U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

NHTSA

DOT HS 812 340 October 2016

Comparison of 2013 VMT Fatality Rates in U.S. States and in High-Income Countries

Suggested APA Format Reference:

Kahane, C. J. (2016, October). *Comparison of 2013 VMT fatality rates in U.S. States and in high-income countries*. (Report No. DOT HS 812 340). Washington, DC: National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 812 340		

4. Title and Subtitle	5. Report Date
Comparison of 2013 VMT Fatality Rates in U.S. States and in High-Income Countries	October 2016
	6. Performing Organization Code
7. Author(s) Charles J. Kahane, Ph.D.	8. Performing Organization Report No.
9. Performing Organization Name and Address Bowhead Logistics Solutions, LLC 4900 Seminary Road, Suite 1200 Alexandria, Virginia 22311-1858	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 1200 New Jersey Avenue SE. Washington, DC 20590	13. Type of Report and Period Covered NHTSA Technical Report 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Traffic fatality rates per 100 million VMT in 2013 are estimated for the 44 U.S. States and the 43 high-income comparison countries with populations of 1,000,000 or more. States and comparison countries are assigned to four groups based on population density, urbanization, and climate (factors that influence fatality rates). Within each of these four groups, the rates for U.S. States are similar to the comparison countries of Western, Northern, and Southern Europe as well as Australia, New Zealand, and Canada; they are usually lower than in the high-income countries of Eastern Europe, East Asia, the Middle East, and Latin America.

These findings point to an international commonality in safety challenges and underline the importance of global collaboration in identifying and sharing techniques for improving road safety.

17. Key Words	18. Distribution Statement
World traffic safety, rank orders in stratified data, non-parametric analysis, van Elteren's test	Document is available to the public from the National Technical Information Service www.ntis.gov.

19. Security Classif. (Of this report)	20. Security Classif. (Of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	33	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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LIST OF ABBREVIATIONS

AAA	American Automobile Association
ANZAC	Australia, New Zealand, and Canada
BAC	Blood alcohol concentration
BASt	Bundesanstalt für Straßenwesen
CUV	crossover utility vehicle
Destatis	Statistisches Bundesamt
FARS	Fatality Analysis Reporting System, a census of fatal crashes in the United States since 1975
FHWA	Federal Highway Administration
GNICAP	gross national income per capita
IIHS	Insurance Institute for Highway Safety
ITF	International Transport Forum
LTV	light trucks and vans, includes pickup trucks, SUVs, CUVs, minivans, and full-size vans
MSA	metropolitan statistical area
NHTSA	National Highway Traffic Safety Administration
OECD	Organization for Economic Cooperation and Development
ONISR	L'Observatoire National Interministériel de la Sécurité Routière
PKT	person kilometers of travel
PROC GLM	general linear model procedure of SAS
SAS	statistical and database management software produced by SAS Institute, Inc.
U.S. DOT	United States Department of Transportation
VKT	vehicle kilometers of travel
VMT	vehicle miles of travel
WHO	World Health Organization

EXECUTIVE SUMMARY

An analysis comparing the fatality rates per 100 million VMT in the United States and other high-income countries during a specific year must take into account the strong influence of demographic and geographic factors on the rates. In particular, urban streets are much safer than rural roads; highways engineered to high standards and with limited access such as U.S. interstates are much safer than roads built to lower standards. In 2013 the fatality rate on rural local roads in the United States was 6.6 times as high as on urban interstates. As a result, all else being equal, a densely populated, highly urbanized area will have a substantially lower fatality rate than one that is not. Recognizing the diverse environments among U.S. States, this study compared VMT fatality rates among an international selection of jurisdictions with similar environmental characteristics. The study:

- Treats each U.S. State as a separate jurisdiction; specifically, the analysis compares VMT fatality rates in 2013, the most recent year that worldwide data is available, in all of the 43 high-income countries, as defined by the World Bank, with populations over 1 million to the 44 States with populations over 1 million; and

- Classifies the countries and States into four somewhat more homogeneous groups, based on demographic and geographic factors: (1) Densely populated places, such as Japan, the United Kingdom, and Massachusetts; (2) Cold climates with some concentrated urban belts, such as Sweden and Minnesota (cold climates mitigate fatality rates by, among other things, discouraging motorcycle travel for much of the year); (3) Temperate places, not densely populated overall but with much of the population concentrated in large metropolitan areas, such as Australia and California; and (4) Less dense, less urbanized places, such as Ireland and Iowa.

The countries and States within each of the four groups are tabulated, ranked from lowest to highest by their fatality rates per 100 million VMT in 2013. A glance at these tables reveals and a non-parametric statistical test of the rank ordering confirms that the States have significantly lower VMT fatality rates than the comparison countries that appear in the same table, when the analysis comprises all 43 comparison countries, including the high-income nations in Asia, the Middle East, Latin America and the former Eastern Bloc as well as Western Europe. However, if the comparison countries are limited to those with per capita incomes similar to the United States – or limited to Western, Northern, or Southern Europe plus Australia, New Zealand, and Canada – the differences between the States and the comparison countries become non-significant. In other words, within each of these four groups, the rates for the States are similar to the comparison countries of Western, Northern, and Southern Europe as well as Australia, New Zealand, and Canada, but they are usually lower than in the high-income countries of Eastern Europe, East Asia, the Middle East, and Latin America.

This report is limited to a cross-sectional analysis of the fatality rates of high-income countries in 2013. In the data, demographic and geographic differences between States or countries appear to account for much of the difference in VMT fatality rates. The study does not compare types or intensity of safety practices such as traffic laws and enforcement. A longitudinal study in one country comparing, say, the fatality rate in 2015 to 1966 would tell a different story. In the United States, the fatality rate per 100 million VMT dropped by 80 percent, from 5.50 in 1966 to

1.12 in 2015.[1] That reduction is due principally to vastly improved safety practices and only secondarily to slowly changing demographic trends.[2] But in the cross-sectional data, there are substantial demographic and geographic differences between countries, even within the four groups.

These findings reflect an apparent global similarity in traffic safety among jurisdictions with comparable economic, demographic, environmental and population density characteristics. While this analysis is limited to high-income jurisdictions, it is possible that such similarities also exist among nations within other economic levels. This international commonality underlines the need for global collaboration regarding solutions for road safety challenges and reinforces the importance of initiatives such as the United Nations Decade of Action for Road Safety that facilitate sharing of effective techniques for reducing road traffic deaths and injuries.

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[1] NHTSA. (2016a). *Traffic safety facts 2014* (Report No. DOT HS 812 261). Washington, DC: Author. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812261; NHTSA. (2016b, July). *Early estimates of motor vehicle traffic fatalities in 2015* (Report No. DOT HS 812 269). Washington, DC: Author. Available at crashstats.nhtsa.dot.gov/Api/Public/Publication/812269

[2] Kahane, C. J. (2015, January). *Lives saved by vehicle safety technologies and associated Federal Motor Vehicle Safety Standards, 1960 to 2012 – Passenger cars and LTVs – With reviews of 26 FMVSS and the effectiveness of their associated safety technologies in reducing fatalities, injuries, and crashes* (Report No. DOT HS 812 069). Washington, DC: National Highway Traffic Safety Administration. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812069

1. Objective: Contrast VMT fatality rates in comparable States and countries

Motor vehicles have enabled rapid advances in our country's economic, social, and cultural development. While they are an integral part of modern life, the inherent risk involved with moving hundreds of millions of people over trillions of miles each year takes a toll on safety. Currently, each year over 30,000 people are killed in motor vehicle crashes on our nation's highways, costing society over $240 billion in economic impacts and over $830 billion in societal harm.[3]

Traffic and motor vehicle safety has long been a public concern and a focus of efforts by Federal, State, and local agencies to reduce the risks from travel. Over the past 5 decades NHTSA has promulgated numerous Federal Motor Vehicle Safety Standards that have made vehicles safer and administered behavioral programs designed to encourage safer driving. Motor vehicle manufacturers have also done their part by engineering and adopting new safety measures. NHTSA estimates that vehicle safety technologies and increased use of seat belts have saved over 600,000 lives since 1960.[4] Furthermore, NHTSA, State, and local jurisdictions have addressed safety through laws and programs to curb drunk driving and other unsafe driver behaviors. State and Federal agencies have implemented safer road designs. The fatality rate per 100 million vehicle miles of travel in the United States has fallen by 80 percent, from 5.50 in 1966 to 1.12 in 2015.[5]

Traffic and motor vehicle safety is now a worldwide concern. Manufacturers design new vehicles for sale in multiple high-income countries, designed to safety standards established by various industrialized nations. High-income nations have generally focused on increasing seat belt use, reducing drunk driving, and building safer roads, and share at least some points of commonality among their laws and safety programs. Nevertheless, each country tailors its programs to address safety in its unique environment. To provide perspective on levels of safety in the industrialized world, this report compares VMT fatality rates in the United States during 2013 to rates in 43 other high-income countries. Direct comparisons can be misleading, however, because countries vary considerably in population density, cultural norms, urbanization, roadway conditions and design, alcohol consumption, vehicle mix, mass transit options, laws, incidence of pedestrian and bicycle transportation, and age demographics, among other factors that make the challenge of improving safety unique to each country.

Specifically, the United States itself encompasses numerous different environments and, as such, cannot easily be compared to some of the more compact, uniform countries. This report compares individual States, some of which are as large and populous as many countries, to the other high-income nations. We will gather the States and countries into more uniform groups and then compare the VMT fatality rates of groups of States to the countries that most resemble them.

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[3] Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2015, May). *The economic and societal impact of motor vehicle crashes, 2010 (Revised)* (Report No. DOT HS 812 013). Washington, DC: National Highway Traffic Safety Administration. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013
[4] Kahane, 2015.
[5] NHTSA, 2016a, 2016b.

