubling pattern of increasing fatalities has developed over the same period for vulnerable road users, namely pedestrians and cyclists.[3,4] Equally concerning is the potential that the risk of traffic fatality may be higher for people of color.

Initial academic and policy analyses are suggestive of disparities by race/ethnicity in traffic fatality counts per population. A study covering the 2015−2019 period found that all-mode traffic fatalities were higher for

From the [1]Department of Environmental Health, Boston University School of Public Health, Boston, Massachusetts; and [2]Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, Massachusetts

Address correspondence to: Matthew Raifman, MPP, Department of Environmental Health, Boston University School of Public Health, 715 Albany Street, Boston MA 02215. E-mail: mraifman@bu.edu.

0749-3797/$36.00

https://doi.org/10.1016/j.amepre.2022.03.012

American Indian and Black Americans than for White and were lowest for Asian Americans.[5] Even when fatality rates change over time, disparities by race/ethnicity persist.[6] The authors note that disparities in traffic fatalities by race/ethnicity would be consistent with a broader transportation system that exhibits racial bias, from the effects of road placement,[7−10] to underinvestment in alternative modes and transit,[11−13] to disproportionate traffic stops,[14−16] to passenger−driver pairing in ride-hail applications,[17] and to potential bias in the travel demand models used to forecast impacts of investments.[18]

Although existing evidence is suggestive of disparities in fatality rate by race/ethnicity, no national analysis to date has explored race/ethnicity disparities using an activity-based method that accounts for differential exposure. Fatality count comparisons ignore exposure altogether, and population-adjusted measures implicitly assume that activity levels per capita are the same for all race/ethnicity groups. The collaborative works of Pucher and Buehler have shown the potential to construct exposure-based measures of fatalities per mile traveled using national transportation activity surveys, including a recent analysis comparing changes in walking and cycling fatality rates between the U.S. and European nations over the 1990–2018 period.[19−22] To address this gap, the authors estimate disparities in fatality rates per person-mile traveled by race/ethnicity separately for pedestrians, cyclists, and light-duty vehicle occupants, with potential implications for the prioritization of transport infrastructure investment and policy making.

METHODS

Study Sample

The authors estimate annual average fatality incidence rates per 100 million person-miles traveled using fatality counts from the Fatality Analysis Reporting System (FARS) and person-miles traveled estimates from the National Household Travel Survey (NHTS)[23,24] for walking, bicycle, and light-duty vehicle modes and 4 race/ethnicity groups—non-Hispanic White, non-Hispanic Black, Asian (non-Hispanic/unknown), and Hispanic—in accordance with the classification guidelines from the Office of Management and Budget.[25] The authors use the nomenclature *all* to denote estimates for all person-miles traveled regardless of time of the day or geography. In secondary analyses, fatality incident rates by race/ethnicity and mode are estimated for person-miles traveled (1) during *darkness* (darkness), defined as the time period between dawn and dusk on the basis of evening and morning nautical twilight times (Appendix S1, available online), and (2) in ^{urban} *areas* (urban), defined as metropolitan statistical areas with a population over 1 million in 2017[26] (Appendix S2, available online). Analyses are done on a national level, and results are reported for the entire U.S.

Measures

The authors define *exposure* as person-miles traveled (PMT), which was estimated using publicly available, deidentified trip-level data from the 2017 NHTS.[24] The 2017 NHTS is the most recent nationally representative travel-diary survey of transportation activity in the U.S; recent previous NHTS surveys occurred in 2009, 2001, and 1995. The authors generated a central estimate of PMT by mode and race/ethnicity using the full sample base weights and SEs using the jackknife replicate base weights (G=98 replicates).

Several alternative measures of exposure to traffic fatality have been considered in the literature, including per capita, vehicle miles traveled, travel time, and person trips. McAndrews et al.[27] (2013) offer a useful comparison of the merits of travel-based measures over population measures within the context of the state of Wisconsin, concluding that person trips are a less applicable measure for cycling and walking than distance-based exposure because it assumes uniform trip distance when evidence suggests that these trips tend to be shorter than vehicle trips. Some exposure-based traffic fatality analyses based on NHTS data before 2017 used person trips instead of a distance-based measure as a second-best option owing to concern for the validity of self-reported distance data.[28−30] However, in 2017, NHTS transitioned to a Google application programming interface–based shortest routing distance method using either the road or network path between trip origin and destination, thus improving the validity of distance-based estimates in NHTS.[31]

As a statistic, PMT offers a common measure of exposure across all modes. For walking or cycling alone, 1 mile traveled is equivalent to 1-person mile traveled. For a light-duty vehicle with 2 occupants, 2 person-miles traveled would be accrued per 1 vehicle-mile traveled. The primary alternative distance-based measure considered is vehicle-mile traveled, which applies only to motor vehicles and therefore does not capture differential exposure by race/ethnicity group by mode. Although beyond the scope of this analysis, the authors believe that additional research is needed to explore how estimates of race/ethnicity disparities by mode change when different exposure measures are employed.

