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Analyzing road safety in the United States

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ABSTRACT

This paper reviews road safety performance in the United States. The paper develops a framework for assessing dimensions of road safety, and analyzes the importance of economic factors, travel patterns, demographics, road/traffic/vehicle technology, driver behavior, and public policy. Issues and challenges for future road safety research are discussed.

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1. Introduction

More than a million people are killed on the world's roads each year. In the United States, road fatalities averaged more than 40,000 annually for the past 40 years. To be sure, during that 40-year period, the number of vehicle miles traveled (VMT) increased by 125 percent, so the rate of fatalities per 100 million VMT fell from 3.4 in 1975 to 1.1 in 2010, a drop of 67 percent. Even so, in 2010 someone was killed in the United States because of a highway accident on average about every 15 min. In 2007, motor vehicle traffic accidents were the leading cause of death for children, youth and young adults from ages eight through 34 (Subramanian, 2011). Annual monetary costs of accidents are estimated at more than $300 billion per year.[2] There also are persistent concerns about motorcycle and large truck safety (Transportation Research Board, 2010a; U.S DOT, 2010).

The United States also is falling behind in efforts to improve highway safety compared to other countries. Prior to the mid-1960s, the United States had the world's safest roads. By 2002, the U.S. had fallen to sixteenth place in deaths per registered vehicle, and to tenth in terms of deaths per vehicle miles traveled (Evans, 2004). As a recent Transportation Research Board Special Report stated, "In recent decades nearly every high-income country has made more rapid progress than has the United States in reducing the frequency of road traffic deaths and the rate of deaths per kilometer of vehicle travel. As a result, the United States can no longer claim to rank highly in road safety by world standards." (Transportation Research Board, 2010b).

This paper begins with a discussion of challenges in analyzing road safety performance. Next, we present a framework for thinking about the dimensions of highway safety, along with some principal findings from the extensive research literature. We then address four questions regarding highway safety in the United States:

1) What factors have contributed to changes in U.S. highway fatality rates?
2) How much do we know about the relative contributions of these factors?
3) How does the U.S. experience compare to the experience in other developed countries?
4) What are the implications for U.S. highway safety policy?

In addressing these questions, the paper will also address what is known about highway safety, where there are gaps or weaknesses in the research, some of the challenges in addressing these gaps, and the implications for public policy.

2. Challenges in evaluating highway safety policies

Highway safety performance involves a multitude of factors, not limited to driver behavior, vehicle design, and traffic engineering.[3] Changing demographics and changing travel patterns have

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[3] In this paper we use "traffic engineering" to refer to activities related to the construction and use of infrastructure related to traffic networks, including road design and geometry, signage, and signaling and control mechanisms. See Mannering and Washburn (2012).

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contributed to the reduction in the overall highway fatality rate. Public policy has also played an important role. But it is difficult to determine how effective an individual policy has been and thus to determine which policies have been the most effective at improving safety.

2.1. Collecting and understanding basic safety data

Accidents are rare events in travel; accidents involving fatalities are rarer still (Davis, 2000; Evans, 2004).[4] Even just trying to measure the number of accidents is problematic, given widespread underreporting, especially of low severity events (Elvik & Mysen, 1999, pp. 133–140; Hauer & Hakkert, 1988, pp. 1–10; Jeffrey et al., 2009). Crash severity can be measured a number of ways, including the extent of vehicle or property damage or the number and degree of injuries or fatalities.[5] In addition, the problem of analyzing accident data presents challenges of using statistical techniques (which generally are based on random processes) to study essentially deterministic events (consistent with the process of accident investigation and reconstruction).[6] These data challenges have two major implications. First, clear effects in data sets must be interpreted with care; biases in data availability and definitions matter. Second, we tend to focus on fatal accidents and rates because this is the most comprehensive and reliable data.[7] In this paper, the focus is on the risk of highway travel as measured by the highway fatality rate – fatalities per million vehicle miles traveled. The highway fatality rate is an imperfect measure of risk in part because it fails to account for injuries, property damage, or the other consequences of highway accidents. However, such rates do measure the most serious adverse consequence of highway accidents and are more consistent across jurisdictions within the United States and across other countries.

Another challenge in assessing the effectiveness of government policies to improve highway safety is the difficulty in determining the cause or causes of highway accidents. The contrast with assessing the causes of airline accidents is striking. With airline accidents, investigators will typically have both a flight data recorder and a cockpit voice recorder to help reconstruct the accident. With highway accidents, there is no equivalent of a cockpit voice recorder. While some vehicles store pre-accident information that could be accessed as part of an accident investigation, that information is not nearly as detailed as that found in a flight data recorder. Moreover, no guidelines have been established for the circumstances under which such information could be used, who might use it, and how it could be used and interpreted. With airline accidents, a highly trained and experienced team of specialists from the National Transportation Safety Board investigates each major accident with a consistent set of procedures. With highway accidents, the information is typically recorded by law enforcement officers from the local jurisdiction who have limited training in accident investigation and limited time to investigate the accident because of other pressing responsibilities at the accident scene. Moreover (as noted above), many accidents go reported.

With limited information, it may be difficult to determine all of the factors that might have contributed to the accident and what role these factors played in the accident. The role of some possible factors, such as fatigue and distractions, can be particularly difficult to determine. While it may be possible to determine that seatbelts were not being used at the time of an accident, it is more difficult to determine whether a fatality would have been prevented in a specific accident had the seatbelts been used. Similarly, it may be possible to estimate whether a vehicle was exceeding the posted speed limit, but it is more difficult to determine whether the specific accident would have been prevented had the vehicle been going more slowly. While the Blood Alcohol Content (BAC) of a driver killed in an accident can be determined through tests, it is more difficult to determine exactly what role the impairments from alcohol consumption played in the accident. Missing BAC data can also be a problem. BAC test data are only available for about 40 percent of drivers, pedestrians, and pedalcyclists as a result of alcohol tests not being administered or test results not being reported to the Fatality Analysis Reporting System (FARS) (NHTSA, 2002). The missing BAC data is filled in using a statistical technique known as multiple imputation (Subramanian, 2002). In essence, many of the BAC values in the FARS database are constructed rather than the result of direct BAC measurements of accident victims.

Another challenge is that traffic accidents often have multiple causes and there can be interactions among factors such as restraint use, alcohol consumption, speeding, fatigue, and distractions. Such interactions are not well understood and are likely to be important. Still another challenge, as already discussed, is that demographics, travel patterns, and other changes also affect highway safety. This problem of accounting for non-policy factors is, of course, common in policy analysis, but the nature of many highway safety policy interventions can make accounting for these factors particularly difficult. Many interventions are tried as demonstration projects of varying duration and applied to limited geographic areas. In such situations, data for that geographic area and time period on demographic and travel pattern changes may be difficult to obtain. There can be a tendency to simply compare measures of safety before and after the intervention without attempting to control for other factors. Another tendency in these situations is to evaluate such programs on secondary measures, such as reductions in average speeds on the highways or the number of citations given for BAC over the limit, rather than on primary measures such as reductions in speed-related accidents or alcohol-related accidents.

Some interventions can also affect travel patterns which can make their evaluations difficult. For example, it appears that one effect of the national 55 mph speed limit and the accompanying enforcement strategies was that some drivers diverted from rural interstates to parallel non-interstate roads. When rural interstate speed limits were raised after 1987, some of those drivers apparently returned to the interstates, so that while the fatalities on those interstates often increased, the overall fatalities, considering both the interstates and the parallel non-interstate roads actually dropped (Lave & Elias, 1994). Studies that focused only on what

[4] In this paper, we use the term "accidents" rather than "crashes". Some researchers prefer the term "crashes" as they feel "accident" conveys unpredictable, chance occurrences. See Evans (1991, p. 8).

[5] Categorizing injuries is difficult. The most widely accepted scale is the Abbreviated Injury Scale (AIS) (Association for the Advancement of Automotive Medicine, 2006). The AIS scale classifies injuries by body part and by severity on six point scale; if there are multiple injuries, it is common to use the Maximum Abbreviated Injury Scale (MAIS), which is the injury of the greatest severity. Since the AIS requires a doctor's examination and data submission, it is not available for the majority of accidents. However, in its place, an alternative classification that can be and is often used at the crash scene by public safety officials is "KABCO", where K = killed, A = incapacitating injury, B = non-incapacitating injury, C = possible injury, and O = no injury. Another data set that includes useful injury data is the National Automotive Sampling System Crashworthiness Data System (NASS CDS), which reports data from accidents that required vehicle towing due to damage. For background and details on the KABCO and NASS CDS classifications, see National Safety Council (2007).

[6] For discussion of these issues, see Hauer (1980, 1982), Davis (2004). Methodological alternatives to these issues are discussed in Lord and Mannering (2010) and Lord and Bonneson (2005, pp. 88–95).

