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A New Traffic Safety Paradigm

19 June 2025

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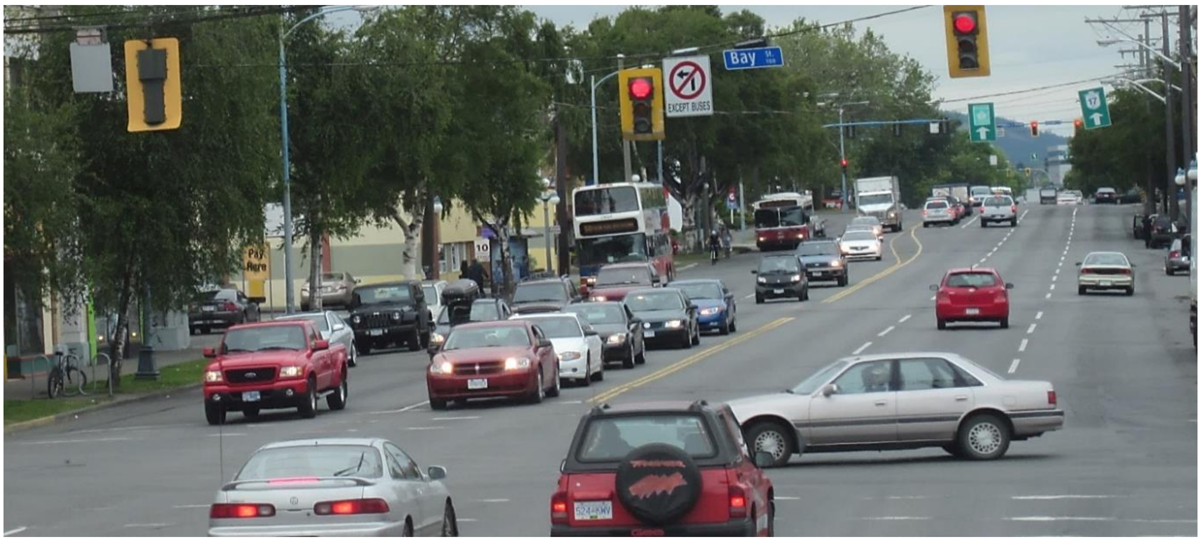


*A new traffic safety paradigm recognizes **exposure**, total vehicle travel, as a risk factor, and therefore the safety benefits of vehicle travel reduction strategies such as multi-modal planning, more efficient transport pricing, Smart Growth development policies and Transportation Demand Management (TDM) programs.*

Abstract

Despite extensive traffic safety programs, vehicle crashes continue to impose high social costs. New strategies are needed to achieve ambitious safety targets such as Vision Zero. Recent research improves our understanding of factors that affect crash risks and identifies new safety strategies. Applying this knowledge requires a paradigm shift, a change in the way problems are defined and solutions evaluated. The old paradigm assumed that driving is generally safe and so favored targetted programs that address special risks such as youth, senior, impaired and distracted driving. The new paradigm recognizes that all vehicle travel imposes danger, so *exposure* (total vehicle travel) is a risk factor, and vehicle travel reductions provide safety benefits. This report examines our emerging understanding of traffic risks and new safety strategies, and the importance of more comprehensive safety analysis.

Summarized in

Todd Litman (2022), "Driving as a Risk Factor: A New Paradigm for Vision Zero," *Vision Zero Cities Journal*; at https://medium.com/vision-zero-cities-journal/driving-as-a-risk-factor.

Todd Litman (2018), "Toward More Comprehensive Evaluation of Traffic Risks and Safety Strategies" *Research in Transportation Business & Management* (https://doi.org/10.1016/j.rtbm.2019.01.003).

Todd Litman (2018), "A New Traffic Safety Paradigm," *Transportation Talk* (Journal of the Canadian Institute of Transportation Engineers), Winter, pp. 12-18; at https://bit.ly/2Febrwx.

Table of Contents

Introduction

Despite concerted efforts to increase traffic safety, motor vehicle crashes continue to impose huge social costs. In a typical year the U.S. has about 40,000 traffic deaths, millions of severe injuries, and tens of million of damaged vehicles which imposes costs estimated between $340 billion, considering just economic losses (property damages, medical expenses and lost productivity) and $1.4 trillion also considering non-market costs such as pain and suffering (Blincoe, et al. 2023). This averages $1,000 to $5,000 per capita or 10¢ to 50¢ per vehicle-mile. International studies show similar results (Wismans, et al. 2017), with traffic crash costs estimated at 5% of GDP in many countries (Welle, et al. 2018, p. 31).

Although traffic casualty rates declined during most of the Twentieth Century they increased after 2010, indicating that new safety strategies are needed to achieve ambitious crash reduction goals such as *Vision Zero* (ITE 2024; Hall and Madsen 2022). This requires a paradigm shift, a change in the ways we measure risks and evaluate potential traffic safety strategies (DeRobertis, et al. 2014; Horrox, et al. 2021; Hughes 2017; Litman 2013; Marshall 2024).