Trips were excluded when (1) the respondent's ethnicity was not determined (other than for Asian, according to Office of Management and Budget guidelines), (2) the respondent's race was not determined, (3) the respondent identified multiple responses for race, (4) trip mode was missing, (5) trip mileage was missing, and (6) walking trips were more than 30 miles, on the assumption that longer walking trips represent incorrect responses or coding errors. Although rare, walking trips exceeding 30 miles make up 25% of the weighted walking mileage, most of which was attributed to just 5 trips longer than 1,000 miles.[31] All told, 32,637 of 889,320 (3.7%) trips were excluded from the analysis, 98% of which (32,047 of 32,637) because of multiple responses for race (27,515) or owing to race not being determined (4,532).

Unlike the NHTS, the FARS is a census of all vehicle crash fatalities on nonprivate roadways published annually by the National Highway Traffic Safety Administration.[23,32] To address potential year-to-year variance, 3-year averages were constructed for the number of pedestrians, bicyclists, and light-duty vehicle occupants who died on U.S. roads for the years 2016–2018, centered on the NHTS survey year of 2017. FARS data are based on a collaboration between National Highway Traffic Safety Administration and states to gather information on all qualifying fatalities, with race/ethnicity data collected from death certificates. Fatalities occurring among occupants of parked/nonmoving light-duty vehicles (<0.2% of the total) were included. Fatalities that were missing information on race, ethnicity, or both (4%) as well as fatalities that indicated multiple races (0.2%) were excluded. In the analysis for darkness, fatalities with missing crash time (<1%) were also excluded. For both urban and darkness analyses, fatalities where county information was missing (~0.01%) were excluded. Finally, a very small number of fatalities (~0.01%) occurred in unknown truck types, which were excluded from the analysis (Appendix S3, available online, provides the variables used to construct analysis groups).

Statistical Analysis

Central estimates of fatality incidence rate per 100 million PMT for all the 4 race categories and for each of the 3 modes were calculated by dividing the 3-year average fatality count per year by estimated PMT per year. The authors implemented the model in R[33,34] using the R package summarizeNHTS[35] and the raw NHTS data and replicate weights to calculate SEs for each estimate, which were then used to calculate 95% CIs assuming normality (Appendix S5, available online). For secondary analyses, the authors further stratified separately for darkness and urban areas using the same approach.

RESULTS

The authors estimate that 2.9 trillion PMT occurred across the 3 travel modes and race categories considered in this study, of an estimated 4.0 trillion total national PMT in the 2017 NHTS. Light-duty vehicles account for about 99% of PMT in both main and secondary analyses; however, shares of PMT for cycling and walking vary in a relative sense. Walking represents 0.82% of all PMT, whereas cycling represents 0.28%. In urban areas, their respective shares increase to 1.0% and 0.32%, whereas during darkness, walking's share decreases to 0.69%. Estimates of PMT by mode and race/ethnicity are reported in Table 1. We do not report results for cycling during darkness or in urban areas owing to small sample sizes for the PMT estimates (<200 non-Hispanic Black respondents).

The share of mode PMT by race/ethnicity differs from the share of population in the 2020 U.S. Decennial Census, indicating differential exposure.[36] Differential activity by race/ethnicity is most pronounced for cycling, where Black and Hispanic populations have substantially lower shares of modal activity than what we would expect on the basis of population (Table 2). The same pattern is observed for walking and light-duty vehicles, albeit attenuated.

To further illustrate this point, the authors present estimated annual PMT per capita in Table 3. Estimated cycling PMT is almost 4 times as large for White Americans as for Black Americans. Large differences in walking activity by race/ethnicity are observed, particularly during darkness, as well as in light-duty vehicle activity. The authors believe that the differences in estimated PMT per capita by race/ethnicity identified in this study suggest that exposure-based estimates of traffic fatality

Table 1. Person-Miles Traveled (100 Million Miles) by Mode and Race/Ethnicity for Situations Considered