[7] In the United States, the Fatality Analysis Reporting System (FARS) is the most widely used fatality database. It is maintained by the National Highway Traffic Safety Administration (NHTSA), part of the U.S. Department of Transportation. FARS is a census of all U.S. fatal crashes since January 1, 1975, and is based mainly on police submissions providing details on crash characteristics, vehicles, and driver characteristics and behavior. See NHTSA (2011a).

happened on the rural interstates following raising speed limits missed this important consequence of the policy change. It can be a challenge to recognize all of the potential impacts of a highway safety policy (Malyshkina & Mannering, 2008, pp. 122–127).

Although factors affecting motor vehicle accidents are complex and hard to identify, many techniques have been developed and have provided useful information for evaluating highway safety interventions (Hauer, 1997). Much progress has been made in collision causes, crash prediction models, microsimulation, and "before–after" studies of safety actions (Persaud & Lyon, 2007; Spiegelman, Park, & Rilett, 2011; Transportation Research Board, 2001). More recently, researchers have made progress using spatial data to evaluate safety interventions (Noland & Quddus, 2004; Quddus, 2008; Shankar, Jovanis, Agüero, & Gross, 2008, pp. 1–8).

3. A framework for thinking about highway safety

We can think about traffic safety as being influenced by three broad sets of factors:

1) Road and Traffic Environment and Engineering
2) Vehicle Characteristics and Performance
3) Driver Behavior and Performance.

We discuss each in turn below. Major improvements have been made in both highway and vehicle design, and in crash countermeasures and mitigation. These changes have shaped the safety environment; current research generally indicates that while all three sets of factors remain important, driver behavior and performance is the most significant (Evans, 2004). Among road and vehicle aspects, road and traffic engineering initiatives are generally perceived as having produced larger benefits in terms of risk reduction than changes in vehicles (Evans, 2004). The relative importance of the three broad factors is open to debate, since many road and traffic engineering interventions are implemented by government action, whereas (excepting some regulations) many vehicle decisions are decentralized. Also, the past may not be prologue – it may be that the next major improvements in safety come via changes in vehicle characteristics and operations. But it remains true that, overall, changes in driver behavior and performance have become central to understanding and improving highway safety.

3.1. Road and traffic environment and engineering

Traffic engineering and operating characteristics of road networks provide the background and context for highway safety (AASHTO, 2010; Brockenbrough, 2009). In their landmark handbook, Elvik et al. classify traffic engineering safety initiatives in terms of road design, road maintenance, and traffic control (Elvik, Hoye, Vaa, & Sorensen, 2009).[8] While a detailed discussion of traffic engineering is beyond the scope of this paper, Elvik et al. find that in a global review of road engineering practices, the best safety benefit/cost investments come from separation of traffic (both direction and by vehicle type); from improved intersection design and control (left turn lanes, channelization, roundabouts at selected locations); black spot control and improvements; and improved signaling (Elvik et al., 2009, see esp. pp. 146–155). Road maintenance practices have been found to have much lower safety impacts; the biggest safety benefits appear to be from increasing road friction and from good winter maintenance in terms of ice and snow control (Elvik et al., 2009, pp. 335–395). Another area that has brought significant safety benefits has been in roadside design, including crash cushions, end treatment of barriers, breakaway poles, and energy-absorbing barriers. The development, investment, and implementation of these devices also have contributed to reductions in the number and severity of crashes (AASHTO, 2011; OECD, 2008).

Traffic control measures are attempts to use investments to change road user behavior. As such, their effectiveness depends on whether such measures are enforced and if behavior does in fact change. Another confounding factor is that many traffic control measures are specific to local conditions and environments, so that generalizable effects are hard to identify. In their comprehensive review of studies of traffic control measures, Elvik et al. find that safety has been improved by area-wide traffic calming, by designated pedestrian streets, by increased access control, stop signs and traffic signal control, and speed-reducing measures (Elvik et al., 2009, see especially pp. 400–401). In contrast, yield signs at intersections, most road markings, one-way streets and reversible lanes do not appear to have statistically significant effects on road safety (Elvik et al., 2009, see especially pp. 400–401). Moreover, flashing yellow signals, right turn on red, increased speed limits, and designated bus lanes appear to lead to an increased number of accidents (Elvik et al., 2009, see especially pp. 400–401).

3.2. Vehicle safety

Vehicle design and performance attributes have two potential effects on safety: first, those aimed at reducing the risk of crashing; second, those aimed at reducing the consequences when accidents do occur.

Vehicle mass, size, and speed have long been important concerns for manufacturers and for safety analysts. When accidents occur, vehicle mass and speed are the two most important aspects determining accident severity and risk. Fatality risk depends strongly on the ratio of the masses of the vehicles; if one car is half as heavy as the other, the driver in the lighter car has approximately twelve times the fatality risk (Evans, 2004, p. 95). For single-vehicle accidents, decreased mass also increases driver fatality risk.

For most of the first 75 years of the automobile, vehicle size, mass and performance grew. The average car had weighed more than 4000 pounds by the mid-1970s (Hakim, 2004). With the advent of the first oil crisis in 1974–1975 and the subsequent introduction of fuel economy standards, vehicle mix and performance began to change, so that by 1981–1982 the average car weighed just over 3200 pounds (Hakim, 2004). Not only were cars and light trucks getting smaller, the diversity of the fleet added new safety complications. This situation was also affected by the fact that manufacturers were able to achieve better fuel efficiency while making cars bigger; the weight of the average car began to increase in the mid-1990s, so that by 2004, the fleet again had an average weight of more than two tons (Hakim, 2004).

Overall, as mentioned above, the effects of vehicle mass on safety are mixed. Larger vehicles have improved safety, at least for their occupants. However, the diversity of the fleet and the growth in large and small vehicle types has increased fatality risk. Other vehicle characteristics, such as higher centers of gravity, have been shown to increase rollover risk (the most harmful event in single vehicle accidents) (Evans, 2004, p. 61).

Other vehicle innovations have been developed to reduce the likelihood or consequences of accidents (Evans, 2004, pp. 63–67, 107–116; Schlumberger Excellence in Educational Development).[9]

[8] It should be noted that the worldwide finding reported here may have different relative importance in the United States, given different operating conditions, travel behavior and societal norms.

[9] Current motor vehicle safety standards in the U.S. are available at NHTSA (2004b).

Examples include occupant protection systems (seat belts and airbags) and anti-lock braking systems (ABS). Motor vehicle safety standards have a long history – windshield wipers (1921), four-wheel brakes (1924), turn signals (1938), among others. Comprehensive standards were introduced in 1966, requiring all vehicles manufactured after 1968 to meet requirements for crash avoidance, occupant protection, and post-crash performance. In particular, energy-absorbing and collapsible steering columns, improvements in instrument panels and in side door beams, and head restraint systems, are widely believed to have made important contributions to vehicle safety.

Accidents by nature involve rapid reductions in speed, and because vehicle occupants continue to move at the prior speed, occupancy protection devices are intended to reduce the likelihood and severity of impact, and to prevent ejection. Both the integrated seat belt and shoulder harness, and even the basic safety belt, have been shown to be associated with major reductions in fatality risk (Cohen & Evans, 2003; NHTSA, 2000, 2010a). In addition, airbags have been shown to be most effective when used in conjunction with seat belts. As discussed in the section on driver behavior below, the growth and prevalence of seat belt usage has come to be thought of in terms of the risk and potential consequences of *not* wearing your seat belt.

In contrast, anti-lock braking systems are good examples of the challenge of vehicle technologies which may themselves induce changes in driver behavior. ABS, which maintain wheel rotation during braking to increase vehicle stability, are demonstratively better braking systems. However, the effects of ABS on improving safety in practice (compared with test tracks or simulations) have been at best marginal. Studies suggest that drivers with ABS equipment tend to drive faster, to wait longer before braking from cruising speed, and to drive in harsher conditions (Evans, 2004, pp. 107–111). Thus, intended safety benefits from technology may be at least partially offset by risk-increasing changes in driver behavior.

3.3. Driver behavior

Driver performance and driver behavior are the biggest challenge to improving road safety (Shinar, 2007). We can think about driver behavior in terms of the characteristics of drivers and in terms of their actions with respect to the key factors of risk-taking, use of restraints/protective devices, impaired and distracted driving, and speed. Research literature finds strong safety effects for increased use of seat belts, and control of speed. Driver education has little impact on safety, but graduated licensing appears to reduce crash risks for younger drivers (Evans, 2004, pp. 201–202). While better awareness and increased enforcement of drunk driving laws has improved safety, we appear to be moving into a world where impairment cases involve drugs as well as alcohol; in addition, an increasing share of alcohol violations are far in excess of legal BAC limits (U.S. Centers for Disease Control and Prevention, 2011).

Experience also matters. As Evans notes, "The basic skills to stop, start, and steer vehicles are acquired remarkably easily and quickly. Complex higher level skills that are acquired only after many years of experience can contribute to reducing crash risk." (Evans, 2004, p. 201). We discuss driver performance and behavior in the United States more extensively in Section 4.4 (below).