The old paradigm assumed that driving is very safe overall and so favored targeted strategies that addressed special risks such as youth, senior, impaired and distracted driving. The new paradigm recognizes that all vehicle travel imposes risk so *exposure* – total vehicle travel – is a risk factor. It recognizes the additional crashes caused when planning decisions induce more vehicle travel and the safety benefits provided by vehicle travel reduction strategies, such as multi-modal planning, efficient transport pricing, transportation demand management (TDM) incentives, and Smart Growth development policies. Since these strategies tend to provide large co-benefits, in addition to safety, the new paradigm supports more comprehensive analysis that considers these impacts. Table 1 compares the old and new safety paradigms.

Table 1 **Comparing the Old and New Traffic Safety Paradigms**

Factor	Old	New
Goal	Make driving safer.	Make transportation systems safer.
Risk measurement	Occupant risks, measured by distance (e.g., occupant deaths per 100,000 million vehicle-miles).	Total risks, including risks to occupants and other road users, measured by distance and per capita.
Solutions considered	Roadway and vehicle design improvements. Graduated licenses and senior driver testing. Seatbelt and helmet requirements. Anti-impaired and distracted driving campaigns.	Walking, bicycling and public transit improvements. Road, parking, fuel and insurance pricing reforms. More connected and complete streets. Smart Growth development policies. Transportation demand management programs. Traffic speed reductions.
Analysis scope	Program costs and traffic safety benefits.	All economic, social and environmental impacts.

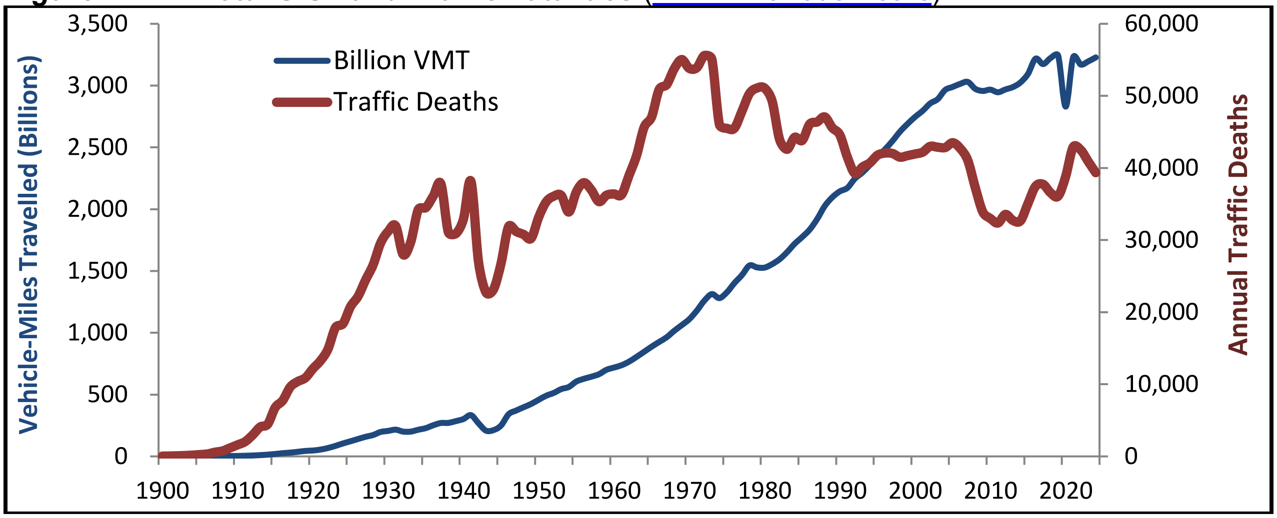
The old and new safety paradigms differ in many ways. The new paradigm considers more impacts and solutions.

This report explores these issues. It describes traffic casualty trends, the need for a new traffic safety paradigm, summarizes recent research on traffic risk factors and innovative safety strategies, evaluates the degree that current safety programs consider these factors, and provides recommendations for new strategies to achieve safety goals. It should be of interest to anybody who wants to identify the most efficient and cost-effective ways to improve traffic safety.

Why a New Paradigm?

This section describes why a new approach is needed for traffic safety.