Strata	Person-miles traveled (100 million miles)[a]		
	All	Darkness[b]	Urban[c]
Walking			
Non-Hispanic Black	29 (25, 32)	3 (2.1, 3.8)	21 (18, 25)
Hispanic	40 (37, 44)	5.1 (3.7, 6.4)	29 (26, 31)
Non-Hispanic Asian	17 (14, 19)	2 (1.4, 2.5)	13 (11, 15)
Non-Hispanic White	160 (140, 170)	23 (17, 28)	92 (84, 100)
Cycling			
Non-Hispanic Black	3.5 (1.6, 5.3)		
Hispanic	11 (5.5, 16)		
Non-Hispanic Asian	4.4 (3, 5.8)		
Non-Hispanic White	63 (55, 72)		
Light-duty vehicles			
Non-Hispanic Black	2,800 (2,500, 3,100)	570 (430, 700)	1,800 (1,500, 2,000)
Hispanic	4,800 (4,100, 5,600)	840 (790, 890)	2,800 (2,600, 3,000)
Non-Hispanic Asian	1,200 (1,000, 1,500)	220 (180, 260)	1,000 (800, 1,300)
Non-Hispanic White	20,000 (20,000, 21,000)	3,100 (2,800, 3,400)	9,500 (9,200, 9,800)

Note: 95% CIs are reported in parentheses. Cycling during darkness and in urban areas is not reported owing to small sample size for those strata.
[a]Estimates reported with 2 significant figures.
[b]*Darkness* defined as the local period between dusk and dawn.
[c]*Urban* defined as metropolitan statistical areas with a population of 1 million or larger.

Table 2. The proportion of Total Miles Traveled by Mode Contributed by People With Each Race/Ethnicity Category Considered Compared With the 2020 Decennial Census

Mode	Black, %	Hispanic, %	White, %	Asian, %
Walking	11.4	16.0	61.9	6.6
Cycling	4.1	12.6	74.2	5.2
Light-duty vehicles	9.2	15.9	66.8	4.0
2020 decennial census	12.1	18.7	57.8	5.9

rates are necessary. Previous analyses that normalize by population implicitly assume equal miles traveled per person by race/ethnicity, thereby underestimating the risks to Black and Hispanic Americans as well as disparities in fatality rates.

Finally, fatality incidence rates per 100 million miles traveled were found to vary across mode, race/ethnicity, darkness, and urbanicity (Figure 1, Appendix Table 1). Regardless of race/ethnicity group, estimates of fatality rate were highest for walking, then cycling, and then light-duty vehicles. Estimates for the *all* situation were similar for walking (~10–40 fatalities per 100 million PMT) and cycling (~4–35) and were an order of magnitude smaller for light-duty vehicle occupants (0.2–1.2). Higher fatality rates were observed for walking and light-duty vehicles during darkness; however, walking becomes even less safe than light-duty vehicles during darkness (4–8 times higher fatality rate compared to the *all* situation for walking compared to 2–3 times higher for light-duty vehicles). Finally, fatality rates per 100 million miles tended to be lower for urban settings.

A clear and consistent pattern of disparity in fatality rate per mile traveled by race/ethnicity emerges from the analysis. Regardless of mode, darkness, or urbanicity, Black Americans had the highest fatality rates per mile traveled. This was followed by Hispanics, who typically had higher fatality rates than Whites. By contrast, Asian Americans had fatality rates lower than Whites for all modes in all 3 situations considered. Trip sample size is relatively small for some combinations of race/ethnicity and trip mode, especially for cycling, resulting in high levels of uncertainty in exposure and wide CIs. This precludes the authors from making conclusive comparisons among cycling fatality rates, other than that Black Americans seem to be at a higher risk than Whites. Figure 1 presents these results with 95% CIs; numerical values can be found in Appendix Table 1 (available online).

Examining trips at all times of the day regardless of geography (the *all* situation), fatality rates were higher for vulnerable modes than for light-vehicle vehicles. The fatality rate per mile traveled for non-Hispanic Black Americans was 4.5 times higher while cycling; 2.2 times

Table 3. Estimated Person-Miles Traveled by Race/Ethnicity and Situation Normalized by 2020 U.S. Population

	Estimated annual person-miles traveled per capita (2020 decennial census)[a]		
Strata	All	Darkness[b]	Urban[c]
Walking			
Non-Hispanic Black	72 (63, 81)	7.5 (5.3, 9.6)	53 (45, 61)
Hispanic	65 (60, 70)	8.2 (6, 10)	46 (42, 50)
Non-Hispanic Asian	85 (70, 99)	10 (7.2, 13)	66 (56, 76)
Non-Hispanic White	82 (75, 89)	12 (8.9, 15)	48 (44, 52)
Cycling			
Non-Hispanic Black	8.6 (3.9, 13)		
Hispanic	17 (8.9, 26)		
Non-Hispanic Asian	22 (15, 29)		
Non-Hispanic White	33 (29, 37)		
Light-duty vehicle			
Non-Hispanic Black	7,000 (6,300, 7,700)	1,400 (1,100, 1,800)	4,400 (3,800, 5,000)
Hispanic	7,800 (6,600, 9,000)	1,300 (1,300, 1,400)	4,500 (4,200, 4,900)
Non-Hispanic Asian	6,300 (5,100, 7,400)	1,100 (900, 1,300)	5,200 (4,100, 6,400)
Non-Hispanic White	11,000 (10,000, 11,000)	1,600 (1,400, 1,800)	5,000 (4,800, 5,100)

Note: Cycling during darkness and in urban areas are not reported owing to small sample size for those strata.
[a]Estimates reported with 2 significant figures.
[b]*Darkness* defined as the local period between dusk and dawn.