Measure of risk: A mile of travel is a unit of exposure – a trip of two miles, all else being equal, is twice as risky as a one-mile trip. The fatality rate per 100 million VMT measures risk per unit of exposure; it has been calculated for many decades in the United States. By contrast, the fatality rate per million registered vehicles is not an intuitive measure of risk, as a person can cut "risk" in half by simply buying a second vehicle; similarly, per capita fatality rates give lower risk to people who drive less, even if they drive just as dangerously as everyone else. We will compare fatality rates in 2013, not the changes in rates from some previous year, say 1995, to 2013. The latter is a meaningful comparison if all the countries had been equally safe in 1995. But they were not. Some of the countries with the largest reductions from 1995 to 2013 may just have been the ones furthest behind in 1995.

Selection of countries and States: It is important that comparison countries have high incomes, because those are the nations with public resources that may fund state-of-the-art roads and behavioral safety programs and private resources for buying late-model vehicles meeting today's safety standards. The World Health Organization's *Global Status Report on Road Safety 2015* lists high-, middle-, and low-income countries based on their gross national income per capita in 2013, as calculated by the World Bank.[6] Our selection is limited to the 44 high-income countries (including the United States) with population at least 1 million – i.e., excluding enclaves such as Monaco or San Marino. However, instead of the United States as a single point, the database will include the 44 States with population at least 1 million – parallel to the minimum-population requirement for the countries. The estimated GNICAP for all of these States is in the high-income range.[7]

Computation or estimation of VMT fatality rates: Not all countries define "traffic fatalities" the same way. For example, one country might include only fatalities within 30 days after a crash, another, a full year; crashes on private roads might be included or excluded. WHO attempts to make all countries' rates comparable by adding, if necessary, an increment for those types of crashes not included in a country's reported number.[8] WHO's counts of estimated fatalities (reported plus increment) in 2013 will be used in all the calculations. Specifically, in the United States, there were 32,719 reported and 34,064 estimated fatalities.[9] Reported counts of fatalities in each State, based on NHTSA's Fatality Analysis Reporting System, are tabulated at the Insurance Institute for Highway Safety's web site.[10] These counts are multiplied by 34,064/32,719 (and rounded to the nearest integer) to estimate fatalities by the WHO definition. "Fatalities" include pedestrians and other non-occupants as well as motor vehicle occupants.

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[6] World Health Organization. (2015). *Global Status Report on Road Safety 2015*, p. 5. Geneva: Author. Available at who.int/violence_injury_prevention/road_safety_status/2015/en/. Country income status was based on data from the World Development Indicators database, World Bank, March 2015 (data.worldbank.org/indicator/NY.GNP.PCAP.CD). Data relate to 2013, whereby low-income ≤ $1,045 per capita; middle-income is $1,046 to $12,745; and high income ≥ $12,746.

[7] GNICAP for the United States was $53,740 in 2013. Personal income per capita in 2012 is listed at infoplease.com/ipa/A0104652.html for each State; it was $42,693 for the United States. GNICAP in 2013 is estimated as 53,740/42,693 times personal income per capita.

[8] WHO, 2015, pp. 70-74 (methodology) and 264-270 (point estimates of deaths in 2013).

[9] *Ibid*., pp. 70-71. The 32,719 statistic is based on FARS. The 34,064 estimate is based on vital records (death certificates). It is higher than 32,719 because it may include fatalities more than 30 days after the crash and/or crashes on private property not included in the FARS count.

[10] Insurance Institute for Highway Safety (n.a.). General statistics (Web page), Arlington, VA: Author. Available at iihs.org/iihs/topics/t/general-statistics/fatalityfacts/state-by-state-overview/2013.

The IIHS table also lists 2013 VMT for each State. Vehicle kilometers of travel in 2013 for 21 of the 43 comparison countries are derived from a report by the International Traffic Safety Data and Analysis Group of the Organization for Economic Cooperation and Development.[11] A second OECD web site provides VKT for 6 additional countries.[12] Another web site lists passenger kilometers of travel for 3 additional countries as well as 16 of the preceding countries for which VKT is known. In those 16 countries, the ratio of total PKT to total VKT (i.e., the occupancy rate) is 1.44; VKT is estimated for the 3 new countries by PKT/1.44.[13] For the remaining 13 countries, VKT is estimated from the number of registered vehicles, taking into account the GNICAP, the median age of the population, and the percentage of the population living in metro areas of 500,000 or more.[14] VMT = .6214 x VKT. The fatality rates per 100 million VMT in 2013 ranged from 0.61 to 2.01 in our 44 States and from 0.57 to 11.10 in the 43 comparison countries.

The analysis is based on 2013 statistics because that is the latest year for which fatality and VKT data are generally available worldwide as of October 2016 (in fact, it was necessary to use 2012 data for a few countries). We are aware that the fatality rate per 100 million VMT increased in the United States from 1.10 in 2013 to 1.12 in 2015 (2% increase), and the number of fatalities increased by 7 percent.[15] But the number of fatalities also rose from 2013 to 2015 by 6 percent in France, 4 percent in Germany, and 1 percent in the United Kingdom (2015 VMT fatality rates for these and other countries are unknown as of October 2016).[16]

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[11] Australia, Austria, Belgium, Canada, Czechia, Denmark, Finland, France, Germany, Ireland, Israel, Japan, New Zealand, Netherlands, Norway, Slovenia, South Korea, Spain, Sweden, Switzerland, and U.K.; statistics for Canada and Czechia are for 2012; OECD/ITF. (2015). *Road safety annual report 2015*. Paris: OECD Publishing. Available at itf-oecd.org/sites/default/files/docs/15irtadannualreport_0.pdf.

[12] Estonia, Greece, Italy, Poland, Portugal, and Slovakia at oecd-ilibrary.org/docserver/download/9713051ec020.pdf?expires=1468344017&id=id&accname=guest&checksum=76FAC92A237F712FB8D8F04F7AE7285A (these are 2011 estimates, but may also serve for 2013 as VKT has changed relatively little in recent years).

[13] PKT data is available at knoema.com/atlas/Lithuania/topics/Transportation/Road-transport/Roads-passengers-carried; Cyprus, Latvia, and Lithuania are the 3 countries for which VKT is estimated by PKT/1.44356; the 16 countries whose data is used to compute average PKT/VKT are Australia, Belgium, Canada, Czechia, Denmark, Finland, France, Germany, Greece, Netherlands, Norway, Slovakia, Spain, Sweden, Switzerland, and the U.K.

[14] Numbers of registered vehicles in 2013 are available from *Road safety annual report* 2015 for the 21 countries with VKT data in that report plus Chile, Greece, Italy, Lithuania, Poland, and Portugal; from WHO at who.int/violence_injury_prevention/road_safety_status/2013/country_profiles/trinidad_and_tobago.pdf (Trinidad & Tobago) or apps.who.int/gho/data/node.main.A997 (all others). In the 30 countries where VKT is known or estimated from PKT, the average annual kilometers per vehicle (VKT_VEH) is 11,835; however, mileage significantly increases with per capita income (GNICAP) and is significantly higher for a younger population. (Population density and urbanization had little correlation with VKT per vehicle.) The regression equation (SAS PROC GLM, weighted by number of registered vehicles) is VKT_VEH = 3509 Log (GNICAP) – 426 MEDIAN_AGE – 6,938. (R-square for the regression is .35; the regression coefficients for Log (GNICAP) and MEDIAN_AGE are both statistically significant at the .01 level.) The regression equation is applied in the remaining 13 countries to estimate VKT from the number of registered vehicles.

[15] NHTSA, 2016b.

[16] ONISR. (2016, May). *Road safety in 2015 – final results*. Paris: Author. Available at securite-routiere.gouv.fr/la-securite-routiere/l-observatoire-national-interministeriel-de-la-securite-routiere/english-version; BASt. (2015, September). *Traffic and accident data – summary statistics, Germany.* Bergisch Gladbach, Germany: Author. Available at bast.de/EN/Publications/Media/Unfallkarten-national-englisch.pdf?__blob=publicationFile; Destatis. (2016, February). *Zahl der Verkehrstoten 2015 um 2,9 % gestiegen*. Wiesbaden: Author. Available at

2. Factors that influence fatality rates

Factors that strongly influence fatality rates, and for which actual or surrogate data is available, are urbanization, highway type, driver age and gender, driving experience, alcohol consumption, and belt use. Some of these, such as urbanization are essentially "givens" for each State or country; others can, to varying degrees, be shaped by their safety programs.

Urbanization and highway type: The Federal Highway Administration estimates that the fatality rate per 100 million VMT in 2013 was almost twice as high on rural roads (1.87) as on urban roads (1.09). Furthermore, the rates on Interstate highways and other freeways are about one third to one half as large as on any of the other functional classes with the same urbanization. The rate on local rural roads (2.72) is 6.6 times as high as the rate on urban Interstate highways (0.41).

Fatalities per 100 million VMT in 2013 in the United States[17]

RURAL	**1.87**	
Interstate		.85
Other principal arterial		2.14
Minor arterial		2.28
Major collector		2.29
Minor collector		1.67
Local		2.72
URBAN	**1.09**	
Interstate		.41
Other freeways/expressways		.47
Other principal arterial		.98
Minor arterial		.77
Major collector		.60
Local		1.14

The FHWA functional classes do not necessarily correspond to specific highway types, but presumably "local" roads include a high percentage of roads or streets with one lane in each direction, while "collectors" and "arterials" may include successively higher proportions of multilane and divided roads, but falling short of the fully limited access of Interstate highways and expressways.

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destatis.de/DE/PresseService/Presse/Pressemitteilungen/2016/02/PD16_060_46241.html; Department for Transport. (2015, June). *Reported road casualties in Great Britain – main results 2014*. London: Author. Available at gov.uk/government/uploads/system/uploads/attachment_data/file/438040/reported-road-casualties-in-great-britain-main-results-2014-release.pdf; Department for Transport. (2016, June). *Reported road casualties in Great Britain – main results 2015*. London: Author. Available at gov.uk/government/uploads/system/uploads/attachment_data/file/533293/rrcgb-main-results-2015.pdf;

[17] www.fhwa.dot.gov/policyinformation/statistics/2013/pdf/fi30.pdf

Clearly, all else being equal, a heavily urbanized State or country will have substantially lower fatality rates than a largely rural jurisdiction. Furthermore, a State or country with population clustered in a few major urban centers, able to channel a large portion of its rural travel on a few highways built to the highest standards will likely have lower rates than a place with a widely dispersed population necessitating a far more extensive grid of roads, most of which cannot be built to expressway standards, given available resources.