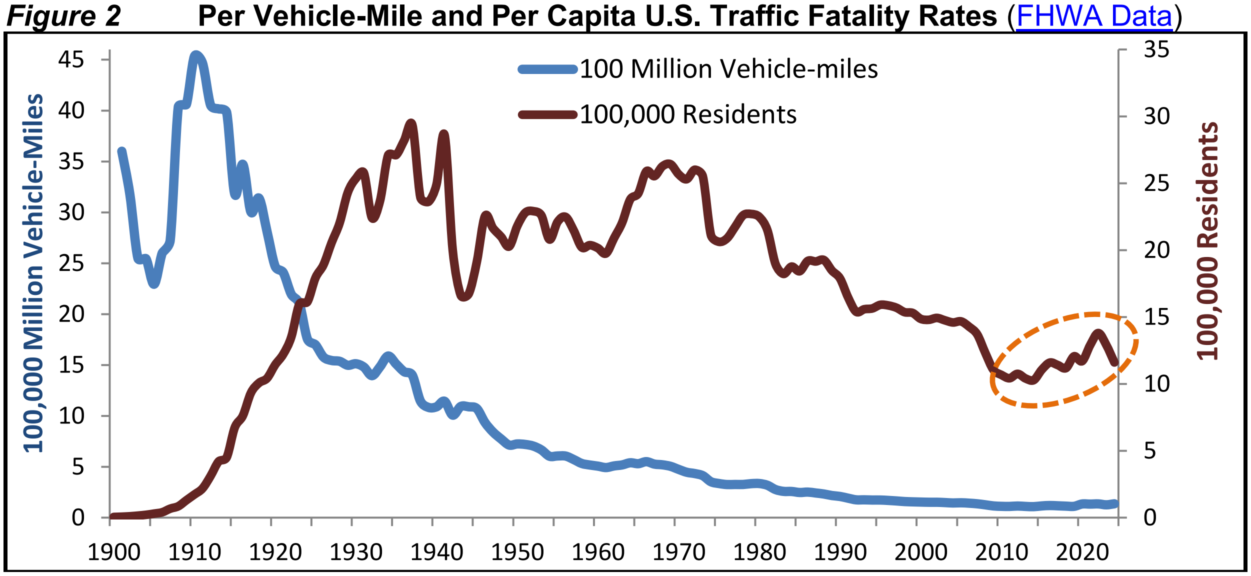
Figure 1 **Total U.S. and Traffic Fatalities** (FHWA Various Years)



U.S. traffic deaths peaked in 1973 and subsequently declined but increased after 2011 indicating that new strategies are needed to achieve ambitious safety goals.

The figure above shows U.S. vehicle travel and traffic fatality trends. Vehicle travel increased steadily during the Twentieth Century but subsequently plateaued. Total deaths peaked in 1973 and declined until 2011 after which they increased. The figure below shows distance-based and per capita traffic fatality rates. These declined during most of the last century but have recently started to rise. This suggests that traditional strategies, such as road and vehicle design improvements, and safety campaigns, have reached their practical limits and new strategies will be required to achieve ambitious safety goals.

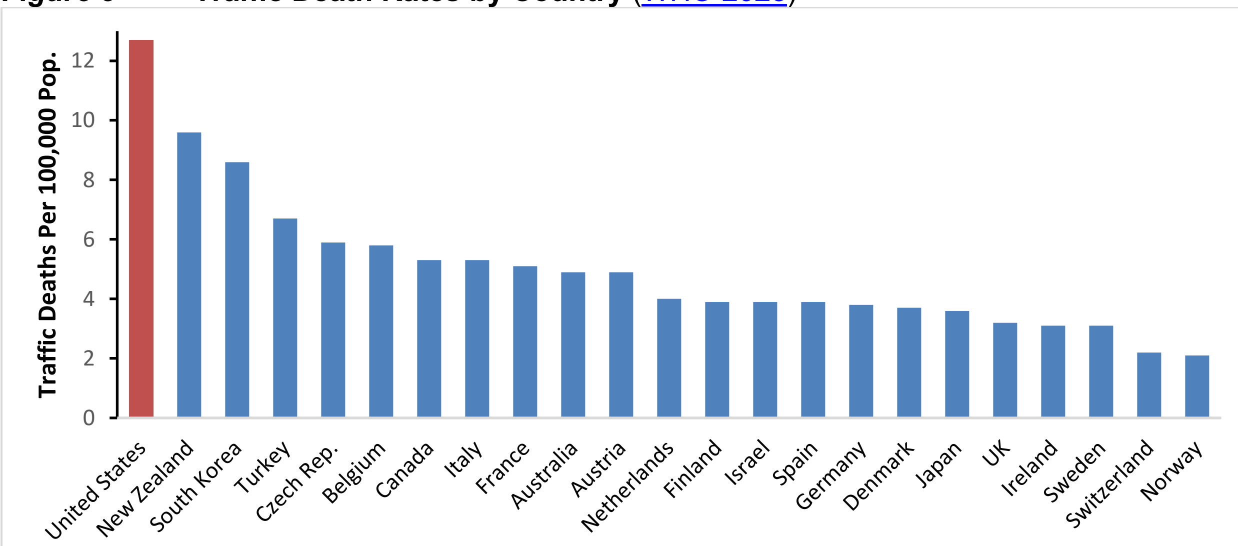
Figure 2 **Per Vehicle-Mile and Per Capita U.S. Traffic Fatality Rates** (FHWA Data)



Traffic fatality rates declined during most of the Twentieth Century but increased after 2011.

The figure below compares per capita traffic fatality rates between countries. The U.S. has the highest rate among its peers. Geographic factors do not explain these differences: Australia and Canada have lower population densities, and Sweden, Norway and Finland have more extreme weather, yet all have much lower traffic death rates and faster crash rates declines than the U.S.