4. The record: U.S. highway fatality rates

Fig. 1 shows the general downward trend of the U.S. highway fatality rate, as measured by fatalities per 100 million vehicle miles traveled (VMT) from 1975 through 2010. As seen in the figure, the drop between 2005 and 2010 is sharper than previous five year periods except for 1980–1985, but as mentioned above, some of that drop may well have been due to the recessionary period starting in 2007. The question as to why accident *rates* decline during economic downturns remains unanswered. Hypotheses include greater reductions in discretionary driving, or greater reductions in driving by those groups that are highest risk, or that lower vehicle miles traveled during recessions reduces the potential for some types of accidents. A related issue is the extent to which the reduction in fatalities can be attributed to the price of gasoline, which affected how people drive both in terms of exposure and reductions in driving speeds, rather than public policy actions (Chi, Cosby, Quddes, Gilbert, & Levinson, 2010; Grabowski & Morrisey, 2004).

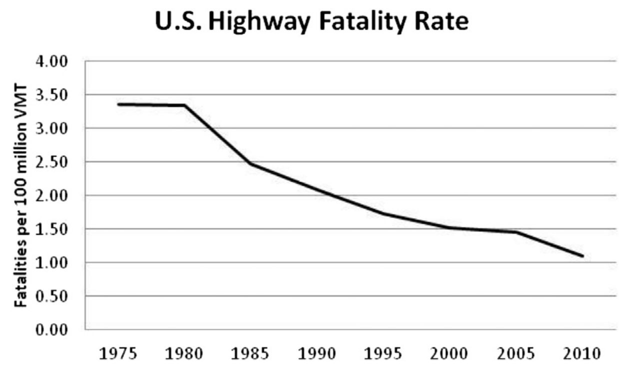

Fig. 1. U.S. highway fatality rate, 1975–2010. Note: VMT – vehicle miles traveled. Source: U.S. Department of Transportation (2012a, Table 2-17) and U.S. Department of Transportation (2011a).

U.S. traffic deaths have fallen sharply since 2007, dropping by 9.3 percent in 2008, an additional 9.7 percent in 2009, and an additional 2.7 percent in 2010 to 32,885, the lowest level since 1949 (NHTSA, 2010b). However, the U.S. economy entered a recession in 2007, and these recent declines are consistent with the experience in past recessions. Indeed, the largest annual declines in U.S. traffic fatalities in the period 1971–2007 all occurred in the recession years of the period: 7.0 percent in 1991, 9.9 percent in 1982, and 16.4 percent in 1974. Unfortunately, U.S. traffic fatalities increased when economic growth resumed after these past recessions and it is too early to determine whether the recent sharp decline represents an improvement over the long-term trend or whether there will once again be increased fatalities accompanying economic recovery.

Even if some of the most recent improvement is related to changing economic conditions, the decline in the fatality rate since 1980 raises questions about what factors have led to these improvements. In announcing the 2010 highway fatality rate, U.S. Transportation Secretary Ray LaHood said, "While we have more work to do to continue to protect American motorists, these numbers show we're making historic progress when it comes to improving safety on our nation's roadways." (U.S. Department of Transportation, 2011a) He went on to credit the work of both federal safety agencies and other organizations. A great deal of effort at the federal, state, and local levels has been devoted to policies to reduce risky driver behavior by increasing seatbelt usage, reducing alcohol impaired driving, reducing speeding, and bringing increased attention to the problems of distracted driving (Regan, Victor, & Lee, 2013). The importance of distracted driving as an accident cause/safety risk remains an open question. Some studies show only about 20 percent of accidents can be linked to inattention (NHTSA, 2010c). Other research suggests that more than 90 percent of crashes have inattention as a contributing factor

(Neale, Dingus, Klauer, Sudweeks, & Goodman, 2005). Other government policies have worked to improve the crashworthiness of vehicles and improve the safety of roadways. These efforts have almost certainly played a role in improving highway safety.

But in addition to these government safety policies, there have also been demographic changes and changes in travel patterns that may have affected highway safety. To assess the impact of safety policies, it is necessary to understand the roles that other factors have played. All too often, both in the United States and in other countries, an improvement in the highway fatality rate following the introduction of a new safety program is attributed entirely or almost entirely to that program without asking what role changing demographics and travel patterns including increasing congestion might have played.

Sivak and Schoettle undertake a detailed review of the 2005–2008 decline in U.S. road fatalities by analyzing all of the 269 variables in the U.S. National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS) database (Sivak & Schoettle, 2010). They analyze the contributions of the five types of variables in the FARS system, related to accidents, vehicles, drivers, occupants, and nonmotorists. Sivak and Schoettle find that economic factors have been significant contributors to lower fatalities, especially decreased commuter and leisure travel, reduced road construction, and reduced freight shipments. Decreased speeds were also found to have reduced fatalities, as have vehicle improvements (most notably the increased prevalence of airbags). Motorcycle fatalities were found to have increased due to newer riders and larger, more powerful motorcycles. Impaired driving had mixed effects, although enhanced enforcement appears to have helped reduce fatalities involving repeat offenders. Inattentive driving was found to have increased fatality rates, including use of technology while driving.

4.1. Urban versus rural travel by highway type

One important, and often overlooked, factor in changes to the overall highway fatality rate is the changing mix of urban versus rural travel. Table 1 shows the fatalities, fatality rates, and VMTs in 2009 for urban and rural travel and the changes in those numbers since 1980. As the top line of the table indicates, there were a little over 4800 more fatalities on rural highways than on urban highways in 2009 and the number of fatalities had declined by a little more than a third since 1980. However, the fatality rate for urban travel is only little more than a third that for rural travel and has been improving more rapidly.

The difference in fatality rates is important because over the last three decades, VMTs have grown about three times as much for urban travel as for rural travel. In 1980, urban VMTs were 27 percent greater than rural VMTs while by 2009, urban VMTs had grown to be over twice as great as rural VMTs. Thus, a good portion of the reduction in the overall fatality rate is due to the continuing urbanization of the United States with a growing proportion of travel in urban areas where fatality rates are lower.

Table 1
U.S. urban versus rural travel.

	Urban	Rural
Fatalities in 2009	14,298	19,125
Change since 1980	−34%	−35%
Fatality rate in 2009	0.71	1.95
Change since 1980	−72%	−56%
VMT in 2009	2,015,084	981,547
Change since 1980	136%	46%

Note: VMT – vehicle miles traveled. Source: calculated from data found in U.S. Department of Transportation (2012a, Table 2-18g).

Table 2
Changing mix of U.S. travel by highway type.

Road type	Fatality rates in 2009		Change since 1980		VMT in 2009		Change since 1980	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Interstate	0.42	0.85	−69%	−50%	480,154	242,361	198%	79%
Other arterials	0.63	2.03	−76%	−56%	1,060,385	372,921	119%	42%
Collector	0.76	2.55	−71%	−52%	181,447	230,980	118%	22%
Local	1.05	2.66	−70%	−55%	293,098	135,285	131%	60%

Note: VMT – vehicle miles traveled. Source: calculated from data found in U.S. Department of Transportation (2012a, Table 2-18t).

One question that emerges from looking at Table 1 is why the urban fatality rate has been improving more quickly than the rural fatality rate. There are undoubtedly many reasons for the differences between urban and rural fatality rates, but one factor is that emergency medical response time is typically much quicker in urban areas than in rural areas. For example, in 2009, in 64.9 percent of fatal urban accidents, the time between the crash and when the victims arrived at the hospital was 40 min or less whereas for rural accidents, the figure was only 29.4 percent (NHTSA, 2010c, Table 27).

Another possible factor is congestion. Indeed, some have argued that increasing congestion is a major factor in the improvement in the overall highway fatality rate arguing that "No one gets killed in a traffic jam." (Richter, Barach, Ben-Michael, & Berman, 2001). Congestion in U.S. cities has certainly increased over the past three decades (Schrank, Lomax, & Eisele, 2011). But the role of increasing congestion in improving highway safety is not clear. Even within urban and rural areas, travel is far from homogeneous from a safety standpoint. Table 2 shows the fatality rates and VMTs as well as the changes in these by road type in both urban and rural areas.[10]

As can be seen in the first two columns of the table, Fatality Rates in 2009, in both urban and rural areas, travel on interstate highways is much safer than travel on other types of highways. The next two columns, Change since 1980, show that the improvements in fatality rate by road type have been consistently greater in urban areas than in rural areas but within each type of area, have been pretty constant. With regard to VMTs, as can be seen in the last two columns in the table, the greater growth in urban VMTs since 1980 is found in all four road types. In both urban and rural areas, the greatest growth is in travel on interstate highways, which have the lowest fatality rates. Thus, at least part of the overall improvement in fatality rates in urban and rural areas is due to the greater increase in the proportion of travel on the safer interstate highways. Part of the reason for greater improvement in urban highway fatality rates compared to rural fatality rates may well be the much greater growth in travel on urban interstates, the safest type of road.

However, the apparent improvement in urban versus rural road safety may also be a function of population growth and classification systems. In many case, it would appear that urban sprawl is associated with increased conflict points and exposure. As formerly rural highways become more urbanized at the boundaries of cities, the physical and operating characteristics, and the classification as a rural road may not change, but the role the road is playing is very different. There is a need for better understanding of road safety data in the boundaries and evolution between urban and rural roads (Kang, Spiller, Jang, Bigham, & Seo, 2012).