Other countries generally do not have FHWA-equivalent classifications of roads as urban or rural or by functional class. Instead, three surrogate variables yield insight on the likely configuration of the road system:

- **Population per square kilometer** is objective and exact (assuming there has been a recent and accurate census). The higher the population density, the higher the likely percentage of driving in urban areas and/or on roads designed to high standards. Population density ranged from 2.4 to 438 in the 44 States and from 3 to 8,227 in the 43 comparison countries.[18]
- The average population density does not necessarily describe how population is distributed. Some places have a lot of near-empty land and most of the people live in a few urban areas; others have widely dispersed populations. The **percentage of the population in metropolitan areas ≥ 500,000** is, theoretically, a uniform way to describe the share of the people living in large urban areas. Unfortunately, the definition of "metropolitan area" is not consistent worldwide. Specifically, American metropolitan statistical areas often include wide swaths of surrounding rural areas, but it is not necessarily so elsewhere. This surrogate variable is at best a relative, not an absolute measure of urbanization. Values range from 0 to 100 percent in the States and from 0 to 100 percent in the comparison countries.[19]
- All the countries in the analysis are high-income, but some have higher income than others. Higher income may mean resources are available to build a large proportion of the road network to expressway standards. Of course, that could also be affected by other societal priorities and the difficulty of the terrain. The previously-defined **gross national income per capita** ranges from an estimated $41,422 to $73,778 in the States and from $13,240 to $102,610 in the comparison countries.

Driver age and gender: VMT fatality rates are as sensitive to driver age and gender as they are to urbanization and highway type.[20] The rate is 2.5 times as high for a 17-year-old male and a 75-

[18] Population density by State (convert from per mi^2 to km^2 by multiplying by .3861): statemaster.com/red/graph/peo_pop_den-people-population-density&b_printable=1; population density by country: indexmundi.com/g/r.aspx?v=21000 (Taiwan), statisticstimes.com/population/countries-by-population-density.php (all others).

[19] demographia.com/db-worldua.pdf is the source for populations of all metro areas ≥ 500,000 (U.S. and international) except Estonia (worldmapsonline.com/academia/europe/academia_estonia_physical_map.htm), Norway (worldpopulationreview.com/world-cities/oslo-population), and Sweden (citypopulation.de/Sweden.html). When MSAs spread over 2 or more States, the population was subdivided, by county, using census.gov/population/metro/data/def.html (lists of constituent counties) and census.gov/newsroom/press-kits/2015/20150326_popestimates.html (population by county, 2014).

[20] Kahane, C. J. (2003, October). *Vehicle weight, fatality risk and crash compatibility of model year 1991-99 passenger cars and light trucks* (Report No. DOT HS 809 662). Washington, DC: National Highway Traffic Safety Administration. P. 68. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/809662

year-old male as for a 35-year-old male; it is about 65 percent higher for males than females of the same age, up to 35. Young drivers have high fatality rates due to risk-taking behavior, driving inexperience, and alcohol. Old drivers have high fatality rates due to their high vulnerability to fatal injury and deteriorating driving performance. Males have higher rates than females because of risk-taking behavior and alcohol.[21]

Nevertheless, age and gender are not nearly as important confounding factors in our analysis as urbanization and road types. That is because the distributions of age and gender do not differ quite so much between countries. All over the world, resident populations have approximately equal numbers of males and females. Gender is a factor only in those countries where, for cultural or historical reasons, the overwhelming majority of drivers are currently males; this would elevate fatality rates. Life expectancy is also quite similar among the high-income countries.[22]

What vary are birth rates: the higher the birth rate, the higher the percentage of young people in the population, and the lower the **median age** – and the higher, all else being equal, the fatality rate (because there are many young drivers). But even here, the differences are mostly small among the high-income countries. In the United States, the median age of the population was 37.8 in 2014, ranging from 30.5 in Utah to 44.1 in Maine.[23] In the European and East Asian comparison countries, Australia, New Zealand, and Canada, median age is usually somewhat higher than in the United States, ranging from 36.1 to 46.5. In the three Latin American comparison countries it is slightly lower, ranging from 33.7 to 35.0. Only in the Middle East are median ages substantially lower, often less than 30; that may be associated with higher fatality rates.[24]

Driver experience: As stated above, inexperience is one likely factor raising fatality rates for young drivers. It is not easy to tease out the role of inexperience from other factors, such as risk-taking behavior, in a society where nearly everybody starts driving at almost the same age. However, a recent study in New Jersey compared crash involvement rates (not necessarily fatal crashes) for drivers of the same age with varying levels of experience, finding significant differences. Freshly-licensed 19- and 20-year-olds had approximately twice as high a crash rate as drivers the same age that had already started driving on or before their 17th birthdays.[25] Driver

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[21] Ibid., pp. 69 and 88; Evans, L. (1991). *Traffic safety and the driver.* New York: Van Nostrand Reinhold, pp. 100-128; Kahane, C. J. (2013, May). *Injury vulnerability and effectiveness of occupant protection technologies for older occupants and women*. (Report No. DOT HS 811 766, pp. 230-233). Washington, DC: National Highway Traffic Safety Administration. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811766; Dang, J. N. (2008, May). *Statistical analysis of alcohol-related driving trends, 1982-2005*. (Report No. DOT HS 810 942). Washington, DC: National Highway Traffic Safety Administration. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/810942

[22] Sandbox Networks, Inc. publishing as Infoplease. (n.a.). Life expectancy for countries, 2015. m(Web page). Retrieved from the web site at infoplease.com/world/statistics/life-expectancy-country.html

[23] Statistia, Inc. (n.a.). Median age of U.S. population in 2015, by state (Web page). Retrieved from the web site at statista.com/statistics/208048/median-age-of-population-in-the-usa-by-state

[24] Central Intelligence Agency (n.a.). The World Factbook: Median Age, Country Comparison to the World. Retrieved from the CIA web site at cia.gov/library/publications/the-world-factbook/fields/2177.html

[25] Curry, A. E., Pfeiffer, M. R., Durbin, D. R., Elliott, M. R., and Kim, K. H. (2014, October). *Young driver crash rates in New Jersey by driving experience, age, and license phase*. Washington, DC: AAA Foundation for Traffic Safety. Available at aaafoundation.org/sites/default/files/OlderVsYoungerNovicesNJ-FINAL%20FTS%20Format.pdf

inexperience could be a factor raising fatality rates in newly industrialized countries where much of the population, not just the teenagers, have recently started driving.

Vehicle type: Motorcycles are much less safe than passenger cars or light trucks and vans (LTV). For example, in the United States during 2013, the occupant fatality rate per 100 million VMT was 22.96 for motorcycles, 0.87 for passenger cars, and 0.71 for LTVs.[26] This will place countries or States with extensive use of motorcycles at a disadvantage. However, it would appear that motorcycle use in high-income countries during 2013 is relatively consistent.

Climate-related effects: In the far north, traffic fatalities decrease during the winter, whereas they stay about the same year-round in warmer climates. For example, in 2013 plus 2014, Massachusetts, Michigan, Minnesota, New York, and Wisconsin experienced 1,934 fatalities in June, July, and August but only 1,347 in January, February, and December (31% drop), whereas California, Florida, and Texas experienced 4,449 and 4,351 (2% drop).[27] Yet the ratio of winter to summer VMT was similar in both groups of States.[28] In other words, the VMT fatality risk declines during winter in those northern States, primarily because there is little travel by motorcycle. Perhaps, also, leisure travel in cars and LTVs declines in winter (VMT with higher risk), while people continue to drive to work, basic shopping, and other essential needs (low-risk VMT). In any case, this constitutes a net advantage for the places with harsh winters.

Other environmental effects: Roadside terrain, vegetation, and man-made development affect the distribution of fatal crashes. For example, during 2013, 43 percent of the single-vehicle crash fatalities in richly forested Virginia were collisions with trees, but only 3 percent in Utah. Collisions with utility poles are common in New England (18% of single-vehicle crash fatalities in Massachusetts), where roads are often illuminated, but not in the interior West (2% of Colorado crashes).[29]

Alcohol: Drunk driving gravely increases risk. Studies have estimated that a driver has 10 to 40 times the risk of a fatal crash per mile of driving drunk than if that same driver had been sober (the increase depending on the blood alcohol concentration).[30] During 2013, 31 percent of the fatal crashes in the United States involved at least one driver with BAC ≥.08.[31] There is a worldwide effort to curb drunk driving. Specifically, all of the States have 0.08 BAC laws in effect.[32] All of our 43 high-income comparison countries either have a BAC law of.08 or lower

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[26] NHTSA, 2016a, pp. 30, 32, and 36.
[27] Analyses of 2013 and 2014 FARS data performed for this report.
[28] Based on FHWA estimates for 2013 (available at fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm), VMT was 90 billion miles in the 5 Northern States during the winter and 104 billion miles during the summer; in California, Florida and Texas it was 177 billion miles in winter and 198 billion miles in summer.
[29] Analyses of 2013 FARS data performed for this report.
[30] Evans (1991), pp. 176-188; Levitt, S. D., and Porter, J. (2001). How dangerous are drinking drivers? *Journal of Political Economy, 109, 6*, pp. 1198-1237.
[31] NHTSA. (2014, December). *Traffic safety facts 2013 data – alcohol-impaired driving* (Report No. DOT HS 812 102). Washington, DC: Author. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812102
[32] NHTSA. (2016, April). *Digest of impaired driving and selected beverage control laws, twenty-ninth edition* (Report No. DOT HS 812 267). Washington, DC: Author. Available at nhtsa.gov/staticfiles/nti/pdf/812267_2014-ImpairedDrivingDigest.pdf

in effect or they entirely ban alcoholic beverages.[33] States or countries where much of the population abstains from alcoholic beverages (e.g., Utah) have a safety advantage.