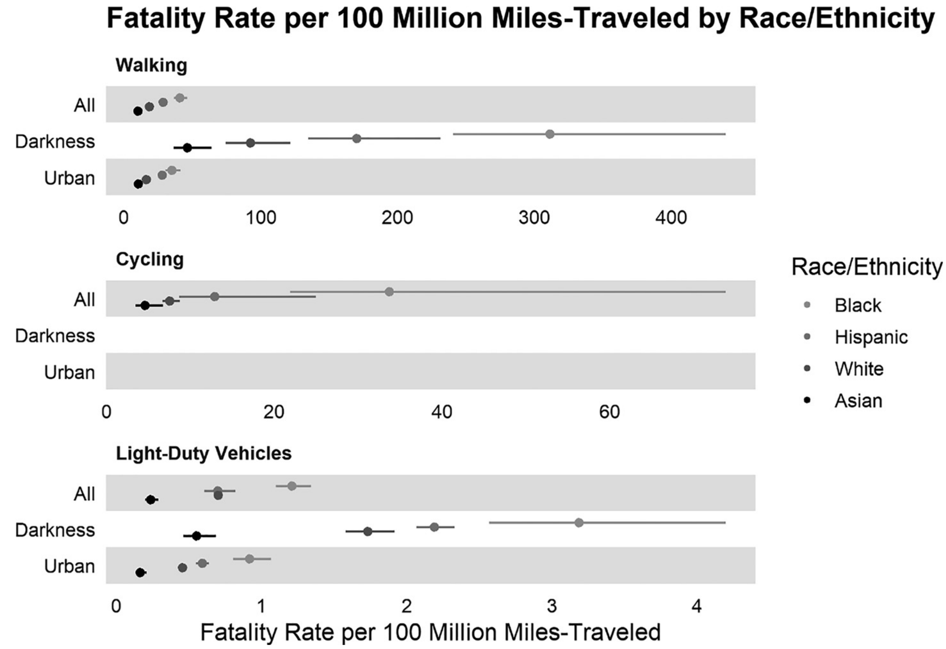

Figure 1. Fatality rate per 100 million miles traveled by race/ethnicity for walking, cycling, and light-duty vehicles and all the 3 situations considered.
Note: Cycling during darkness and in urban areas are not reported owing to small sample size for those strata.

higher while walking; and 1.8 times higher while an occupant was in a light-duty vehicle than for White Americans. A similar pattern was observed for Hispanic Americans for cycling and walking, albeit attenuated.

During darkness, race/ethnicity disparities appear to be exacerbated for walking. The estimated fatality rate of non-Hispanic Black Americans walking rose to 3.4 times that of White Americans. Again, the authors observed a similar pattern of increased fatality risk for Hispanic Americans walking during darkness as for White, although not as severe.

Finally, fatality rates per mile traveled in urban areas are consistently lower, but the pattern of race/ethnicity disparities is similar to the pattern observed in other estimates (owing to the limited sample size in NHTS, which drives the PMT estimates, we do not report results for cycling). Walking fatality rates per 100 million PMT in urban areas is elevated for Black (35.2) and Hispanic (27.9) Americans compared with that for White Americans (16.5), as they are for light-duty vehicles: Hispanic (0.59) and Black (0.92) Americans compared with White Americans (0.45) and Asian Americans (0.16).

DISCUSSION

This analysis suggests that race/ethnicity disparities in traffic fatalities are larger than previously thought after accounting for differential exposure. Disparities persist when the analysis is restricted to urban areas and are exacerbated during darkness.

These updated exposure-based estimates of fatality rate per 100 million PMT by race/ethnicity may be of particular interest to researchers implementing health impact assessments that incorporate traffic fatality rates. The findings are directionally consistent with previous research efforts that showed race/ethnicity disparities in traffic fatality risk per capita; however, it appears that disparities are underreported when not accounting for differential exposure. For example, the authors estimate that fatality rate per mile traveled for Black Americans cycling is 4.5 times the rate for White Americans, whereas a recent per capita analysis that did not account for differential exposure estimated an increased risk of only 1.25 times.[5]

In secondary analyses, the authors considered both time of the day and urbanicity. The findings align with the general understanding that vulnerable road users are at heightened risk of traffic fatality during evening hours.[36] Although public messaging on the risk factors for vulnerable road user fatalities has focused on heightened risk during the 6–9PM period,[37] the approach used in this study employs a moving time range of darkness. The authors believe that this approach is a more appropriate measure of darkness because it accounts for changes in the length of the day by location and season.