With respect to the role of congestion, at first glance, the figures in the table are consistent with increasing congestion, which is

[10] For definitions of road types, see U.S. Department of Transportation (2012b).

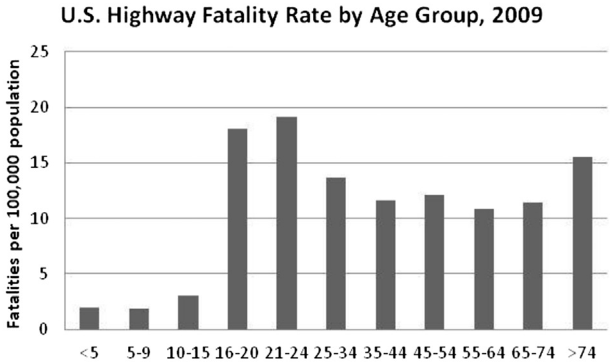

Fig. 2. U.S. highway fatality rate by age group, 2009. Source: NHTSA (2010b, Table 57).

Table 3
Change in share of the U.S. population by age group, 1980–2009.

Change in share of the U.S. population by age group	
Age group	Change in share, 1980–2009
<5 years	−0.3%
5–9 years	−0.7%
10–14 years	−1.5%
15–19 years	−2.3%
20–24 years	−2.4%
25–34 years	−2.8%
35–44 years	2.2%
45–54 years	4.5%
55–64 years	1.8%
65–74 years	−0.1%
>74 years	1.7%

Source: calculated from U.S. Census Bureau (2012, Table 7).

primarily an urban phenomenon, contributing to the greater improvement in the urban highway fatality rate than in the rural highway fatality rate. However, a closer look reveals that the smallest improvement in the urban fatality rate is on urban interstates, which is where the VMTs have shown the greatest proportional growth and where one might expect the increases in congestion to be greatest. Clearly the role of congestion in urban highway fatality rates is a topic about which more needs to be known.

4.2. Changing demographics

A well known factor in highway fatalities is the age of the driver. Young drivers, particularly those in the age groups 16–20 and 21–24, are much more likely to be involved fatal accidents than are drivers in other age groups. Fig. 2 shows the highway fatality rate, as measured in highway fatalities per 100,000 of population by age group for 2009. For cohorts of legal driving ages, the figure shows that drivers in the 25–34 and 75 and over age groups also have higher fatality rates than drivers in the 35 to 74 age groups. Given these differences by age, one thing to consider is the extent that demographic change in the population is having an impact on overall fatality rates.

Table 3 shows the change in the share of the population by age group between 1980 and 2009.[11] As a comparison of the table and the prior figure indicates, for three of the four highest highway fatality rate age groups, their share of the population has been shrinking while those age groups with drivers who have better safety records has been growing. Thus, even if the rates within each age group did not change, the changing demographics would result in an improvement in the overall highway safety rate.

The one exception to this pattern is older drivers (particularly the greater than 74 age group), which is growing as a share of the population. There is considerable uncertainty about the impact of the increasing population of older drivers on the overall highway safety rate. Some studies have found that older drivers travel predominantly by car (Burkhardt & McGavock, 1999) and intend to continue to drive as long as they can (Kostyniuk, Shope, & Molnar, 2001, pp. 783–795). A concern is that as people age, various physical and cognitive changes can result in a reduced ability to drive a car safely (Burkhardt & McGavock, 1999). Some older drivers, however, compensate for these changes by avoiding certain driving situations such as on freeways, during peak traffic conditions, in poor weather, or at night (Kostyniuk, Trombley, & Shope, 1998). Even with these adjustments, however, some find that crash rates per mile are higher for older drivers than for most other age groups (recall that Fig. 2 is based on fatalities per 100,000 population and not on vehicle miles) (Evans, 2000). However, other research has found that as the share of the population over age 75 increases, fatalities and injuries decrease (Noland, 2003).

In addition to age, the gender of the driver plays a role in highway safety. Fig. 3 shows the highway fatality rate by age group and gender and demonstrates that females in all age groups have substantially lower highway fatalities per 100,000 population than do males. Some transportation analysts have found that VMTs by women are increasing relative to those of men, although the research at this point doesn't appear conclusive (Sloboda & Yao, 2006). Fig. 4 shows the changes in female share of the civilian labor force between 1975 and 2009. That share has been steadily increasing over the period. To the extent that this increasing labor force participation rate by women results in more trips to work, it is certainly plausible that women's share of VMTs has been increasing over the 1975 to 2010 period. If so, and given women's lower fatality rates, this could also explain part of the decline in overall highway fatality rates shown in Fig. 1.

4.3. Changing vehicle mix

Another potential factor in changes to the overall highway fatality rate is the change in the mix of vehicles on the nation's highways over the last 30 years, particularly the growth in the use of light trucks. Table 4 shows highway fatalities broken down by vehicle occupant versus nonoccupant fatalities. The overwhelming majority of highway fatalities (86 percent) are occupant fatalities.

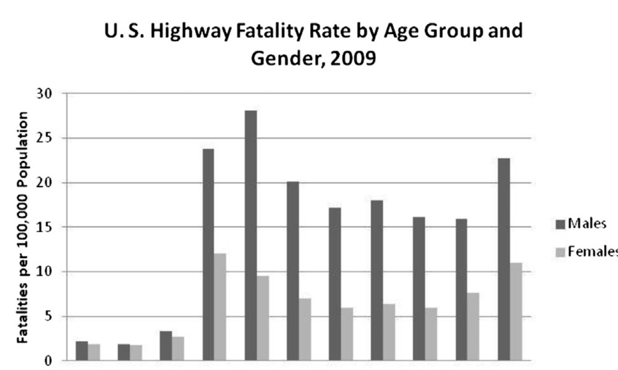

Fig. 3. U.S. highway fatality rate by age group and gender, 2009. Source: NHTSA (2010b, Table 57).

[11] Unfortunately, the National Highway Traffic Safety Administration and the U.S. Bureau of the Census use slightly different age groupings, but the patterns are still apparent.

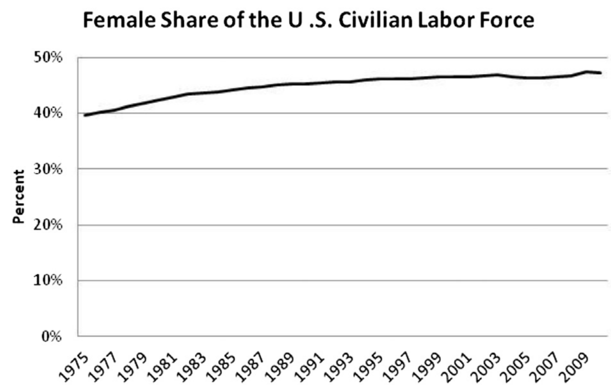

Fig. 4. Female share of the U.S. civilian labor force. Source: Bureau of Labor Statistics (2011). Calculated from data in Table 2.

Of the nonoccupant fatalities, 84 percent are pedestrian fatalities with most of the remaining being pedalcyclist fatalities. As can be seen in the table, pedestrian fatalities have dropped sharply since 1980 while pedalcyclist fatalities have dropped a little more than occupant fatalities (Weng, Jin, Zhao, & Zhang, 2010).

Table 5 shows 2009 occupant fatalities, fatality rates, and VMTs by vehicle type as well as changes in these figures since 1980. Perhaps the most striking figure in the table is the 288 percent increase in light truck VMTs during a period where passenger car VMTs increased by only 43 percent. Some analysts have argued that increased use of light trucks has increased highway fatalities (Anderson, 2008). The arguments are that light trucks are more dangerous to their own occupants; that they are more dangerous to the occupants of other, lighter vehicles that they might collide with; and that they pose a greater hazard to pedestrians. The issue is clearly complex and other analysts have found that, to the contrary, the increased use of light trucks has reduced highway fatalities (Coate & VanderHoff, 2001). It is beyond the scope of this paper to resolve this issue, but it is difficult to reconcile the claim that light trucks pose a greater hazard to pedestrians when during the period when light truck use increased by 288 percent, pedestrian fatalities dropped by 49 percent, a drop much greater than the drop in occupant fatalities. Moreover, it is difficult to reconcile the claim that light truck occupants are at markedly greater risk when the fatality rate of light truck occupants is virtually the same as the rate for passenger car occupants. Similarly, it is difficult to reconcile the claim that increased light truck use has greatly increased the risk to passenger car occupants when the changes in the fatality rates for light truck occupants and passenger car occupants are the same during the period of dramatically increased light truck use.

Table 5 shows that large truck occupants have by far the lowest fatality rate and have seen the greatest improvement in the fatality rate since 1980. Several factors may be at work here. One is that these occupants are primarily professional drivers with a Commercial Driver's License subject to drug and alcohol testing and hours of service regulations (U.S. Department of Transportation, 2011b). It is also possible that some of the improvement came during the recessionary years after 2007 when a larger share of the large truck VMTs might have been driven by more senior and more experienced drivers. Table 5 also shows the record for motorcycle fatalities. While motorcycle fatalities dropped between 1990 and 2009, the drop was much smaller than for the other vehicle types. Similarly, while the fatality rate improved for motorcycles over the period, the improvement was smaller than for other vehicle types.