Seat belts: NHTSA estimates that buckling up 3-point seat belts reduces fatality risk by 45 percent for front seat occupants and by 44 percent for rear seat passengers of cars; by 60 percent for front seat occupants and 73 percent for rear seat passengers of LTVs.[34] In 2013 seat belt use in the United States was 87 percent for drivers.[35] All except one of the States had seat belt laws for drivers and right front passengers, many also for rear seat passengers; in our 44 States, drivers' belt use ranged from 73 percent up to 98 percent (in Oregon) during 2013.[36] Each of the 43 high-income comparison countries also had laws requiring seat belt use for drivers in 2013, many also for front and rear seat passengers. In the 36 countries that surveyed belt use, it ranged from 20 percent up to 99 percent (in France and Japan); the median was 91 percent.[37] Thus, belt use is fairly high around the world; in those States or countries that still have much higher-than-average fatality rates, it is in most cases due to factors other than low belt use.

3. Findings: rank order, within groups, of the States and comparison countries

Population density and concentration, as discussed above, is a key "given" affecting VMT fatality rates. The closer people live together, the higher the proportion of their mileage on city streets and on expressways, where fatality rates are much lower than on lower-standard rural roads. The population per square kilometer is an accurate and consistent measure of density. This will be our first criterion for classifying the States and high-income comparison countries into four somewhat more uniform groups. The first of our four groups will consist of all the States and countries with more than 150 inhabitants per square kilometer. This is a characteristic feature of many of the heavily industrialized countries of Western Europe and the East Asian industrial "tiger" countries – but only six States, all in the Northeast, New York barely making the cut at 155.

Table 1 and Figure 1 rank the fatality rates from lowest to highest for the 6 States and 15 countries with more than 150 people per square km. Results for comparison countries are printed with blue shading in Table 1 and blue bars in Figure 1 (with light tips if the rate exceeds the scale of the chart), while data for the States is on a plain white background in Table 1 and yellow bars in Figure 1 – to help illustrate where the States fit in relative to other countries. Table 1 also presents statistics: the first three columns of Table 1 present the fatality rate per 100 million VMT, the number of crash fatalities (as estimated by WHO), and the billions of VMT. The fatality rates range from 0.578 in the United Kingdom up to 7.854.

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[33] WHO, 2015, pp. 32 and 280-287; Podda, F. (2012, April). *Drunk driving: towards zero tolerance*. Brussels: European Transport Safety Council. Available at etsc.eu/wp-content/uploads/2014/02/Drink_Driving_Towards_Zero_Tolerance.pdf

[34] Kahane, 2015, p. 201.

[35] Pickrell, T. M., & Liu, C. (2014, January). *Seat belt use in 2013 – overall results* (Report No. DOT HS 811 875). Washington, DC: National Highway Traffic Safety Administration. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811875

[36] Chen, Y. Y. (2014, May). *Seat belt use in 2013–use rates in the states and territories* (Report No. DOT HS 812 030). Washington, DC: National Highway Traffic Safety Administration. Available at crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812030

[37] WHO, 2015, pp. 296-303.

An “eyeball” review of Table 1 or Figure 1 suggests how closely our six densely populated States compare with the highly industrialized countries of Western Europe and Israel. Massachusetts (0.61) matches with the United Kingdom (0.58) and Switzerland (0.69); New Jersey (0.76) with the Netherlands (0.73) and Germany (0.79); Rhode Island (0.85) and Maryland (0.85) with Israel (0.87); whereas Connecticut (0.91) and New York (0.96) are a bit safer than Italy (1.09) and Belgium (1.17). The four East Asian countries, Japan, Taiwan, Singapore, and South Korea, although highly industrialized, affluent, and densely populated, all have higher rates; so do Bahrain, Kuwait, Qatar, and Trinidad & Tobago. That is the visual impression from Table 1 and Figure 1; after defining and tabulating all four groups, we will statistically test the differences in the rank orderings of the States and the comparison countries.

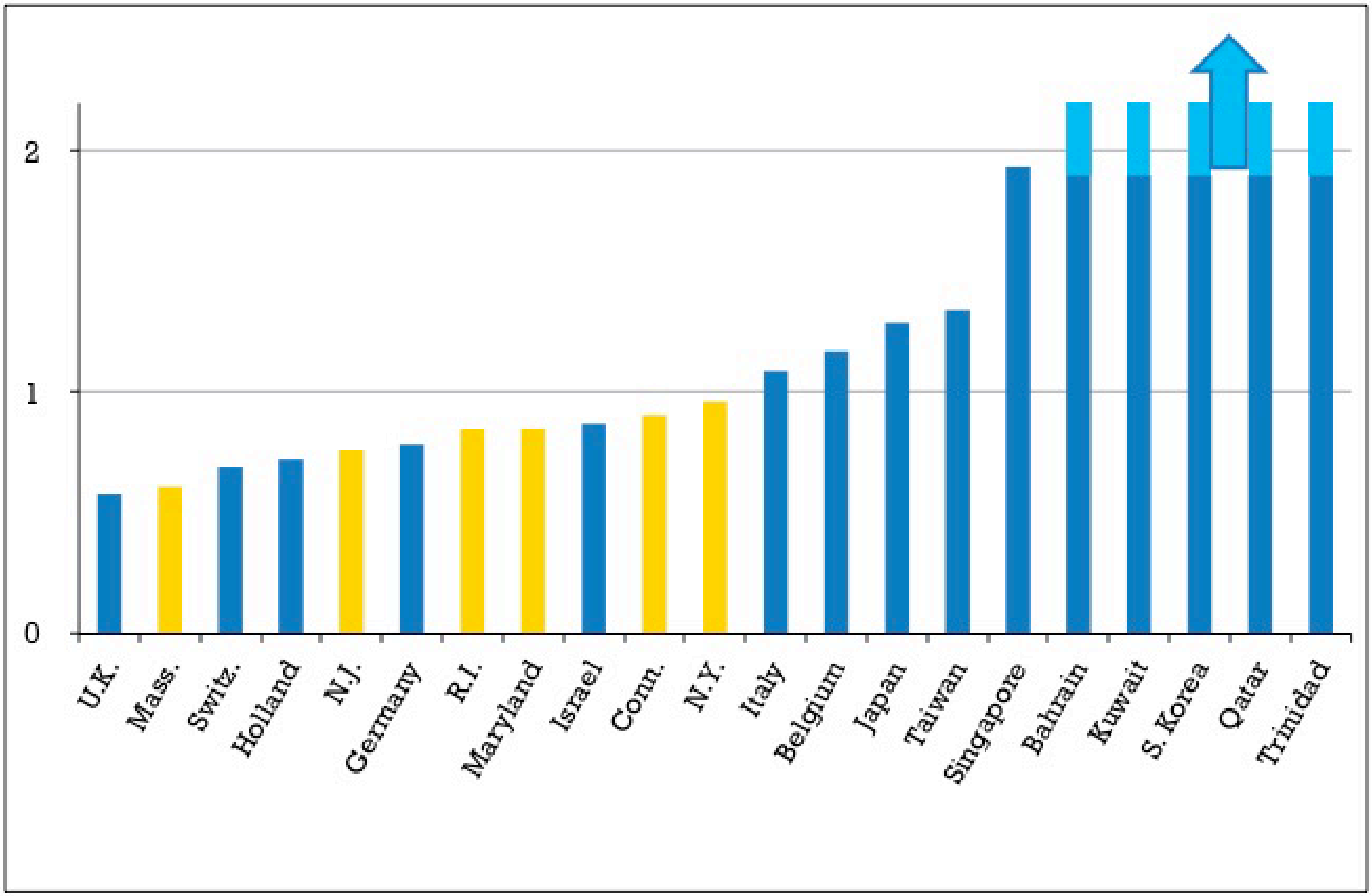
The four middle columns of Table 1 provide demographic data: people per square mile, percentage of the population living in metropolitan areas with 500,000 people or more, gross national income per capita, and the median age of the population. Population density ranges from 155 in New York State to 8,227 in Singapore; it is usually over 200. As discussed above, the definition of “metropolitan area” is not consistent across countries; as a result, the percent in large metro areas varies considerably – but all of these places are highly urbanized. Almost all of them are also quite affluent, as indicated by the GNICAP. The European and East Asian countries tend to have an aging population, as do some New England States.