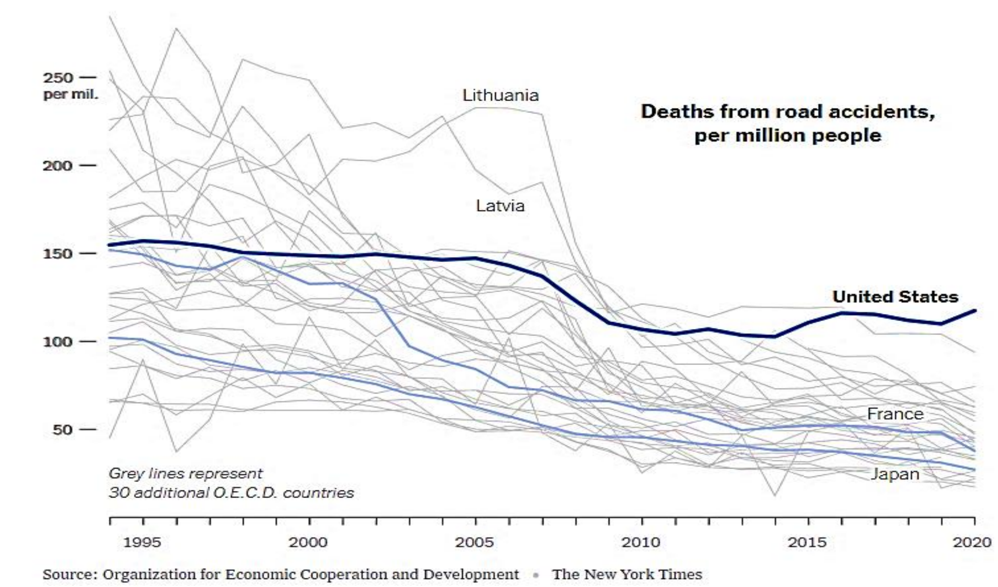
Figure 3 **Traffic Death Rates by Country** (WHO 2023)



The U.S. has, by far, the highest traffic fatality rate among peer countries.

The disparity between the U.S. and peer countries is increasing, as illustrated below.

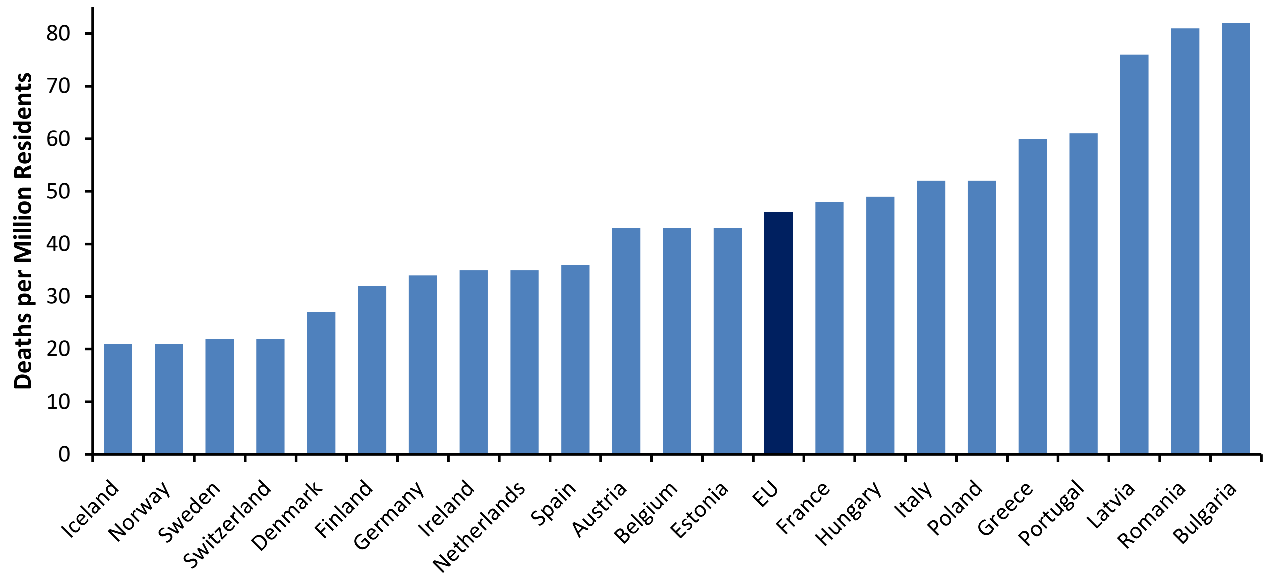
Figure 4 **Traffic Deaths per Million Residents** (Badger and Parlapiano 2022)



Traffic death rates declined much less in the U.S. than other OECD countries, and are now much higher than peers.

The figure below compares European country per capita traffic fatality rates.