For light-duty vehicles and walking, the fatality rate is lower in urban settings. One potential explanation for this could be that all vehicles, especially light-duty vehicles, tend to travel at lower speeds in urban environments. Previous analysis has established that the risk of fatality and severe injury increases considerably with vehicle speed, particularly for vulnerable road users.[38]

The authors believe that these findings, in aggregate, are potential evidence of structural racism in the safety of the transportation sector meriting further causal analysis. Regardless of mode and particularly for walking and cycling, Black and Hispanic Americans are at higher risk of traffic fatality per mile traveled. This analysis is not a causal analysis but rather a descriptive one that highlights these disparities with the hope of catalyzing further research. Possible explanations to consider include systemic underinvestment in pedestrian and cycling infrastructure in communities of color,[39,40] disparities in emergency response,[41] quality of care and outcomes,[42−44] access to medical insurance,[45] and economic constraints. Some have also suggested that disparities in traffic fatalities by race/ethnicity may be the product of risky behavior, for example alcohol consumption.[46] It is notable that liquor stores are disproportionately concentrated in communities of color and may be considered another component of structural racism in society.[47] Furthermore, more recent evidence suggests that the share of pedestrian and cycling fatalities where alcohol is a contributing factor is declining.[48]

Although the authors believe that exposure-based estimates of risk are a more accurate measure of disparity than previous per capita measures because of differential exposure, they also recognize that research should focus on understanding the ways to eliminate disparities in both per capita and exposure-based measures of fatality risk. If only the former is resolved, disparities in fatality risk per mile would remain, whereas if only the latter is resolved, it may indicate disparities in access to transportation given the differences in activity levels by race/ethnicity. Regardless, the authors believe that the findings are suggestive of the need to prioritize road safety for Black and Hispanic Americans, especially vulnerable road users. Finally, although exposure-based measures are a more accurate measure of disparity, a limitation for national-level assessments is that NHTS is carried out infrequently, and therefore per capita measures of disparities are also useful to track progress annually.

The findings are particularly troubling because they suggest that Black and Hispanic Americans are less able to safely enjoy the health benefits of walking and cycling, namely increased physical activity, which has been linked to improved cardiovascular and respiratory health.[49] Health disparities are also evident in the U.S.,[50] particularly for illnesses where increased physical activity could improve health outcomes, such as diabetes, hypertension, and heart disease.[51] As such, elevated risk of traffic fatality while walking and cycling may constrain healthful activity more for the populations that would benefit the most.

Limitations

The analysis leverages the best possible exposure assessment survey (NHTS); however, there are some important caveats and limitations. First, the NHTS sample is small for certain strata (Appendix Table 2, available online). This results in large uncertainties in exposure estimates and prevents further stratification by location to carry out a spatially explicit analysis. States have broad discretion to allocate federal transportation resources through funding formulas, and increasingly, discretionary federal resources are being allocated directly to localities for specific road safety projects. Although not possible with NHTS, measuring local changes in person-miles traveled by mode is important for both understanding mode shift resulting from investment in infrastructure and the impact of road safety projects on traffic fatality risk.

Another limitation is that this analysis is restricted to fatalities, which are a vital component of road safety but do not themselves capture the full social cost of motor vehicle crashes. In 2010, fatal crashes represented 36% of the total social cost and 43% of the monetized lost quality-adjusted life years of motor vehicle crashes in the U.S.[52] Future research to address these limitations would benefit from surveys that include better locale-specific exposure measures by race/ethnicity and mode as well as better data on nonfatal crashes. The exclusion of a small portion of trips and fatalities owing to missing data or multiple races also adds uncertainty to the results, but its effects are likely limited (Appendix S4, available online). Finally, the analysis can only be as accurate as the self-reported trip origin−destination data recorded in the NHTS.

CONCLUSIONS

Traffic fatalities are a substantial and preventable public health challenge in America that disproportionately affects Black and Hispanic Americans. This analysis reveals that observed disparities by race/ethnicity in traffic fatalities are even greater than previously thought after accounting for differences in activity levels. The authors note that future research would benefit from access to street-segment activity data to estimate neighborhood-level disparities in traffic fatalities or injuries. One possible source of these data is mobile mapping applications, such as Google and Apple Maps, enabled through mode inference on the basis of velocity and location data. Perhaps future collaborations between the academy and industry will make these data available, opening the door to local-level exposure-based estimates of traffic fatality by race/ethnicity that can directly inform policymaking and placemaking.