Table 1: Fatality Rate per 100 Million VMT in States and High-Income Countries
With Population Densities **Greater than 150** People per Square Kilometer

	Fatalities & VMT			Demographics				Safety Measures		
	VMT Fatality Rate	Estim Fatals (WHO)	VMT Billions	People Sq Km	Pct in Metros ≥ 500K	Gross Nat'l Income per Cap	Median Age	Pct Seat Belt Use	Pct Fatals Attrib Alcohol	Pct Fatals Motor-Cyclists
United Kingdom	**0.578**	1,827	316.03	162	40	41,680	40.4	90	16	19
Massachusetts	**0.610**	339	55.58	313	85	68,492	39.4	75	36	12
Switzerland	**0.691**	269	38.93	199	24	90,760	42.1	92	16	20
Netherlands	**0.725**	574	79.14	406	30	51,060	42.3	97	19	13
New Jersey	**0.761**	564	74.14	438	95	67,165	39.4	91	27	10
Germany	**0.785**	3,540	450.93	231	29	47,270	**46.5**	97	9	19
Rhode Island	**0.848**	68	8.01	387	100	56,347	39.8	86	38	17
Maryland	**0.849**	484	57.03	209	81	65,090	38.3	91	30	13
Israel	**0.871**	277	31.82	358	72	33,930	**29.6**	97	**3**	14
Connecticut	**0.907**	287	31.64	271	80	73,778	40.5	87	**41**	20
New York State	**0.963**	1,248	129.56	155	72	65,245	38.2	91	30	14
Italy	**1.087**	3,721	342.38	203	32	35,860	**44.8**	**64**	25	26
Belgium	**1.172**	746	63.64	366	33	46,290	41.4	86	25	16
Japan	**1.288**	5,971	463.65	336	66	46,330	**46.5**	**99**	6	17
Taiwan	**1.339**	2,024	151.15*	653	65	20,925	39.7	unk	unk	unk
Singapore	**1.936**	197	10.18*	8,227	100	54,040	34.0	unk	11	**46**
Bahrain	**2.223**	107	4.81*	1,959	100	19,700	31.8	**20**	**3**	**3**
Kuwait	**3.002**	629	20.95*	201	100	45,130	**29.0**	unk	unk	unk
South Korea	**3.224**	5,931	183.95	500	76	25,920	40.8	87	14	16
Qatar	**4.316**	330	7.65*	214	75	86,790	32.8	unk	unk	**0**
Trinidad & Tobago	**7.854**	189	2.41*	263	39	15,760	35.0	95	unk	**3**

* Estimated from number of registered vehicles, median age, and gross national income per capita

Figure 1: Fatality Rate per 100 Million VMT in States and High-Income Countries
With Population Densities **Greater than 150** People per Square Kilometer



The three right columns of Table 1 present three measures that may be indicators of safety (or the lack of it): the observed, on-the-road percentage of drivers using seat belts;[38] the percentage of fatalities attributed to alcohol;[39] and the percentage of fatalities that are motorcycle riders.[40] The purpose is to see if good performance levels on these measures are strongly associated with low fatality rates. For these three measures as well as for median age, levels especially favorable to safety are printed in bold green type – namely, high median age indicating a low proportion of young drivers, high belt use, low percentage of fatalities attributed to alcohol, and low percentage of motorcyclists among fatalities. Bold red type indicates levels associated with higher risk.

The alcohol variable, however, is probably not consistently measured across countries. The United States has a longstanding effort to obtain BAC data on fatalities whenever possible and an imputation algorithm to estimate BAC if there is no test data. That might not be the procedure in all the other countries, as suggested by surprisingly low reported percentages in some countries where there is little taboo against drinking. Furthermore, the alcohol and motorcycle variables are outcome-based (i.e., percentage of fatal crashes) and that can sometimes obscure their meaning – namely, if a State or country is extraordinarily safe for sober drivers of cars and LTVs, a high percentage of the residual fatalities will, of necessity, be drunk drivers or motorcyclists, even if that place does not have a high incidence of drunk drivers or large numbers of motorcyclists.

Generally speaking, Table 1 does not show a concentration of bold green print at the top and bold red print in the lower section. Table 1 is a cross-sectional analysis of fatality rates in 2013. As discussed above, by 2013, most States and high-income countries had effective safety programs and practices in place for some time. Furthermore, if a safety measure proves highly effective in one State or country, it may quickly spread to others, because safety information is widely shared. Thus, demographic and other factors may be accounting for more of the cross-sectional variation in fatality rates. By contrast, in a longitudinal study comparing fatality rates in 2013 to, say, 1966, the effects of safety programs and practices would be paramount. A NHTSA analysis showed that most of the 80-percent reduction in VMT fatality rates over the past 50 years in the United States is attributable to vehicle, driver, and road safety improvements.[41] Analyses of other countries show similar dramatic improvements over time.

The higher fatality rates in some East Asian and other non-European countries might also reflect driver inexperience if much of the adult population may have acquired their first motor vehicles fairly recently. Low alcohol consumption in the Middle East has a safety benefit, but it is partly offset by a high proportion of young drivers. A preponderance of male drivers may also push up fatality rates in some of those countries. The high use of motorcycles in Singapore may be contributing to the fatality rate. Bahrain and Italy have relatively lower belt use despite seat belt laws.

The remaining States and countries all have fewer than 150 inhabitants per square mile. Climate is another "given" that affects VMT fatality rates, because cold winters decrease motorcycle

[38] Sources – States: Chen, 2014; countries: WHO, 2015, pp. 296-303.
[39] Sources – States: NHTSA, 2014. *data – alcohol-impaired driving*; countries: WHO, 2015, pp. 280-287
[40] Sources – States: 2013 FARS data; countries: WHO, 2015, individual country profiles.
[41] Kahane, 2015, pp. x-xvi.

riding and perhaps also some types of higher-risk non-essential travel. Even though climate is not that important a factor, it is useful as a grouping variable, because there are some States and countries with remarkably similar characteristics: very cold winters, large parts of the country that are thinly populated with limited economic activity, and one or more strongly industrialized, urbanized belts. These five States and eight countries constitute our second group: the tier of northernmost States with large urban areas, Canada, and Scandinavia. Also in this group, but perhaps not matching up quite so well (except for climate) are Russia, Estonia, and Latvia. The specific criterion, in addition to cold winters, is that at least 20 percent of the population lives in metropolitan areas ≥ 500,000.[42] Table 2 and Figure 2 compare the fatality rates of these States and countries.

Here, the northernmost States match up fairly well with Canada and Scandinavia. Sweden (0.57) is somewhat safer than any of the States, but Minnesota (0.70) is not far from Denmark (0.64) and Norway (0.70); Washington State (0.79) is close to Finland (0.77); and Wisconsin (1.02) and Michigan (1.03) resemble Canada (1.00). New Hampshire, with somewhat lower belt use, has the highest rate among the States (1.09) but not as high as Estonia (1.45). Latvia and Russia are considerably higher. All of these places have relatively old populations. Except for the Eastern European countries they are quite affluent. Canada, Estonia, Latvia, and Russia have relatively few motorcyclist fatalities.

The remaining States and countries are split into two groups, based on the proportion of the population living in metropolitan areas ≥ 500,000. Because the definition of metropolitan area varies across countries, the criterion will be applied separately for the United States and elsewhere, as follows. Half of the remaining States, the ones more metropolitan than average, are in Group 3 and the other half, the less metropolitan ones, are in Group 4; likewise, half the countries are in Group 3 and half are in Group 4. Thus, Group 3 includes the 17 States with 43 percent or more of the population in large metropolitan areas, whereas Group 4 includes the 16 States with 41 percent or fewer in large metro areas. Group 3 includes 10 countries with 30 percent or more in metro areas; Group 4, the 10 countries with 26 percent or fewer in the metro areas. All States and countries in Groups 3 and 4 have fewer than 150 inhabitants per square mile. All have relatively temperate climates – except Idaho, Maine, Montana, and Lithuania, which have cold winters but were not included in Group 2 because fewer than 20 percent of the people live in large metro areas.

[42] Southeastern New Hampshire is part of Boston's metropolitan area.

Table 2: Fatality Rate per 100 Million VMT in States and High-Income Countries
With **Cold Winters**, Many Sparsely Populated Areas, But Some Large Cities (At Least 20% in Metro Areas ≥ 500,000)

	Fatalities & VMT			Demographics				Safety Measures		
	VMT Fatality Rate	Estim Fatals (WHO)	VMT Billions	People Sq Km	Pct in Metros ≥ 500K	Gross Nat'l Income per Cap	Median Age	Pct Seat Belt Use	Pct Fatals Attrib Alcohol	Pct Fatals Motor-Cyclists
Sweden	**0.567**	272	47.96	22	41	61,760	41.2	**98**	19	17
Denmark	**0.638**	196	30.73	131	23	61,680	41.8	94	unk	14
Minnesota	**0.701**	403	57.50	24	49	57,896	37.8	95	25	16
Norway	**0.704**	192	27.29	13	30	102,610	39.1	96	17	13
Finland	**0.766**	258	33.66	16	22	48,820	42.4	91	22	11
Washington State	**0.786**	454	57.77	34	56	56,877	37.5	95	34	17
Canada	**0.999**	2,114	211.70	4	49	52,200	41.8	96	34	**8**
Wisconsin	**1.024**	565	55.18	38	30	50,770	39.2	82	33	16
Michigan	**1.026**	986	96.11	68	43	46,962	39.6	93	27	15
New Hampshire	**1.093**	141	12.90	53	32	58,937	42.5	**73**	34	18
Estonia	**1.448**	90	6.21	28	42	17,690	42.1	94	25	**6**
Latvia	**3.569**	205	5.74**	31	30	15,280	42.9	83	6	**7**
Russia	**8.711**	27,025	310.24*	8	34	13,850	39.1	**74**	9	**4**

* Estimated from number of registered vehicles, median age, and gross national income per capita
** Estimated from passenger kilometers of travel

Figure 2: Fatality Rate per 100 Million VMT in States and High-Income Countries
With **Cold Winters**, Many Sparsely Populated Areas, But Some Large Cities (at Least 20% in Metro Areas ≥ 500,000)