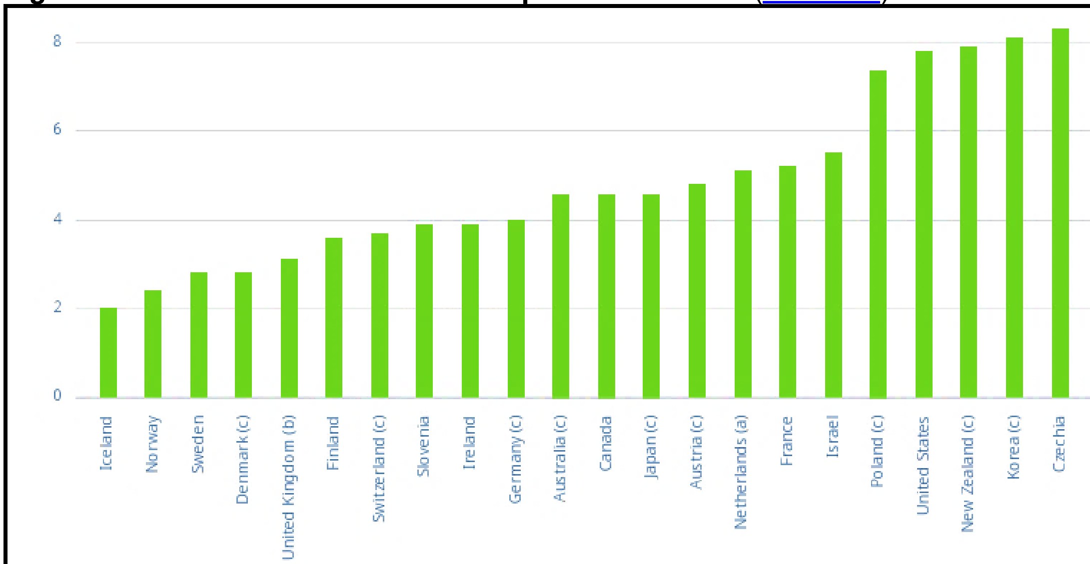
Figure 5 **European Traffic Fatalities Per Capita** (European Commission 2023)



European country crash rates range from about 20 to 80 traffic deaths per million residents.

The figure below compares OECD country traffic fatalities per billion kilometers.

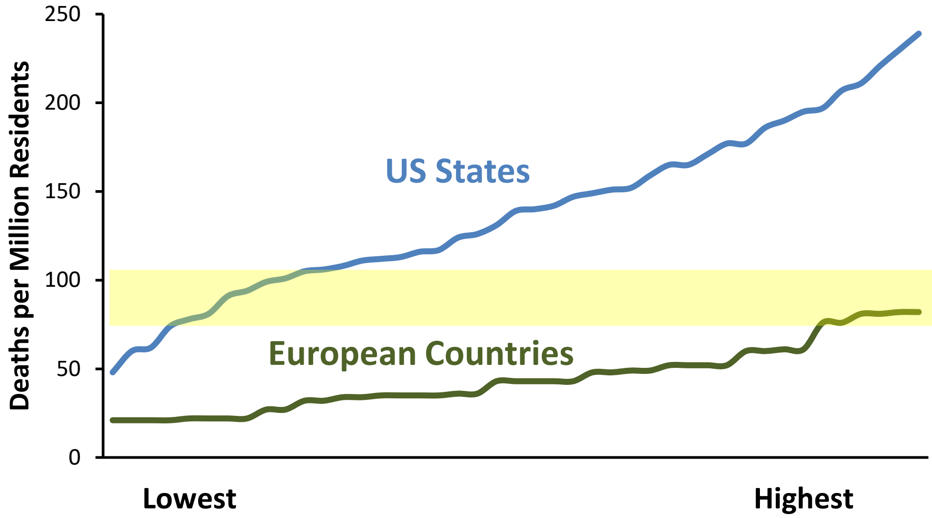
Figure 6 **OECD Traffic Fatalities per Billion Kms.** (ITF 2024)



OECD country crash rates range from about 2 to 8 deaths per billion kilometres. The U.S. rate is among the highest.

The following figure compares traffic fatality rate ranges between U.S. states and European countries. The five *safest* U.S. states have about the same traffic fatality rates as the five *most dangerous* European countries: both have 50-80 deaths per million residents (yellow band).

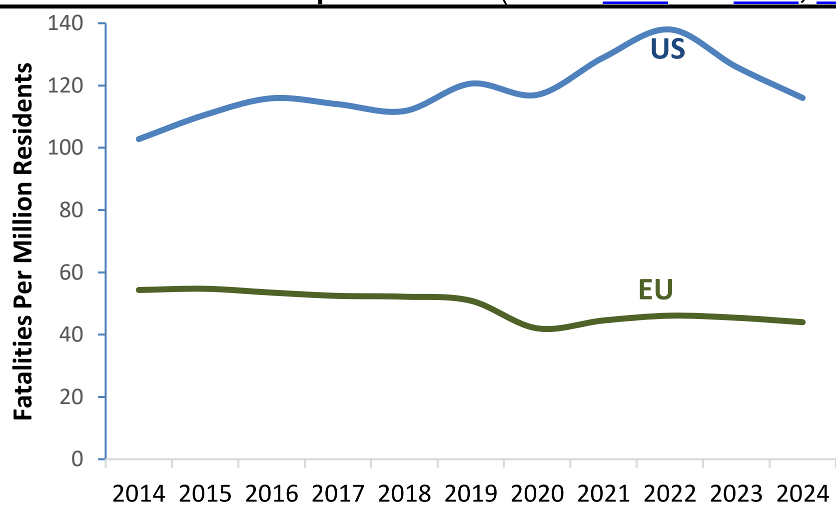
Figure 7 **US Versus European Traffic Fatality Rates** (IIHS 2024; European Com. 2023)



This figure compares traffic fatality rate ranges of U.S. states and European countries. The safest U.S. states have about the same fatality rates as the most dangerous European countries (yellow band).