Table 4
Occupant and nonoccupant U. S. highway fatalities.

	2009 fatalities	Change since 1980
Total traffic fatalities	33,808	−34%
Occupant fatalities	28,936	−31%
Nonoccupant	4872	−47%
Pedestrian	4092	−49%
Pedalcyclist	630	−35%
Other nonoccupant	150	16%

Source: calculated from data found in U.S. Department of Transportation (2012a, Table 2-19).

Table 5
Occupant highway fatalities by vehicle type.

Vehicle type	2009 fatalities	Change since 1980	2009 VMT	Change since 1980	Fatality rate	Change since 1980
Passenger car	13,095	−52%	1,578,948	43%	0.92	−63%
Light truck	10,287	37%	1,145,505	288%	0.94	−63%
Large truck	503	−60%	227,458	110%	0.30	−74%
Motorcycle	4462	−13%	20,800	118%	21.45	−37%
Other vehicle	589	1%	na	na	na	na

For passenger cars, light trucks, and large trucks the most recent data is for 2008. For motorcycles, the change data are from 1990.
Note: VMT – vehicle miles traveled. Source: calculated from data found in U.S. Department of Transportation (2012a, Tables 2-19, 2-21, 2-22, and 2-23).

Another potential factor in changing vehicle mix has been the impacts of the Corporate Average Fuel Economy standards. A National Research Council study found that, "the downweighting and downsizing that occurred in the late 1970s and early 1980s, some of which was due to CAFE standards, probably resulted in an additional 1300 to 2600 traffic fatalities in 1993." (Transportation Research Board, 2002, p. 3).[12] The recent policy decisions to raise the Corporate Average Fuel Economy standard starting in the 2012–2016 period with additional increases in the standard in the 2017–2025 period again raise concerns about possible safety consequences (NHTSA, 2011c).

Overall, it seems clear from the discussion above that some portion, and perhaps a large portion, of the improvement in the highway fatality rate over the last three decades is due to changing demographics and changing travel patterns. What is not clear is how large a contribution these factors have made and until that is well understood, it will not be possible to understand how much government policies to improve safety have made or which of these policies have been the most effective.

4.4. Driver characteristics and behavior: seatbelts/helmets, alcohol, speed, distracted driving

4.4.1. Younger drivers

Table 6 shows the reduction in fatality rate by age group between 1980 and 2009. The large reductions for the age groups below age 16 are striking. Multiple factors may have contributed to these reductions, such as the increased use of infant seats and other child restraints since 1980. All 50 states and the District of Columbia now require child safety seats and rear safety belt use for children (NHTSA, 2011d). The large reduction in fatality rate for 16–20 year olds may be in part due to the increased use of graduated driver's license programs (Foss & Evenson, 1999; Shope & Molnar, 2003; Simpson, 2003). By June 2010, 49 of the 50 states and the District of Columbia had graduate driver's license programs (NHTSA, 2010b).

[12] It should be noted that two of the committee members dissented on this finding. See Appendix A of this TRB report for their dissent.

Table 6
U.S. fatality rate reduction by age group, 1980–2009.

U.S. fatality rate reduction, 1980–2009	
Age group	Percent reduction
<5	64%
5–9	49%
10–16	63%
16–20	61%
21–24	56%
25–34	51%
35–44	41%
45–54	32%
55–64	30%
65–74	28%
>74	14%

Source: NHTSA (2010b, Table 6).

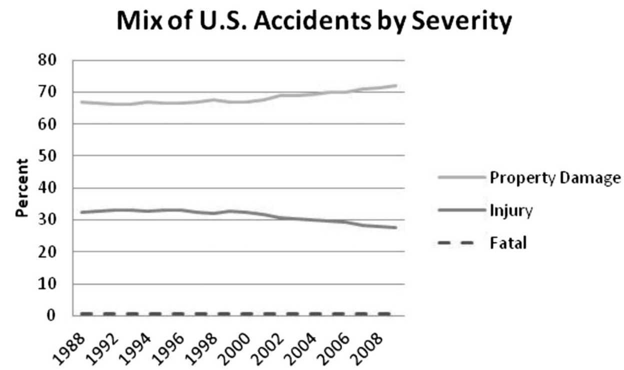

Fig. 6. Mix of U.S. accidents by severity, 1988–2009. Source: NHTSA (2010b, Table 1).

But the greater improvement in fatality rate for a particular age group may not be simply the result of programs targeted at that age group. While part of the problem with teen drivers is inexperience and lack of driving skills, which might be aided by graduated driver's license programs, teen drivers are also often found to engage in high risk driving behavior such as driving after drinking, exceeding the speed limit, and following too closely (NHTSA, 2003a). For example, teen drivers have historically had among the lowest seat belt usage rates, (NHTSA, 2003a) so programs to increase seatbelt usage might well have a disproportionate impact on teen driver fatality rates. Young drivers, particularly males, are also at greater risk of fatigued driving (NHTSA, 2004a). Finally, drivers under age 20 were the group with the largest proportion of distracted drivers (NHTSA, 2010c). Sorting out the separate impacts of simultaneous behaviors programs is always a difficult research task and particularly so with highway safety programs.

4.4.2. Seatbelts and occupant restraints

Part of the decline in highway fatality rates is widely attributed to increased seatbelt usage. Few question that in the vast majority of types of accidents, wearing a seatbelt reduces the chances of being killed or injured (Cummings & Rivara, 2004). Estimating how much wearing a seatbelt reduces the chances of being killed, however, is difficult. Controlled crash tests have found that in straight frontal impacts, seatbelts may reduce the odds of being killed by as much as 45 percent, but real world accidents are more complicated and seatbelts are typically not as effective in other kinds of accidents. Studies comparing fatality rates with and without seatbelts for people involved in real world accidents have estimated seatbelt effectiveness of around 40 percent for those in the front seat and in the range of 20 percent for those in the rear seat, but such studies are difficult to do and the results are often disputed (Evans, 1988). Thus, estimates of how much seatbelt use reduces fatalities can vary widely. NHTSA produces an annual report of how many lives they estimate were saved from seatbelt use and how many more would have been saved had all people worn seatbelts. For 2009, for example, NHTSA estimated that 12,713 lives (of people age 5 and older) were saved by seatbelt use, an additional 2381 lives were saved by frontal airbags, and 309 lives were saved of people age 4 and younger by child restraints (NHTSA, 2011b).

Publicity and law enforcement campaigns to increase seatbelt use have been widespread in the United States and, as Fig. 5 shows, belt use for both drivers and passengers has been increasing. By December 2011, 32 states and the District of Columbia had Primary Seat Belt Laws while 17 states had secondary seatbelt laws (Hedlund et al., 2009). Primary seat belt laws allow law enforcement officers to issue a ticket to a driver for not wearing a seat belt, without any other traffic offense taking place. Secondary seat belt laws allow law enforcement officers to issue a ticket for not wearing a seat belt only when there is another citable traffic infraction. Seatbelt use varies across groups in the population (Hedlund et al., 2009).

With increased seatbelt use and considering NHTSA's estimates of lives saved from seatbelt use, one might expect that seatbelts would result in accidents becoming less severe from a fatality and injury standpoint. In other words, one would expect that accidents that would result in fatalities without seatbelt use would instead result in only injuries with seatbelt use. As Fig. 6: The Mix of U.S. Accidents by Severity shows, however, the proportion of accidents resulting in a fatality has remained constant at about 0.6 percent for the last 20 years which is surprising in the face of increased seatbelt use. However, the proportion of accidents resulting in injury has decreased while the share resulting in only property damage has correspondingly increased.

4.4.3. Motorcycles

While there has been a clear and steady decline in the overall highway fatality rate and an increase in seatbelt use, albeit with some ambiguity about precisely how much that may have contributed to reducing the highway fatality rates, the picture for motorcycle helmet use, and indeed for the motorcycle fatality rate has been more varied.

Motorcycle safety has become a more prominent issue. In 2010, there were 4502 motorcycle related fatalities in the U.S., a 55 percent increase since 2000 (U.S. Centers for Disease Control, 2012). Fig. 7 shows the U.S. motorcycle fatality rate from 1980 through 2009. While the rate dropped fairly steadily from 1984 through 1997, it increased even more sharply from 1998 through 2005,

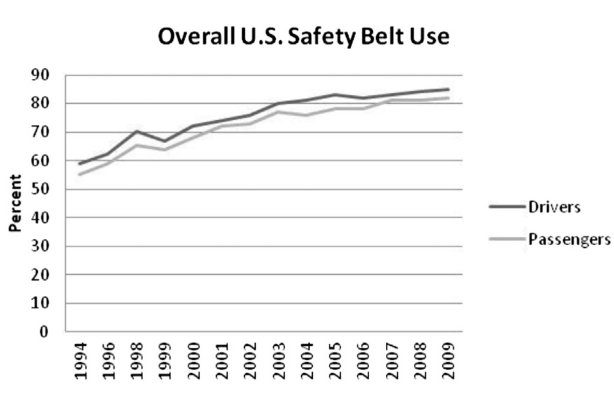

Fig. 5. Overall U.S. safety belt use, 1994–2009. Source: U.S. Department of Transportation (2012a, Table 2-30).