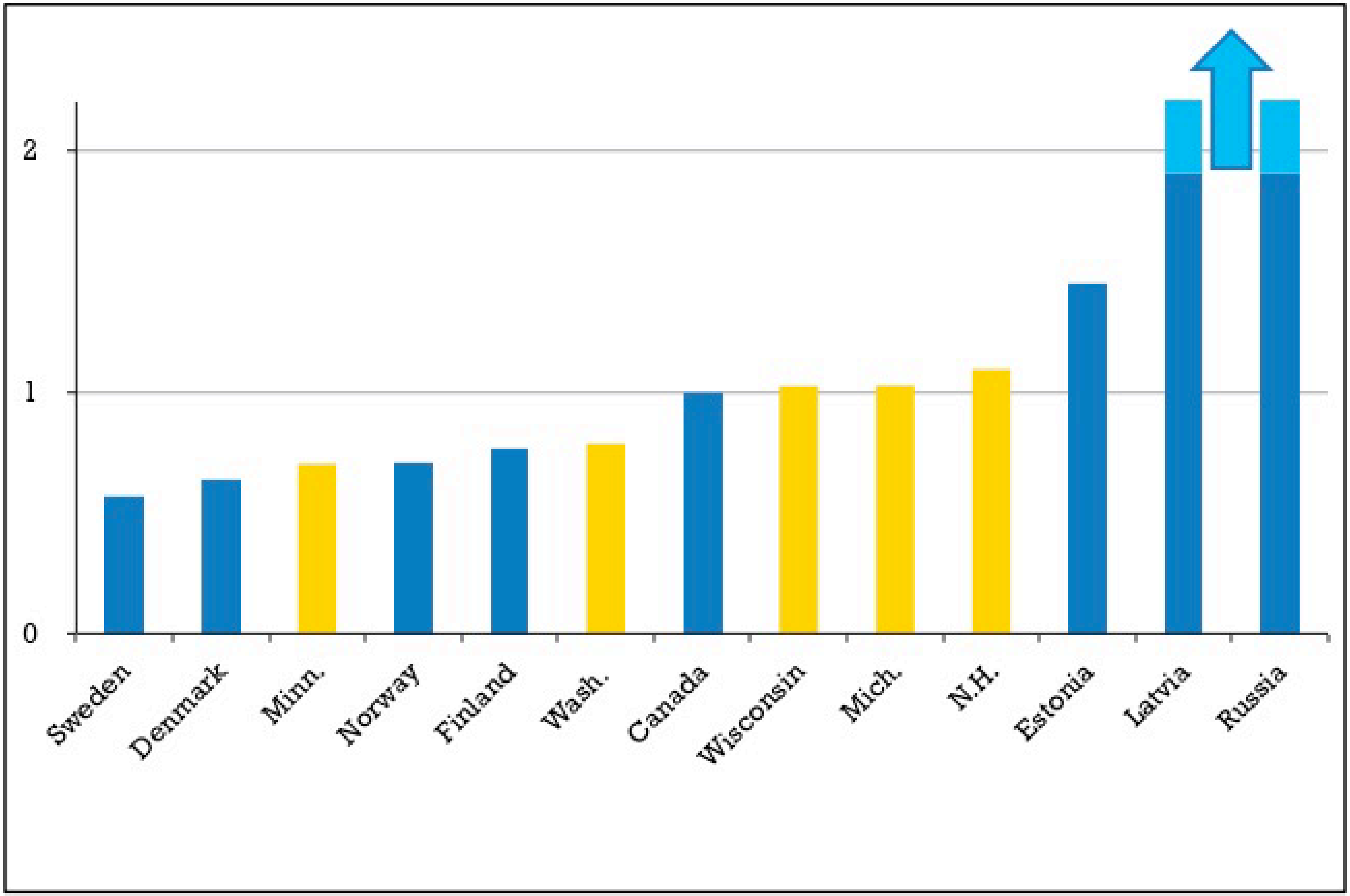


Table 3 and Figure 3 compare the fatality rates of the States and countries in Group 3. The 17 States in Group 3 have quite a range of fatality rates, from Utah at 0.86 to Oklahoma at 1.47. Australia (0.84), France, New Zealand, Spain, and Portugal (1.40) cover almost the same range. Australia (0.84) is close to Utah (0.86), France (0.93) between Ohio (0.91) and Virginia (0.94), New Zealand (1.08) not far from Georgia (1.12), Spain (1.26) between Pennsylvania (1.25) and Florida (1.29), and Portugal (1.40) close to Texas (1.46). Greece (1.99) is somewhat higher than any of the States. The four countries outside Europe and ANZAC are a lot higher. Utah has the highest proportion of young people among the States, but this is more than compensated by the lowest proportion of fatalities attributable to alcohol. Uruguay, Greece, and Hawaii have high proportions of motorcyclist fatalities; in addition, belt use is relatively low in Uruguay. Texas has a high proportion of fatalities attributable to alcohol. The Middle Eastern and Latin American countries have relatively higher proportions of young drivers; there may also be a preponderance of male drivers in some of those countries.

Group 4 consists of places like Montana that are quite sparsely populated; like Slovenia that are somewhat densely populated but have no really large cities; or like Austria and Kentucky that have a large metropolitan area or two, but most of the population is widely dispersed and outside that metropolitan area(s). With populations that are predominantly rural and/or dispersed among numerous small cities and towns, these places are likely to have extensive grids of rural roads, many not built to expressway standards – roads that tend to have high VMT fatality rates. It is noteworthy that there are only two Western European countries (Ireland and Austria) in the group, but there are 16 States in the group. Much of the United States is more rural than just about any part of Western Europe.

Table 4 and Figure 4 compare the fatality rates of these States and countries. The fatality rates of the 16 States in Group 4 range widely, from Oregon at 0.96 to Montana at 2.01. One country, Ireland, is an outlier in this group, with a much lower fatality rate (0.63). Otherwise, Austria (0.94) is fairly close to Oregon (0.96), Iowa (1.04), Maine (1.05) and Indiana (1.05); Slovenia (1.23) is between Nebraska (1.14) and North Carolina (1.28); and Cyprus (1.90), Czechia (2.23), and Lithuania (2.30) are not far from West Virginia (1.80) and Montana (2.01). Poland, Slovakia, Croatia, and Oman have substantially higher rates. Oregon, the safest State in this group, has 98 percent use of seat belts; Maine, also at the low end, has the lowest percentage of young people among the States. Among the jurisdictions with the higher fatality rates, Mississippi, Montana, and Croatia have relatively low belt use; South Carolina and Montana have a high percentage of fatalities attributable to alcohol; Cyprus has numerous motorcyclist fatalities; and Oman has an exceptionally young population.

Table 3: Fatality Rate per 100 Million VMT in States and High-Income Countries
With **Higher-Than-Median** Percent in Metro Areas ≥ 500,000, < 150 People/Sq. Km., Temperate Climate

	Fatalities & VMT			Demographics				Safety Measures		
	VMT Fatality Rate	Estim Fatals (WHO)	VMT Billions	People Sq Km	Pct in Metros ≥ 500K	Gross Nat'l Income per Cap	Median Age	Pct Seat Belt Use	Pct Fatals Attrib Alcohol	Pct Fatals Motor-Cyclists
Australia	**0.841**	1,252	148.92	3	58	65,390	38.4	97	30	18
Utah	**0.861**	229	26.60	11	80	43,335	**30.5**	82	**17**	14
Ohio	**0.907**	1,030	113.59	107	54	49,207	39.4	85	27	13
France	**0.926**	3,268	352.81	118	32	43,460	41.1	**99**	29	24
Virginia	**0.937**	770	82.14	69	53	58,967	37.7	80	34	11
California	**0.960**	3,123	325.39	84	73	56,334	36.0	97	29	15
Illinois	**0.986**	1,032	104.72	86	70	56,128	37.5	94	32	15
Colorado	**1.037**	490	47.27	16	61	56,528	36.3	82	30	18
Hawaii	**1.038**	106	10.21	73	61	55,137	38.1	94	33	**28**
New Zealand	**1.084**	272	25.11	17	30	35,550	37.7	96	31	15
Nevada	**1.113**	273	24.54	7	81	46,792	37.4	95	30	22
Georgia	**1.115**	1,227	110.01	55	51	46,176	36.1	96	25	10
Missouri	**1.129**	788	69.78	31	45	48,906	38.5	80	33	10
Kansas	**1.195**	364	30.45	13	46	52,395	36.2	81	29	10
New Mexico	**1.247**	323	25.90	6	50	43,934	37.2	92	30	13
Pennsylvania	**1.250**	1,258	100.63	106	47	54,626	40.7	84	30	15
Spain	**1.256**	1,730	137.70	93	39	29,920	42.0	90	17	21
Florida	**1.288**	2,506	194.61	114	67	50,528	41.6	89	28	20
Portugal	**1.403**	828	59.03	115	39	21,260	41.5	96	31	20
Texas	**1.462**	3,521	240.85	31	62	51,940	34.3	90	**40**	15
Arizona	**1.463**	884	60.43	18	79	45,061	36.9	85	26	18
Oklahoma	**1.466**	706	48.15	19	43	48,852	36.2	84	25	14
Greece	**1.988**	1,013	50.95	84	39	22,640	43.8	77	unk	**32**
United Arab Emirates	**3.573**	1,021	28.57*	115	46	38,360	30.3	unk	unk	**3**
Uruguay	**3.771**	567	15.03*	20	38	15,180	34.5	**62**	38	**53**
Chile	**6.583**	2,179	33.10*	24	45	15,230	33.7	82	14	7
Saudi Arabia	**11.101**	7,898	71.15*	14	61	26,260	**26.8**	unk	unk	unk

* Estimated from number of registered vehicles, median age, and gross national income per capita

Figure 3: Fatality Rate per 100 Million VMT in States and High-Income Countries
With **Higher-Than-Median** Percent in Metro Areas ≥ 500,000, < 150 People/Sq. Km., Temperate Climate