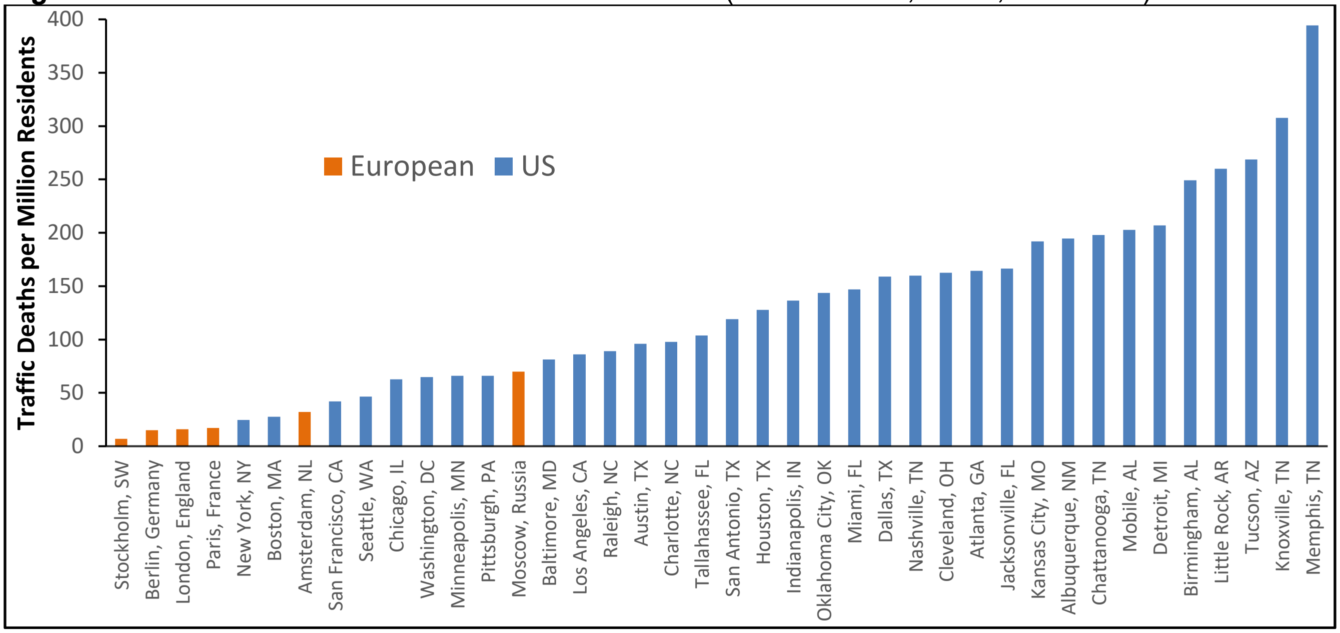
The figure below compares U.S. and European traffic fatality trends. During the last decade traffic fatality rates increased in the U.S. while declining in Europe, and are now more 2.6 times higher in the U.S.

Figure 8 **US Vs. European Trends** (FHWA 2023 and 2025; European Commission 2023)



Between 2014 and 2024 traffic fatality rates increased 13% in the U.S. and declined 19% in Europe. This probably reflects more multimodal transportation, stronger traffic safety programs and safer vehicle standards in Europe.