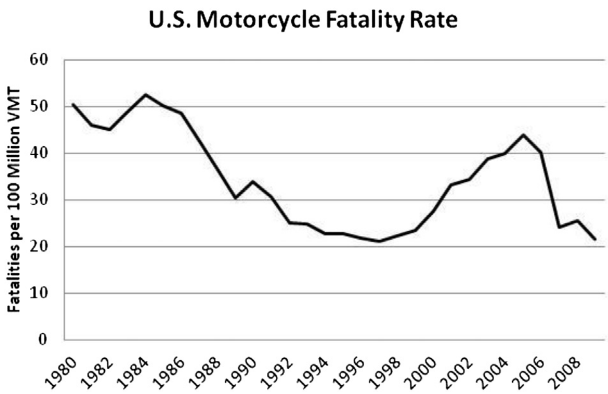

Fig. 7. U.S. motorcycle fatality rate, 1980–2009. Note: VMT – vehicle miles traveled. Source: NHTSA (2010b, Table 10).

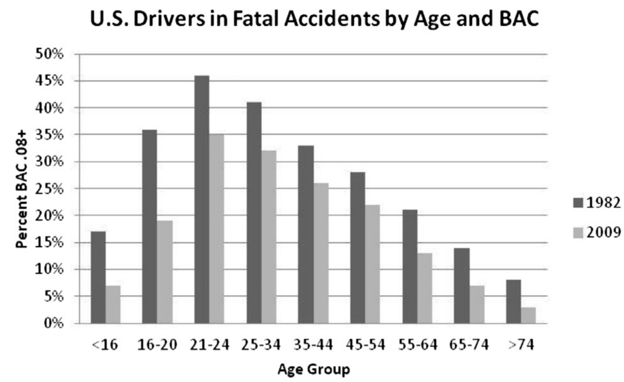

Fig. 9. Drivers in fatal accidents by age and BAC. Source: NHTSA (2010b, Table 18).

perhaps in part due to the repeal of mandatory helmet laws during the early to mid-2000s. The fatality rate then began dropping again through 2009 (Hedlund, 2010). By June 2010, twenty states and the District of Columbia had Universal Motorcycle Helmet Laws (where all riders must wear helmets) (NHTSA, 2010b, Table 128).

Fig. 8 shows U.S. motorcycle helmet use for both operators and riders from 1994 through 2009, with data not available for 1995, 1997, 1999, 2001, and 2003. One would expect for many factors to influence the fatality rate, but in the 1994 to 1998 period, helmet use seemed to be increasing slightly while the fatality rate was dropping; from 2000 through 2005, helmet use was dropping and the fatality rate was increasing; and from 2005 through 2009, helmet use was increasing while the fatality rate was dropping. Most research finds that wearing a helmet reduces the risk of death and injury (Neiman, 2007). It would take much more evidence than these general patterns to demonstrate that the changes in the share of riders wearing helmets cause corresponding changes in the fatality rate, but the patterns are nevertheless suggestive. Research has also shown that motorcycle fatalities have generally gone up in states that repealed mandatory helmet laws (Ulmer & Preusser, 2003). For all years shown in the figure except 1998, the percent of motorcycle operators wearing helmets was substantially greater than the percent of motorcycle riders wearing helmets (U.S. Department of Transportation, 2012a, Table 2-30).

4.4.4. *Drunk and impaired driving*

Another major public policy concern is the impact on safety of driving under the influence of alcohol. Fig. 9 shows the percent of drivers with blood alcohol content of 0.08 or greater by age group in 1982 and 2009. In both years, the 21–24 and 25–34 age groups had a very high share of fatal accidents with high blood alcohol content. Comparing Fig. 9 with Fig. 2 suggests that a major contributor to the higher fatality rates in these age groups is driving under the influence of alcohol. In Fig. 9, comparing 1982 with 2009 shows that there has been significant reduction in alcohol impaired driving in every age group with the reductions in the less than 16 and 16–20 groups being particularly large. Part of this change is likely due to the raising of the legal drinking age in many states. The issue of underage drinking and driving has become a major public concern, although research in somewhat limited (Little & Clontz, 1994; NHTSA, 2003b). However, a closer look at the original data shows that most of the reductions had come by the mid-1990s and that there has been little or no improvement since then. Indeed, in virtually all the age groups, the share in 2009 was slightly higher than it had been in the late 1990s (NHTSA, 2010b, Table 18).

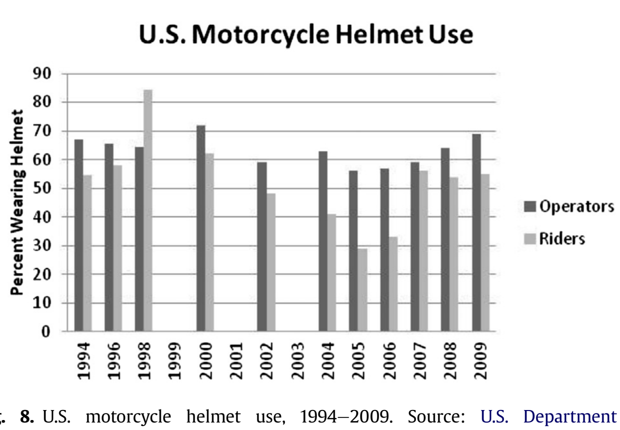

Fig. 8. U.S. motorcycle helmet use, 1994–2009. Source: U.S. Department of Transportation (2012a, Table 2-30).

4.4.5. *Speeding*

Another concern in highway safety is speeding (Transportation Research Board, 1998). NHTSA considers a crash to be speeding-related "if the driver was charged with a speeding-related offense or if an officer indicated that racing, driving too fast for conditions, or exceeding the posted speed limit was a contributing factor in the crash." (NHTSA, 2010d). NHTSA attributes about 30 percent of highway fatalities to speeding and that share has changed little in the past decade (NHTSA, 2010d, Table 1). A higher percentage of males are found to be speeding in fatal accidents than females and the percent for both genders decreases with age (NHTSA, 2010d, Fig. 1). The relationship between speed and safety can be tricky (Shinar, 1998). Speed is directly related to injury severity in a crash simply because at higher speeds, there is more energy to be dissipated. The relationship between speed and the probability of a crash, however, is much more complex because accidents can seldom be related to a single factor. Some research has shown that it is the dispersion of speeds rather than the average speed that is the more important determinant of fatality rates (Davis, 2002; Lave, 1985). Still a great deal of uncertainty remains about the impacts of speed limits on speed dispersion and highway safety (McCarthy, 1998).

Fig. 10 shows the percent of fatal accidents by posted speed limit. The figure includes accidents for all causes, not just speeding, but it's still interesting that more accidents are on roads with 55 mph speed limits than roads with any other posted speed limit. This is perhaps not surprising since, as seen in Table 2, many of the most hazardous roads, particularly in rural areas, are of a type likely to have 55 mph speed limits. However, the distribution of fatal crashes by speed limit does not characterize the actual crash risk,

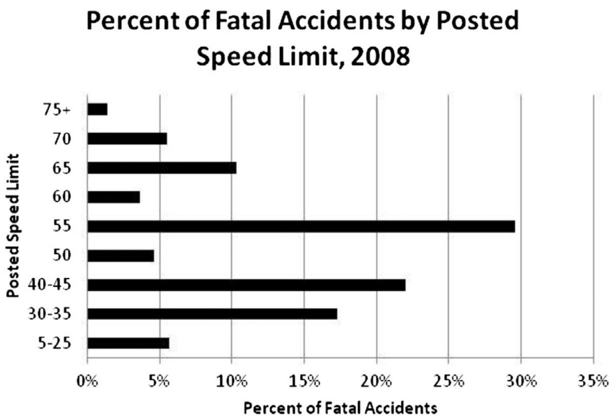

Fig. 10. Percent of U.S. fatal accidents by posted speed limit, 2008. Source: U.S. Department of Transportation (2012a, Table 2-29).

since the percentages of crashes is associated with the percentages of roads having each speed limit and the vehicle miles traveled on each type of road.

Seatbelt use, alcohol-impaired driving, and speeding are not the only factors that contribute to accidents, but they have been important factors and the focus of much highway policy for quite some time. Unfortunately, accidents are often thought of as having single causes and these factors are typically regarded as separate, each with individually designed programs. Highway accidents, like many other types of accidents, often have multiple causes and more attention needs to be paid to how these separate factors interact to result in accidents. Table 7 shows the share of fatal accidents caused by these three factors, both singly and in combination. As can be seen in the top four rows of the table, it is often the case, a little over 50 percent of the time, that an accident is attributed to only a single factor. However, it is also often the case, over 45 percent of the time, that more than one of these factors was interacted to cause the accident. How multiple factors interact with each other to cause highway accidents would seem an area needing further research.