CREDIT AUTHOR STATEMENT

Matthew Raifman: Conceptualization, Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing - original draft, Writing - review and editing. Ernani F. Choma: Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing - original draft, Writing - review and editing.

ACKNOWLEDGMENTS

The authors would like to acknowledge Profs. Jonathan Levy and Patrick Kinney of the Department of Environmental Health at the Boston University School of Public Health (Boston, MA) and Professor John Spengler of the Department of Environmental Health at the Harvard T.H. Chan School of Public Health (Boston, MA). MR and EFC contributed equally to all aspects of the manuscript.

The research presented in this paper is that of the authors and does not reflect the official policy of the NIH. The views expressed in this paper do not necessarily reflect the views of the Robert Wood Johnson Foundation.

This research was supported by the Barr Foundation and by training Grant Number 5T32ES014562-13 from the NIH National Institute of Environmental Health Sciences. This research was supported, in part, by the Akira Yamaguchi Endowment for Environmental Health and Human Habitation at the Harvard T.H. Chan School of Public Health and, in part, by the Robert Wood Johnson Foundation grant number 74275, "Building a Culture of Health: A Business Leadership Imperative," a joint initiative between the Harvard T.H. Chan School of Public Health and the Harvard Business School.

No financial disclosures were reported by the authors of this paper.

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2022.03.012.

REFERENCES

1. Centers for Disease Control and Prevention (CDC). Motor-vehicle safety: a 20th century public health achievement [published correction appears in *MMWR Morb Mortal Wkly Rep.* 1999;48(22):473] *MMWR Morb Mortal Wkly Rep.* 1999;48(18):369–374.https://www.cdc.gov/mmwr/preview/mmwrhtml/mm4818a1.htm. Accessed July 22, 2020.
2. U.S. Department of Transportation. USDOT releases new data showing that road fatalities spiked in first half of 2021. Washington, DC: U.S. Department of Transportation; 2021. https://www.transportation.gov/briefing-room/usdot-releases-new-data-showing-road-fatalities-spiked-first-half-2021. Published 2021. Accessed October 31, 2021.
3. FARS: national statistics. National Highway Traffic Safety Administration. https://www-fars.nhtsa.dot.gov/Main/index.aspx. Updated March 22, 2022. Accessed August 5, 2021.
4. Schneider RJ. United States pedestrian fatality trends, 1977 to 2016. *Transp Res Rec.* 2020;2674(9):1069–1083. https://doi.org/10.1177/0361198120933636.
5. An analysis of traffic fatalities by race and ethnicity. Governors Highway Safety Association. https://www.ghsa.org/resources/Analysis-of-Traffic-Fatalities-by-Race-and-Ethnicity21. Updated June 2021. Accessed August 5, 2021.
6. QuickStats: Age-adjusted Pedestrian* Death Rates,† by race/ethnicity - National Vital Statistics System, United States, 2009 and 2018. *MMWR Morb Mortal Wkly Rep.* 2020;69(39):1434. https://doi.org/10.15585/mmwr.mm6939a7.
7. Archer DN. Transportation policy and the underdevelopment of Black communities, 2021, Iowa Law Review 2125, 2021, Available at: https://ssrn.com/abstract=3797364, accessed May 2 2022, Published March 28.
8. Fears D, Muyskens. Highway runs though Black homes, for a third time, in South Carolina. *Washington Post.* September 8, 2021 https://www.washingtonpost.com/climate-environment/interactive/2021/highways-black-homes-removal-racism/.
9. Kruse KM. What does a traffic jam in Atlanta have to do with segregation? Quite a lot. *N Y Times Mag.* August 14, 2019 https://www.nytimes.com/interactive/2019/08/14/magazine/traffic-atlanta-segregation.html.
10. Mohl RA. Stop the road: freeway revolts in American cities. *J Urban Hist.* 2004;30(5):674–706. https://doi.org/10.1177/0096144204265180.
11. Lipsitz G. *How Racism Takes Place.* Philadelphia, PA: Temple University Press, 2011.
12. Golub A, Marcantonio RA, Sanchez TW. Race, space, and struggles for mobility: transportation impacts on African Americans in Oakland and the East Bay. *Urban Geogr.* 2013;34(5):699–728. https://doi.org/10.1080/02723638.2013.778598.
13. Pucher J. Discrimination in mass transit. *J Am Plann Assoc.* 1982;48(3):315–326. https://doi.org/10.1080/01944368208976181.
14. Gelman A, Fagan J, Kiss A. An analysis of the New York City Police Department's "Stop-and-Frisk" policy in the context of claims of racial bias. *J Am Stat Assoc.* 2007;102(479):813–823. https://doi.org/10.1198/016214506000001040.
15. Roh S, Robinson M. A geographic approach to racial profiling: the microanalysis and macroanalysis of racial disparity in traffic stops. *Police Q.* 2009;12(2):137–169. https://doi.org/10.1177/1098611109332422.
16. Lundman RJ, Kaufman RL. Driving while Black: effects of race, ethnicity, and gender on citizen self-reports of traffic stops and police actions. *Criminology.* 2003;41(1):195–220. https://doi.org/10.1111/j.1745-9125.2003.TB00986.X.
17. Ge Y, Knittel CR, MacKenzie D, Zoepf S. Racial discrimination in transportation network companies. *J Public Econ.* 2020;190(C):104-205. https://doi.org/10.1016/j.jpubeco.2020.104205.
18. Karner A, Niemeier D. Civil rights guidance and equity analysis methods for regional transportation plans: a critical review of literature and practice. *J Transp Geogr.* 2013;33(C):126–134. https://doi.org/10.1016/j.jtrangeo.2013.09.017.
19. Buehler R, Pucher J. The growing gap in pedestrian and cyclist fatality rates between the United States and the United Kingdom, Germany, Denmark, and the Netherlands, 1990-2018. *Transp Rev.* 2021;41(1):48–72. https://doi.org/10.1080/01441647.2020.1823521.
20. Pucher J, Buehler R, Merom D, Bauman A. Walking and cycling in the United States, 2001-2009: evidence from the National Household Travel Surveys. *Am J Public Health.* 2011;101(Suppl 1):S310–S317. https://doi.org/10.2105/AJPH.2010.300067.