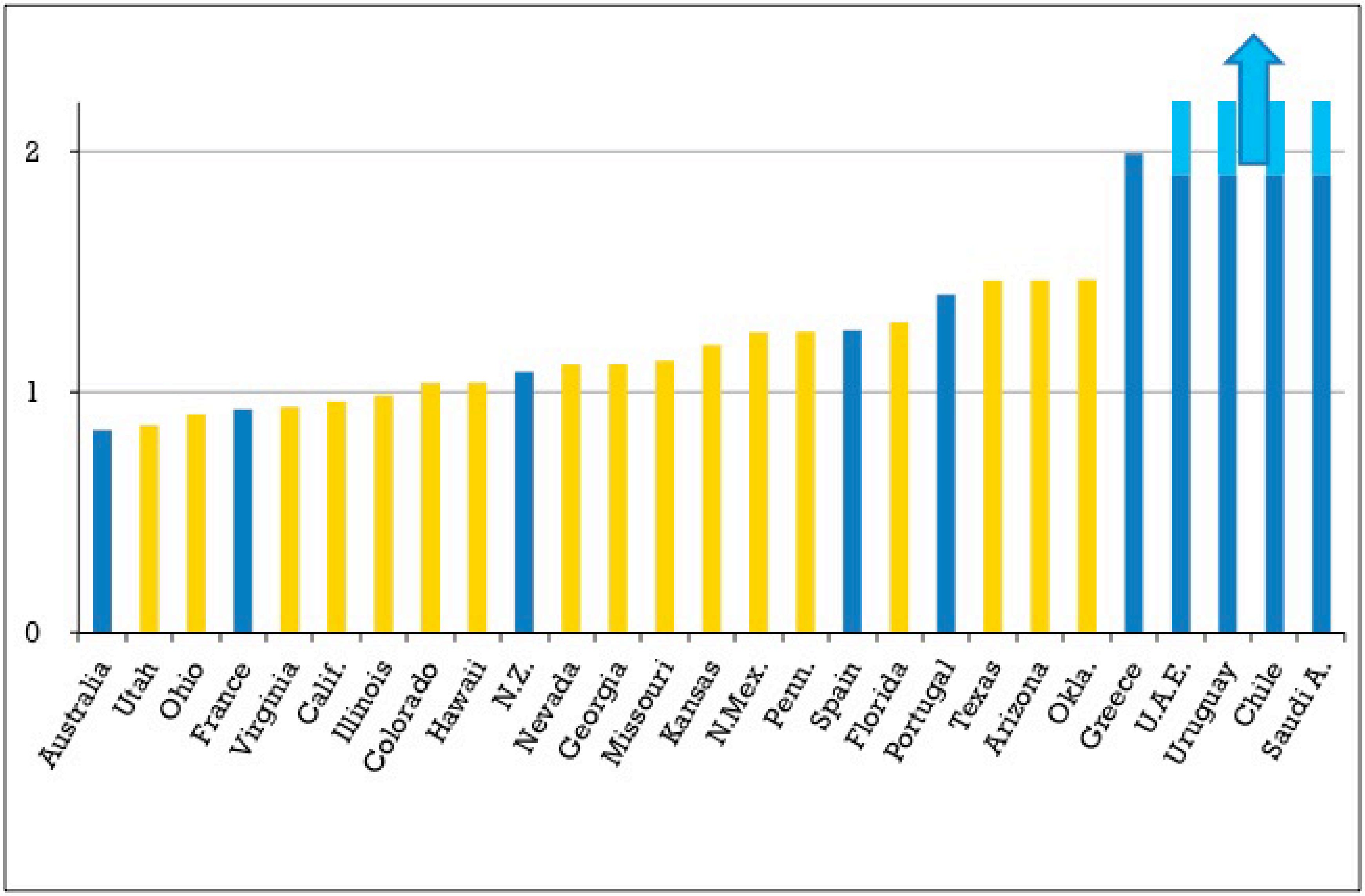
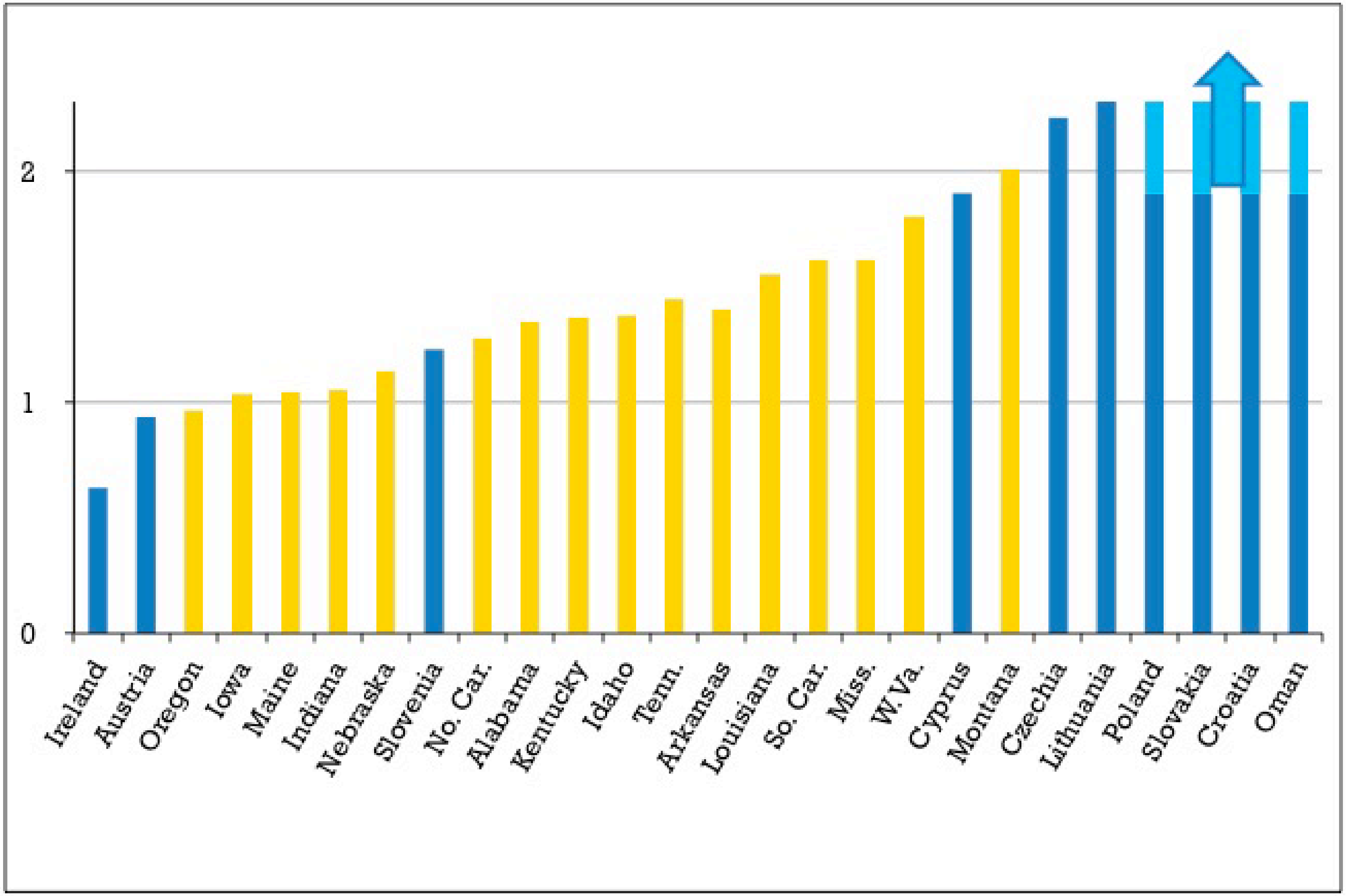


Table 4: Fatality Rate per 100 Million VMT in States and High-Income Countries
With **Lower-Than-Median** Percent in Metro Areas ≥ 500,000, < 150 People/Sq. Km., Temperate Climate

	Fatalities & VMT			Demographics				Safety Measures		
	VMT Fatality Rate	Estim Fatals (WHO)	VMT Billions	People Sq Km	Pct in Metros ≥ 500K	Gross Nat'l Income per Cap	Median Age	Pct Seat Belt Use	Pct Fatals Attrib Alcohol	Pct Fatals Motor-Cyclists
Ireland	**0.630**	188	29.84	67	26	43,110	36.1	94	16	14
Austria	**0.937**	455	48.53	102	21	50,430	43.6	87	7	22
Oregon	**0.963**	326	33.85	14	39	48,577	39.3	**98**	33	11
Iowa	**1.040**	330	31.72	20	20	52,760	38.2	92	32	13
Maine	**1.045**	151	14.45	16	0	49,447	**44.1**	83	29	10
Indiana	**1.050**	815	77.58	65	41	46,217	37.4	92	25	15
Nebraska	**1.136**	220	19.37	9	35	54,034	36.2	79	28	**7**
Slovenia	**1.228**	132	10.75	103	0	23,210	43.8	93	30	17
North Carolina	**1.275**	1,342	105.26	64	24	46,401	38.3	89	29	15
Alabama	**1.347**	887	65.85	34	17	44,618	38.6	97	31	**9**
Kentucky	**1.362**	664	48.75	39	27	43,886	38.5	85	26	14
Idaho	**1.379**	223	16.17	6	0	42,268	35.9	82	27	12
Tennessee	**1.444**	1,036	71.77	53	40	47,189	38.6	85	28	14
Arkansas	**1.505**	503	33.43	20	2	43,488	37.8	77	25	13
Louisiana	**1.551**	732	47.18	40	34	49,362	36.1	83	33	12
South Carolina	**1.616**	799	49.43	51	33	42,916	38.8	92	**44**	19
Mississippi	**1.619**	638	39.41	23	8	41,422	36.7	**74**	34	**6**
West Virginia	**1.799**	346	19.24	29	0	43,180	41.9	82	27	**7**
Cyprus	**1.904**	59	3.10**	126	0	25,210	36.1	86	14	**34**
Montana	**2.012**	238	11.83	2	0	46,803	39.6	**74**	**40**	15
Czechia	**2.231**	654	29.31	137	13	18,950	41.3	97	9	11
Lithuania	**2.301**	320	13.91**	46	17	14,900	43.1	unk	16	**7**
Poland	**3.179**	3,931	123.65	118	21	13,240	39.9	83	16	**9**
Slovakia	**3.621**	360	9.94	111	0	17,810	39.6	unk	23	**8**
Croatia	**4.115**	395	9.60*	75	16	13,430	42.6	**70**	19	17
Oman	**7.668**	924	12.05*	13	23	25,150	**25.1**	97	**< 1**	**2**

* Estimated from number of registered vehicles, median age, and gross national income per capita
** Estimated from passenger kilometers of travel

Figure 4: Fatality Rate per 100 Million VMT in States and High-Income Countries
With **Lower-Than-Median** Percent in Metro Areas ≥ 500,000, < 150 People/Sq. Km., Temperate Climate



4. Statistical analysis of the rank orderings

Tables 1 to 4 showed a generally similar pattern – namely, an interleaving of the States and the countries of Western, Northern, and Southern Europe, Australia, New Zealand, and Canada; then, higher fatality rates for countries that, although "high income" by World Bank definitions, tended to be less affluent and/or in other parts of the world. Within each table, the "eyeball" impression is: (1) the States would appear to rank somewhat safer if all comparison countries are included, but (2) there is no clear-cut difference if the comparison countries are limited to Western Europe and ANZAC. A statistical test can clarify these initial impressions.