4.4.6. Distracted driving

A growing highway safety concern is distracted driving. There are three kinds of distractions: 1) visual where the distraction causes the driver to take his or her eyes off the road; 2) manual where the distraction causes the driver to remove his or her hands from the steering wheel, and 3) cognitive where the distraction causes the driver to take his or her mind off of the task of driving. Distractions are not new and have long involved activities such as talking to passengers in the car, looking at a map, or changing a radio station. With the near ubiquity of cell phones, cell phone use while driving is a growing concern and texting poses a particular risk because it involves all three kinds of distractions simultaneously. A study of driver distractions in commercial vehicle operations found that text messaging increased the odds of a crash 23 times compared to not text messaging while driving (U.S. Department of Transportation, 2009, Table 3). Another study found that drivers conversing on a cell phone, either hand held or hands free, had delays in their reaction time with a resulting increase in traffic accidents equivalent to driving with a blood alcohol content of the legal limit of 0.08 percent (Strayer, Drews, & Crouch, 2006).

Fig. 11 shows the percent of U.S. fatal accidents involving driver distraction from 2005 to 2009. Unfortunately, the share has grown over this period, which is perhaps not surprising given the growth in the use of cell phones and similar devices. Fig. 12 shows the percent of distracted drivers in U.S. fatal accidents by age group for 2009. As can be seen in the figure, the share is largest for teenagers and next largest for those in their 20s, again probably not surprising given the high intensity of use of electronic devices by people in these age groups. In response to the growing problem of distracted driving, as of June 2010, 29 states and the District of Columbia have passed distracted driving laws, most commonly targeted at prohibiting texting while driving (NHTSA, 2010b, Table 128).

Table 7
Role of multiple causes in fatal accidents for motor vehicles (excluding motorcycles), 2005.

Cause category	Share of fatal accidents		
	Total	Urban	Rural
Alcohol (only)	8.4%	9.9%	7.7%
No restraints (only)	34.9%	33.3%	35.0%
Speed (only)	10.4%	11.4%	10.2%
Total for single cause	**53.8%**	**54.7%**	**52.8%**
Speed + no restraints	12.3%	11.0%	13.1%
Alcohol + no restraints	15.3%	14.6%	15.6%
Alcohol + speed	5.6%	7.4%	4.8%
Alcohol + no restraints + speed	13.0%	12.4%	13.7%
Total for multiple causes	**46.2%**	**45.3%**	**47.2%**

Source: authors' calculations from FARS data.

5. International comparisons

As seen earlier in Fig. 1, the U.S. highway safety record has continued to improve. However, nearly every other high-income country has been reducing annual traffic fatalities and fatality rates faster than is the United States; and in several countries where fatality rates per kilometer of travel had been substantially higher than in the United States 15 years ago those rates are now below the U.S. rate (Transportation Research Board, 2010b). Fig. 13 shows the aggregate highway fatality rate for 15 high-income countries and for the United States for the 1975 through 2008 period. As the figure clearly shows, as a group these countries were much less safe than the United States in 1975 but had become safer by 2001 and continued to improve at a faster rate since then.

Many of these countries have more aggressive policies to reduce risky driver behavior than are found in the United States. Compared to the United States, many other countries have come to view road safety as a public health issue, rather than a public safety issue. This has increased incentives for more safety investment and regulation, because the scope of potential benefits is larger. This perspective also creates incentives for prevention efforts rather than the enforcement emphasis that often characterizes public safety activities. It is also common for these countries to consider driving as a public activity rather than a private one, with a result that

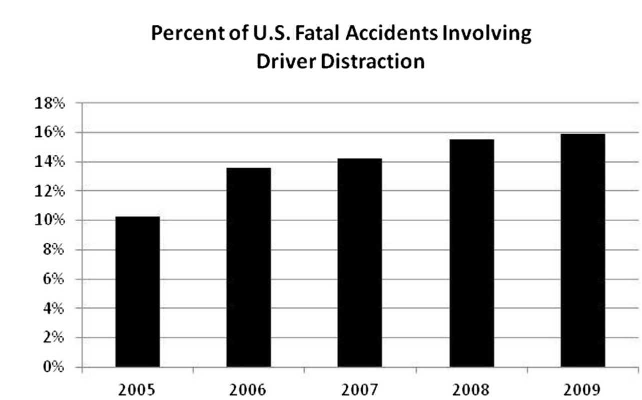

Fig. 11. Percent of U.S. fatal accidents involving driver distraction. Source: NHTSA, 2010c.

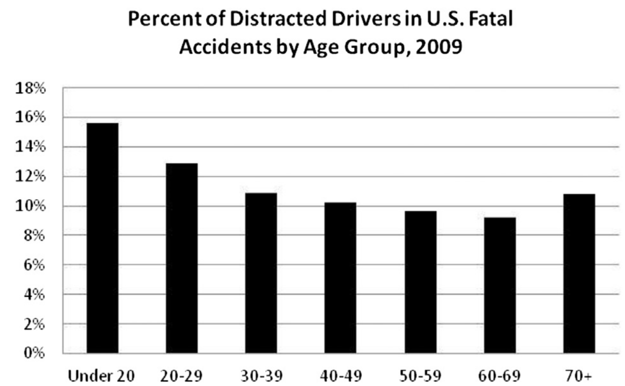

Fig. 12. Percent of distracted drivers in U.S. fatal accidents by age group, 2009. Source: NHTSA, 2010c.

public policy initiatives often impose more monitoring and control of individual behavior. For example, many of these other high-income countries use automated enforcement of speed limits (cameras and speed-measuring devices installed in the roadway) and frequent roadside sobriety checks combined with lower permitted limits on BAC. Similarly, all of these other high-income countries have universal motorcycle helmet laws and have higher rates of seatbelt use than typically found in the United States (Transportation Research Board, 2010b). In the United States, however, speed enforcement using automated cameras often encounters active public opposition and is used much less often. Similarly, motorcycle helmet laws faced organized opposition and were repealed in many states. The U.S. constitutional prohibition of unreasonable searches prevents U.S. police from conducting the frequent and routine driver sobriety testing without probable cause, a practice that is common in some other countries.

Safety officials in these countries often attribute the improvement in fatality rates to these and other programs. Unfortunately, evaluations that try to estimate the contribution of each program or each element of a program are quite rare. As the Transportation Research Board report found, “As a result of gaps in evaluation, even the most advanced benchmark countries lack a comprehensive, quantitative understanding of the major factors that have been driving trends in their traffic casualties.”(Transportation Research Board, 2010b, p. 72). The Transportation Research Board study also concluded, “The causes of these disparities in highway safety experience among the high-income countries are not well understood. Government traffic safety policies are a significant influence. However, research has shown that differences in demographic, geographic, and economic factors and in characteristics of vehicle fleets and transportation systems also affect international differences in crash rate trends, and evaluations designed to test the causal linkage between interventions and crash rates rigorously have been conducted too infrequently.” (Transportation Research Board, 2010b, p. 12).

Some insight into these differences may be gained by looking at the differences in highway fatality rates across the states in the United States. In the U.S. government safety policies are implemented primarily at the state and local levels, so variations in those policies likely have some impact on highway safety rates. However, there are also important differences in demographics and travel patterns across the states, as there are across the high-income countries. A study of differences across the states found that most of the variation in fatality rates among the states could be explained by differences in demographics, travel patterns, and other economic variables (Babcock & Gayle, 2009). Further, analytic models using these characteristics could fairly accurately predict the fatality rate ranking of each of the states. States with a higher percentage of urban population, higher population density, higher traffic density, higher incomes, and fewer young people were found to have lower fatality rates (O'Neill & Kyrychenko, 2006).

So in much the same way as understanding these characteristics is important to understand the sources of change of highway fatality rates in the U.S. over time or differences across the states, understanding differences in demographics, travel patterns, and other characteristics is important in understanding differences across countries. For example, Fig. 14 shows the median age in some of these countries in 2000 and Fig. 15 shows the change in median age between 1975 and 2000. Most of these nations have older populations than the United States and many are aging faster. Such demographics almost certainly affect both the highway fatality rates across these countries and the changes in those rates (Kopits & Cropper, 2008). In addition to demographics, it's possible that changes in the mix of urban versus rural travel and changes in vehicle mix have also had an impact on reducing fatality rates, but

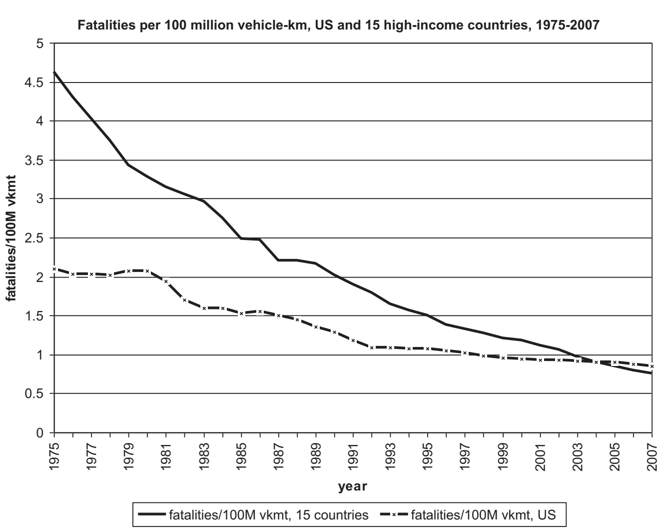

Fig. 13. Fatalities per 100 million vehicle kilometers, United States and 15 high-income countries, 1975–2008. Note: countries included are Australia, Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Israel, Japan, Netherlands, Norway, Slovenia, Sweden, and Switzerland. Source: Transportation Research Board (2010b, Fig. 2-2c).