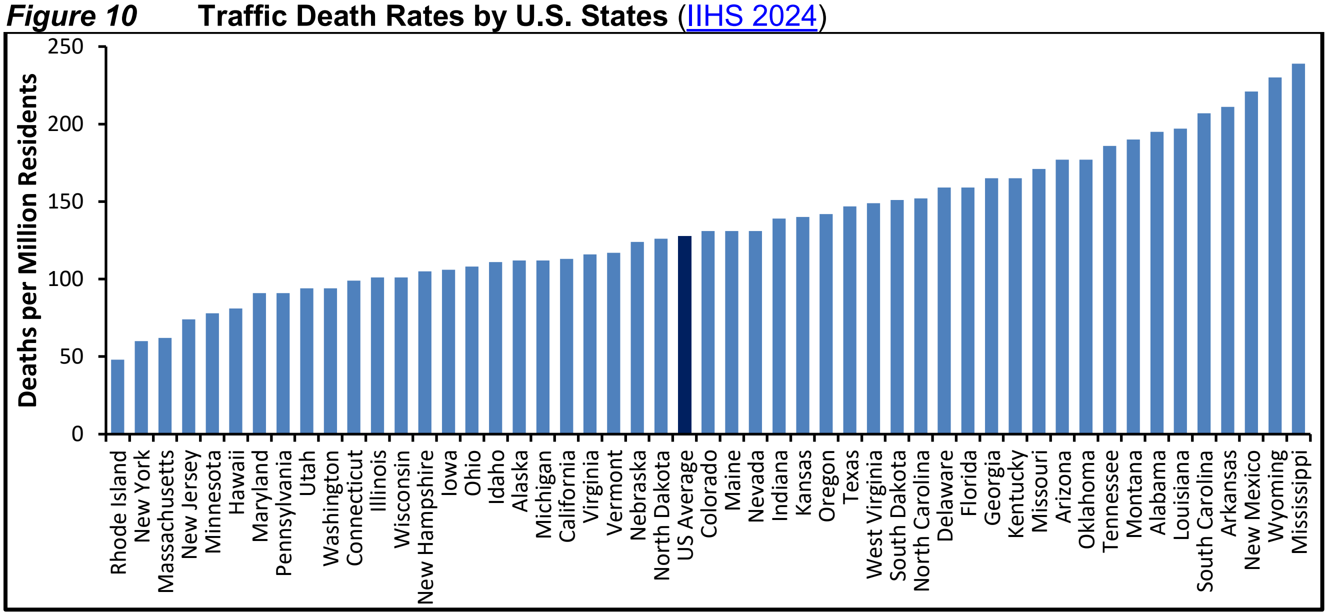
Figure 9 **Traffic Death Rates in Selected Cities** (NHTSA 2022; Welle, et al 2015)



Crash rates vary significantly between cities due to differences in transportation and land use patterns.

These two figures show the large variations in traffic fatality rates among U.S. urban regions and states. The most dangerous regions and states have about four times the fatality rates as the safest. What explains these variations? Are New York, San Francisco and Cleveland drivers more responsible than in Miami, Glendale and Memphis? Do Rhode Island, New York and Massachusetts have better roads, more effective traffic safety programs or milder climates than New Mexico, Wyoming or Mississippi? Probably not. Other transportation and community design factors better explain these differences, as discussed later in this report.

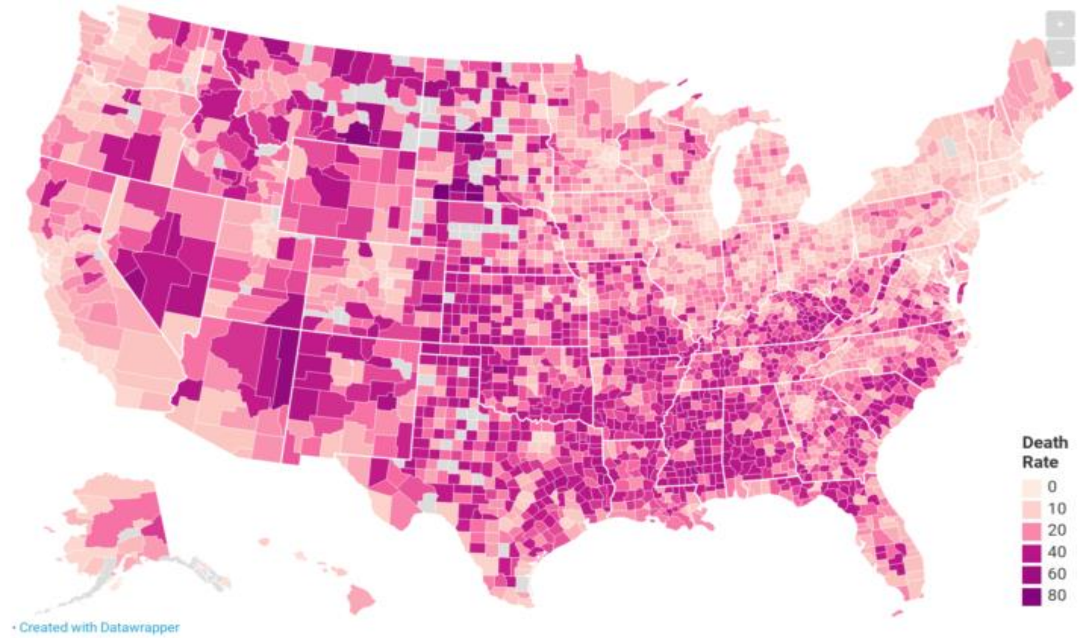
Figure 10 **Traffic Death Rates by U.S. States** (IIHS 2024)



Crash rates vary significantly between U.S. states, reflecting differences in their transport and land use patterns.

The following heatmap shows traffic fatality rates for U.S. counties.