21. Buehler R, Pucher J. Cycling to work in 90 large American cities: new evidence on the role of bike paths and lanes. *Transportation.* 2012;39 (2):409–432. https://doi.org/10.1007/s11116-011-9355-8.
22. Buehler R, Pucher J. Trends in walking and cycling safety: recent evidence from high-income countries, with a focus on the United States and Germany. *Am J Public Health.* 2017;107(2):281–287. https://doi.org/10.2105/AJPH.2016.303546.
23. Fatality Analysis Reporting System (FARS). National Highway Traffic Safety Administration. https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars. Updated March 2, 2022. Accessed May 18, 2021.
24. National Household Travel Survey. Federal Highway Administration. U.S. Department of Transportation; 2017. https://nhts.ornl.gov/.
25. Office of Management and Budget (OMB) Standards. Office of Research on Women's Health, NIH. https://orwh.od.nih.gov/toolkit/other-relevant-federal-policies/OMB-standards. Accessed August 18, 2021.
26. Metropolitan and micropolitan statistical areas population totals and components of change: 2010-2019. *U.S. Census.* 2021 https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-metro-and-micro-statistical-areas.html.
27. McAndrews C, Beyer K, Guse CE, Layde P. Revisiting exposure: fatal and non-fatal traffic injury risk across different populations of travelers in Wisconsin, 2001-2009. *Accid Anal Prev.* 2013;60:103–112. https://doi.org/10.1016/j.aap.2013.08.005.
28. Beck LF, Dellinger AM, O'Neil ME. Motor vehicle crash injury rates by mode of travel, United States: using exposure-based methods to quantify differences. *Am J Epidemiol.* 2007;166(2):212–218. https://doi.org/10.1093/aje/kwm064.
29. Huebner KD, Porter MM, Marshall SC. Validation of an electronic device for measuring driving exposure. *Traffic Inj Prev.* 2006;7(1):76–80. https://doi.org/10.1080/15389580500413067.
30. Braver ER. Race, Hispanic origin, and socioeconomic status in relation to motor vehicle occupant death rates and risk factors among adults. *Accid Anal Prev.* 2003;35(3):295–309 https://doi.org/10.1016/s0001-4575(01)00106-3". https://doi.org/10.1016/s0001-4575(01)00106-3.
31. Oak Ridge National Laboratory. 2017 NHTS compatibility with prior data. Oak Ridge, TN: Oak Ridge National Laboratory; 2020. https://nhts.ornl.gov/assets/2017%20NHTS%20Compatibility%20with%20Prior%20NHTS%20Data.pdf. Published 2020. Accessed September 8, 2021.
32. Manuals & documentation - document type — CrashStats. National Highway Traffic Safety Administration, U.S. Department of Transportation. https://crashstats.nhtsa.dot.gov/#!/DocumentTypeList/23. Updated March 2, 2022. Accessed May 2, 2022.
33. The R Foundation for Statistical Computing. R Software, Version 4.0.2 2020-06-22 — *Taking off Again.* 2020. https://cloud.r-project.org/ Published. Accessed May 3, 2022.
34. The R Foundation for Statistical Computing. R Software, Version 4.1.1 2021-08-10 – *Kick Things.* 2021 https://cloud.r-project.org/ Published. Accessed May 3, 2022.
35. Westat - Center for Transportation, Technology & Safety Research. R package 'summarizeNHTS'. National Household Travel Survey R Analysis Toolkit. Package version 0.0.0.9000. Published 2021. https://github.com/Westat-Transportation/summarizeNHTS
36. U.S. Department of Transportation, National Highway Traffic Safety Administration, National Center for Statistics and Analysis. Bicyclists and other cyclists: 2018 data. (Traffic Safety Facts. Report No. DOT HS 812 884). Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, National Center for Statistics and Analysis; 2020. https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812884.