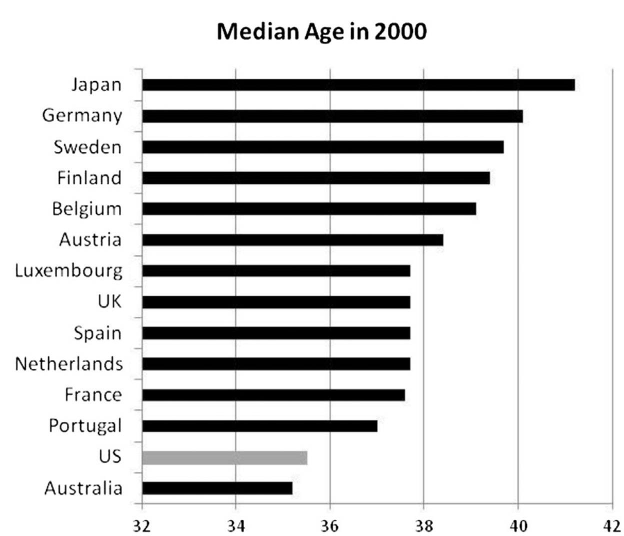

Fig. 14. Median age in 2000. Source: United Nations, 2002.

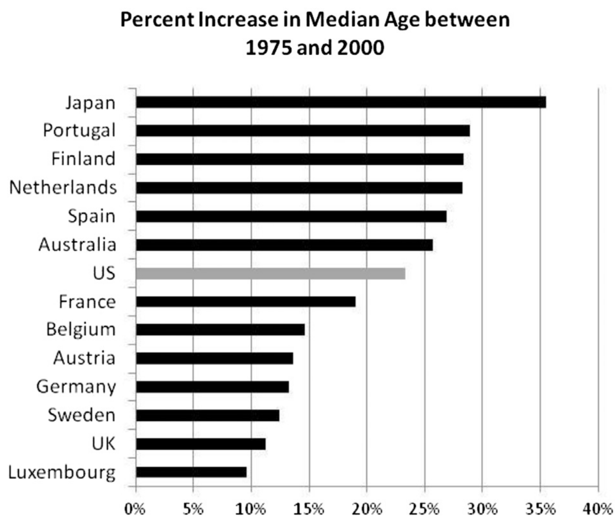

Fig. 15. Percent increase in median age between 1975 and 2000. Source: United Nations, 2002.

the extent of or even whether these factors have been present is not well understood.

So while the data clearly indicate that many other countries have made greater improvements in highway fatality rates than the United States and now have lower rates, little is understood about how these gains were achieved and what policies might be applicable to the United States. Even where there is good evidence that some of these policies have been effective in other countries, applying such policies to the United States can be difficult. In most other high income countries, the design, implementation, and enforcement of highway safety policies are the responsibility of a single national authority. In the United States, however, 50 state and thousands of local governments operate the roads, enact highway safety regulations particularly with respect to speed limits, and provide police and courts that enforce highway safety laws within their local jurisdictions. Small local jurisdictions may also lack the capacity or resources to enact or monitor highway safety programs for their effectiveness. Decentralized government in the United States can also require enormous coordination efforts to implement policies over a large geographic area. For example, to implement a statewide anti-drunk driving program, the state of Georgia obtained commitments from 587 law enforcement agencies in the state to participate in the program (Transportation Research Board, 2010b, p. 78). It was also necessary to work with the many local courts and prosecutors to gain their support and prepare for an increased workload. In addition because of the heterogeneity across the states in terms of things like population density, traffic volumes, and road networks, a highway safety program designed for one state may not be well suited for another state.

6. Summary

We return to the four questions posed at the beginning of the paper.

6.1. What factors have contributed to changes in U.S. highway fatality rates?

While public policy has certainly played a role, it seems clear that changing travel patterns and changing demographics have been important factors in reducing highway fatalities. The continuing urbanization of the United States is a major factor. Urban highway fatality rates were only 36 percent of rural fatality rates in 2009 and urban rates dropped 72 percent since 1980 while rural rates dropped only 56 percent. These differences are important because between 1980 and 2009, urban VMTs increased 136 percent while rural VMTs increased only 46 percent. Within both urban and rural areas, VMTs increased most on interstate highways which are the safest of all the highway types. Changing demographics also played an important role in improving the overall highway fatality rate. In 2009, drivers in the 16–20 year old age group and the 21–24 year old age group had the highest fatality rates of any age group. Between 1980 and 2009, these age groups decreased their share of the U.S. population by 2.3 percent and 2.4 percent respectively, while older drivers who have lower fatality rates increased their share of the population. Similarly women, whose highway fatality rates are well below those of men for all age groups, most likely increased their share of VMTs as their labor force participation rate increased over the period. Conversely, changing vehicle mix and particularly the growth in the use of light trucks compared to passenger cars likely had little impact on the overall highway fatality rate since light trucks and passenger cars had very similar fatality rates in 2009 and those rates had improved by the same amount since 1980.

Turning to driver behavior that can be influenced by public policy, seatbelt use increased steadily over the period for both drivers and passengers, which almost certainly helped improve highway safety. It's puzzling, however, that while the share of accidents that resulted in injury decreased as seatbelt use increased, the share of accidents that resulted in fatalities remained the same. Drunk driving was also reduced during the period as the share of drunk drivers in fatal accidents was lower in 2009 for every age group than it had been in 1982, although most of this improvement had been achieved by the mid-1990s with little change since then. While the trend in drunken driving and seatbelt use is encouraging, the trend in accidents caused by distracted driving is not. Every year between 2005 and 2009 saw an increase in the percent of fatal accidents involving driver distraction, with the greatest share of distracted drivers in the under 20 and 20–29 age groups.

6.2. How much do we know about the relative contributions of these factors?

Unfortunately, the relative contributions of these factors are difficult to determine so much less is known than would be desirable from the standpoint of setting safety policy. One problem is the limited information about the causes of highway accidents, particularly in comparison with other modes such as commercial aviation. With limited information, it is also difficult to examine the interactions among the multiple causes of accidents. Another problem is that changing demographics and travel patterns are occurring simultaneously with the implementation of highway safety programs and disentangling these multiple factors can be difficult if it is even attempted. All too often, the assessment of the effectiveness of highway safety policies is limited to a simple before and after comparison or to examining secondary measures.

6.3. How does the U.S. experience compare to the experience in other developed countries?

While the United States used to have the lowest highway fatality rates of any country, over the last few decades, nearly every other high-income country has been reducing annual traffic fatalities and fatality rates faster than is the United States. In several countries where fatality rates per kilometer of travel had been substantially higher than in the United States 15 years ago those rates are now well below the U.S. rate. Many of these countries have more aggressive policies to reduce risky driver behavior than are found in the United States, consistent with a different view of the boundaries between public and private activities, monitoring, and control. Safety officials in these countries often attribute the improvement in fatality rates to such programs – in particular, efforts to manage speed and impaired driving. Unfortunately, evaluations that try to estimate the contribution of each program or each element of a program are quite rare. As in the United States, differences in demographic, geographic, and economic factors and in characteristics of vehicle fleets and transportation systems also affect crash rate trends. Also, evaluations designed to test the causal linkage between interventions and crash rates rigorously have been conducted too infrequently.

6.4. What are the implications for U.S. highway safety policy?

Much more attention needs to be given to sorting the effects of highway safety policies in a rigorous manner that takes careful account of changes in external factors such as changing travel patterns and changing demographics. Without such analyses, there is no way to determine the effectiveness of various highway safety policies, particularly in comparison to their associated costs. While other high income countries present different political, economic, and transport environments and while the experiences of many of these countries have not been rigorously studied, these countries have achieved greater gains in safety than has the United States; there are still potential lessons to be learned from their experiences. In adapting the successful foreign policies to the United States, particular attention needs to be paid to the decentralized responsibility for highway operation and highway safety policy in the United States compared to the single national authority for highway safety more commonly found in other countries.

Road safety is multidimensional. Accidents are rare, and are the outcome of multiple variables that interact at a specific time and place. Improving results requires us to think about highway safety as a system. Traffic and vehicle design and engineering, as well as driver behavior, all play roles. However, as road networks and vehicles have become safer, more of the responsibility for safety improvement is shifting toward driver performance and behavior. But we need to remember than not all driver behavior is intentional or illegal – people make mistakes. One goal for improving road safety is to reduce the likelihood that these mistakes occur, and when they happen, that their consequences are diminished. We also need to take into account – especially in the United States in comparison with other countries – that safety often conflicts with other social norms such as mobility, independence, privacy, and freedom.

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