A test of the relative rankings (i.e., non-parametric), rather than the absolute rates is desirable because some countries with very high fatality rates might skew an analysis of variance. The Wilcoxon or Kruskal-Wallis tests can compare the rank orderings of two classes (e.g., the States and the countries) within a single table. Van Elteren extended Wilcoxon's test to compare the rank orderings of two classes over multiple tables: when all the tables are taken into account, does one class rank significantly better overall than the other?[43] When all of the 43 comparison countries are included in the analysis, van Elteren's test shows that the States – on the whole and across the four tables – rank significantly better (two-sided $p < .05$) on VMT fatality rates than the comparison countries that appear in the same table.

Effect of excluding some of the comparison countries: The World Bank's definition of a high-income country in 2013 was GNICAP of $12,746 or more. If we exclude 12 marginally high-income countries and limit the analysis to the 31comparison countries with GNICAP over $20,000, the difference between the States and the comparison countries in the overall rank-order score is not statistically significant. There are 22 comparison countries with GNICAP over $30,000; these countries, whose GNICAP ranges from $33,930 to $102,610, have incomes fairly comparable to the States, which range from $41,422 to $73,778. If we further limit the analysis to these 22 countries, the difference in the ranking of the States and the comparison countries is again not statistically significant.

Alternatively, if we limit the comparison countries to the 20 nations that are in the European Union but were never part of the Eastern Bloc, plus Switzerland, Norway, Australia, New Zealand, and Canada, the difference in the ranking of the States and these 20 comparison countries is likewise not statistically significant. Thus, the statistical test results are consistent

[43] Van Elteren, P. H. (1960). On the combination of independent two-sample tests of Wilcoxon. *Bulletin of the International Statistical Institute*, *37*, pp. 351-361; Lehmann, E. L. (1975). *Nonparametrics: statistical methods based on ranks*. San Francisco: Holden-Day, pp 132-137 and 145; support.sas.com/kb/25/022.html; our situation is analogous to College A challenging College B in 4 sporting events, each of which are individual competitions and each of which will be scored like cross-country races – i.e., summing the rank orders of the finishers on each team, without regard to their actual running times: if each college has 5 runners, the runners from College A finish 1st through 5th and those from College B 6th through 10th, then College A wins the cross-country event by 15 to 40; the total score for each college is the sum of their scores in the 4 sporting events; van Elteren's test will tell us if the differences in the total scores is so large that would not likely have occurred if both colleges had drawn their teams by simple random sampling from a single assemblage of athletes that happened to be in the stadium immediately before the competition – e.g., with both colleges drawing from a single assemblage, we might easily see one college happening to win by a narrow margin such as 109 to 111 or 108 to 112, but it is extremely unlikely that one college would win by 60 to 160; in our analysis, the simple rank-order scores are replaced by modified ridits (percentile scores, essentially) to allow for different numbers of States and countries in the various tables.

with the “eyeball” impressions that: (1) the States rank safer if all comparison countries are included, but (2) there is no significant difference if the comparison countries are limited to Western Europe and ANZAC, or to the more affluent comparison countries.

Sensitivity tests: The States and countries not included in Group 1 (> 150 people per square kilometer) or Group 2 (cold climate) are assigned to Group 3 or 4 depending on the percentage of the population living in metro areas of 500,000 people or more (an indicator of population concentration). The definition of a “metro area” is not necessarily the same in the United States as in other countries; partly because of that, Groups 3 and 4 currently use a different percentage criterion for the United States and elsewhere. An alternative is to define Groups 3 and 4, like Group 1, based on the population density per square kilometer, an unambiguous statistic. In the first sensitivity test, Group 3 will consist of the States and countries (not part of Groups 1 and 2) with 35 to 150 people per square kilometer and Group 4, those with fewer than 35. Here, just as in the baseline analysis, van Elteren’s test shows the States are significantly safer if all comparison countries are included, but there is no significant difference if the comparison countries are limited to those with more than $20,000 GNICAP, those exceeding $30,000 GNICAP, or to the countries of Western/Northern/Southern Europe plus ANZAC.

Another alternative is simply to combine Groups 3 and 4 into a single table. Here, too, van Elteren’s test shows the States are significantly safer if all comparison countries are included, but no significant difference for the three analyses involving the subsets of the comparison countries.

Three of the comparison countries, Australia, Canada, and Russia, cover large, continental areas comparable to the United States, possibly indicating diverse regions within them. VMT fatality rates were obtained for the Australian states and Canadian provinces with populations over 1,000,000; each of these states or provinces was included as a separate comparison “country” in place of Australia and Canada.[44] Again, van Elteren’s test shows the States are significantly safer if all comparison countries are included, but no significant difference for the three analyses involving the subsets of the comparison countries.

Table 5 summarizes the results of all the statistical analyses of the baseline case, the various combinations of comparison countries, and the sensitivity tests.

[44] The 4 maritime provinces of Canada were combined in this analysis; the 5 Australian states, individually, each remain in Group 3; Saskatchewan and the Maritimes, which do not have a metro area > 500,000 move to Group 4, but Alberta, British Columbia, Manitoba, Ontario, and Quebec remain in Group 2.

Table 5: Statistical Analysis of the Rank Orderings of the States and the Comparison Countries
(VMT fatality rates in 2013 across groups 1 to 4)

	Baseline	Gps 3 & 4 Based on Pop/Sq Km	Group 3 and 4 Combined	Canada & Australia Split Up
All comparison countries	+	+	+	+
GNICAP > $20,000	**o**	**o**	**o**	**o**
GNICAP > $30,000	**o**	**o**	**o**	**o**
W/N/S Europe + ANZAC	**o**	**o**	**o**	**o**

\+ States significantly safer than comparison countries (based on rank order within groups 1 to 4)

o No statistically significant difference between the States and the comparison countries

5. Limitations

The study has certain limitations. Some data elements are based on information that might be defined or collected differently in various countries: VMT, income, percentage of population in metropolitan areas, percentage of crashes involving alcohol, and the belt use rate. In some countries, VMT had to be estimated from the number of registered vehicles. For a few countries, the latest data on fatalities and/or VMT was from 2011 or 2012, not 2013.

As discussed above, in a cross-sectional study comparing fatality rates of different jurisdictions at a single time (2013), the effects of demographic and geographic diversity appear to account for most of the differences in traffic fatality rates. An observed difference in fatality rates could easily be due to one country having a slightly younger population, or slightly greater urbanization, or a slightly different vehicle mix or climate. Conversely, an observed similarity of rates could easily be due to a slight demographic or geographic advantage for one country canceling out the effect of a superior safety program in the other country. The data should not be over-analyzed. This report goes about as far as is feasible. It classifies the States and countries into a few groups based on population density, urbanization, and climate to help level the playing field, then applies a not-too-powerful non-parametric test to see if, on the whole, States' rankings within groups were substantially different from countries'. But there are still substantial differences even within each group in jurisdictions' population density, urbanization, per capita income, and the populations' age distribution and driving experience: even two jurisdictions within the same group may not be directly comparable.

6. Summary of principal findings

- Within each of the four groups based on population density, urbanization, and climate (factors that influence fatality rates), the fatality rates per 100 million VMT for the States are similar to the high-income comparison countries of Western, Northern, and Southern Europe as well as ANZAC; they are usually lower than in the high-income countries of Eastern Europe, East Asia, the Middle East, and Latin America.
    - The statistical analysis indicates that the States have significantly lower VMT fatality rates than the comparison countries that appear in the same table, but if the comparison countries are limited to those with the higher incomes or to those located in Western/Northern/Southern Europe and ANZAC, the difference becomes non-significant.
- Within each group, there are order-of-magnitude differences in the fatality rates among the various jurisdictions. These differences are only to a limited extent readily attributable to safety practices (e.g., low fatality rates in places with high use of seat belts), primarily because this is a cross-sectional analysis of fatality rates in 2013. By 2013, most States and high-income countries had effective safety programs and practices in place for some time.
    - Abundant evidence demonstrates the effectiveness of these safety practices in reducing crashes and fatalities, so the combination of high fatality rates with

positive safety practices in certain countries suggests that other factors may be overwhelming the impact of the safety behaviors.

  - The country-to-country differences between programs and safety behaviors were not so great in 2013. Thus, demographic and other factors may be accounting for more of the cross-sectional variation in fatality rates. By contrast, if this had been a longitudinal study comparing fatality rates in 2013 to, say, 1966, the effects of safety programs and practices would have been paramount.

- There are substantial differences between groups. The median fatality rate is close to 1.00 in Groups 1 and 2, 1.20 in Group 3, and 1.47 in Group 4. (Limited to the States, ANZAC, and Western, Northern, and Southern Europe, the medians are 0.80 for Groups 1 and 2, 1.08 for Group 3, and 1.35 for Group 4.) The less densely populated, less urbanized places (Group 3 and, especially, Group 4) have substantially higher fatality risk.

- Much of Western Europe is densely populated and highly urbanized; much of the United States is not. When the Western European countries are compared to the States that most closely resemble their demographics and climate, the ranges of fatality rates for those countries and those States largely overlap and the rankings of these countries and the States are not significantly different.

- These findings reflect an apparent global similarity in traffic safety among jurisdictions with comparable economic, demographic, environmental and population density characteristics. While this analysis is limited to high-income jurisdictions, it is possible that such similarities also exist among nations within other economic levels. This international commonality underlines the need for global collaboration regarding solutions for road safety challenges and reinforces the importance of initiatives such as the United Nations Decade of Action for Road Safety that facilitate sharing of effective techniques for reducing road traffic deaths and injuries.

DOT HS 812 340
October 2016

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12747-102616-v2