37. Bicycle safety. National Highway Traffic Safety Administration. https://www.nhtsa.gov/road-safety/bicycle-safety. Updated March 22, 2022. Accessed September 7, 2021.
38. Rosén E, Sander U. Pedestrian fatality risk as a function of car impact speed. *Accid Anal Prev.* 2009;41(3):536–542. https://doi.org/10.1016/j.aap.2009.02.002.
39. Flanagan E, Lachapelle U, El-Geneidy A. Riding tandem: does cycling infrastructure investment mirror gentrification and privilege in Portland, OR and Chicago, IL? *Res Transp Econ.* 2016;60(C):14–24. https://doi.org/10.1016/j.retrec.2016.07.027.
40. Braun L, Rodriguez D, Gordon-Larsen P. 2397 - Social (in)equity in access to cycling infrastructure: examining the distribution of bike lanes with respect to area-level sociodemographic characteristics in 23 large U.S. cities. *J Transp Health.* 2018;9(Suppl):S28. https://doi.org/10.1016/j.jth.2018.05.086.
41. Hanchate AD, Paasche-Orlow MK, Baker WE, Lin MY, Banerjee S, Feldman J. Association of race/ethnicity with emergency department destination of emergency medical services transport. *JAMA Netw Open.* 2019;2(9):e1910816. https://doi.org/10.1001/jamanetworkopen.2019.10816.
42. Crompton JG, Pollack KM, Oyetunji T, et al. Racial disparities in motorcycle-related mortality: an analysis of the National Trauma Data Bank. *Am J Surg.* 2010;200(2):191–196. https://doi.org/10.1016/j.amjsurg.2009.07.047.
43. Haskins AE, Clark DE, Travis LL. Racial disparities in survival among injured drivers. *Am J Epidemiol.* 2013;177(5):380–387. https://doi.org/10.1093/aje/kws242.
44. Hamann C, Peek-Asa C, Butcher B. Racial disparities in pedestrian-related injury hospitalizations in the United States. *BMC Public Health.* 2020;20(1):1459. https://doi.org/10.1186/s12889-020-09513-8.
45. Courtemanche C, Marton J, Ukert B, Yelowitz A, Zapata D, Fazlul I. The three-year impact of the Affordable Care Act on disparities in insurance coverage. *Health Serv Res.* 2019;54(Suppl 1):307–316. https://doi.org/10.1111/1475-6773.13077.
46. Leaf WA, Preusser DF, Group PR. *Identification of alcohol-pedestrian crash problems among selected racial/ethnic groups.* Washington, DC: U. S. Department of Transportation. National Highway Traffic Safety Administration; 1997. https://rosap.ntl.bts.gov/view/dot/12555/dot_12555_DS1.pdf?.
47. Scott J, Danos D, Collins R, et al. Structural racism in the built environment: segregation and the overconcentration of alcohol outlets. *Health Place.* 2020;64:102385. https://doi.org/10.1016/j.healthplace.2020.102385.
48. Ortiz N, Ramnarayan M. 1949 - Analysis of alcohol-involved pedestrian fatalities in the United States, 2003-2015. *J Transp Health.* 2017;5(suppl):S95. https://doi.org/10.1016/j.jth.2017.05.250.
49. Woodcock J, Givoni M, Morgan AS. Health impact modelling of active travel visions for England and Wales using an integrated transport and health impact modelling tool (ITHIM). *PLoS One.* 2013;8(1):e51462. https://doi.org/10.1371/journal.pone.0051462.
50. Bilal U, Diez-Roux AV. Troubling trends in health disparities. *N Engl J Med.* 2018;378(16):1557–1558. https://doi.org/10.1056/NEJMc1800328.
51. Russell L. Fact sheet: health disparities by race and ethnicity. *Center for American Progress.* December 16, 2010 https://www.americanprogress.org/issues/healthcare/news/2010/12/16/8762/fact-sheet-health-disparities-by-race-and-ethnicity/.
52. Blincoe L, Miller TR, Zaloshnja E, and Lawrence BA, The economic and societal impact of motor vehicle crashes, 2010. (Revised), 2015, Report No. DOT HS 812 013, National Highway Traffic Safety Administration, Washington, DC. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013. Published May 2015, Accessed January 26, 2022.