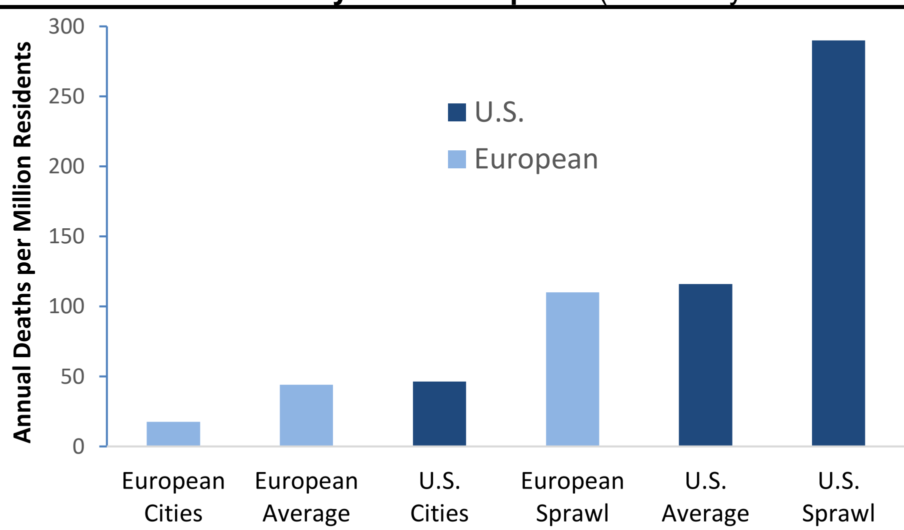
Figure 11 **County Traffic Fatalities per 100,000 Residents** (Academiaadvice 2018)



Per capita traffic fatality rates tend to be higher in rural counties and decline in areas that are more compact and multimodal.

Similar variations occur within regions. Compact, multimodal neighborhoods have about a fifth the traffic fatality rates as sprawled, auto-dependent areas, Europe has 60% lower rates than in the U.S. and an order of magnitude lower rates than in U.S. sprawled areas, as illustrated below. Reducing U.S. traffic casualty rates to those of Europe would save more than 20,000 lives and avoid a quarter million injuries annually.

Figure 12 **Traffic Fatality Rates Compared** (Previously Described Sources)



European cities average less than 20 traffic fatalities per million residents, which is lower than U.S. cities and an order of magnitude lower than U.S. auto-dependent, sprawled areas.

Reducing US traffic casualties to European levels would save about 24,000 lives and avoid about a quarter million serious injuries and disabilities annually.

The following section examines specific factors that can help explain these variations in traffic casualty rates.

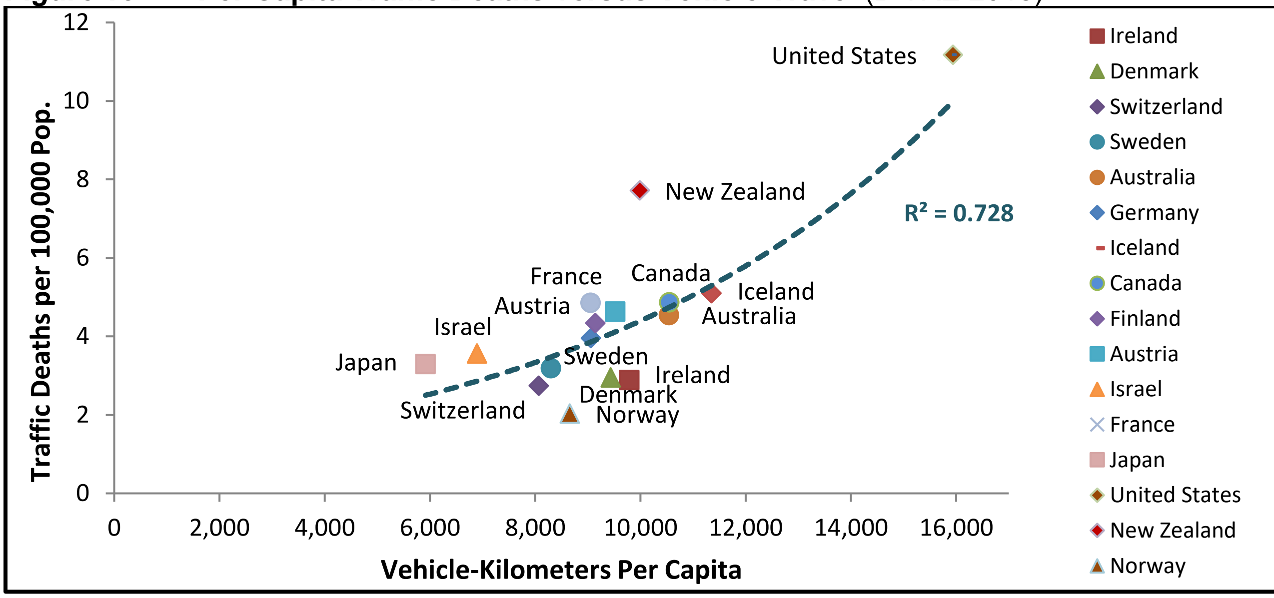
New Understanding of Traffic Risk

This section describes new research concerning how transport and land use factors affect crash risks. Also see Hamidi, Ewing and Grace (2016); ITF (2019); Marshall 2024; and Welle et al. (2018).

Total Vehicle Travel

Although many demographic, geographic and economic factors affect traffic risks, all else being equal, that is, for a given group or area, per capita fatality rates tend to increase with vehicle travel. The figure below illustrates this relationship among OECD Countries.

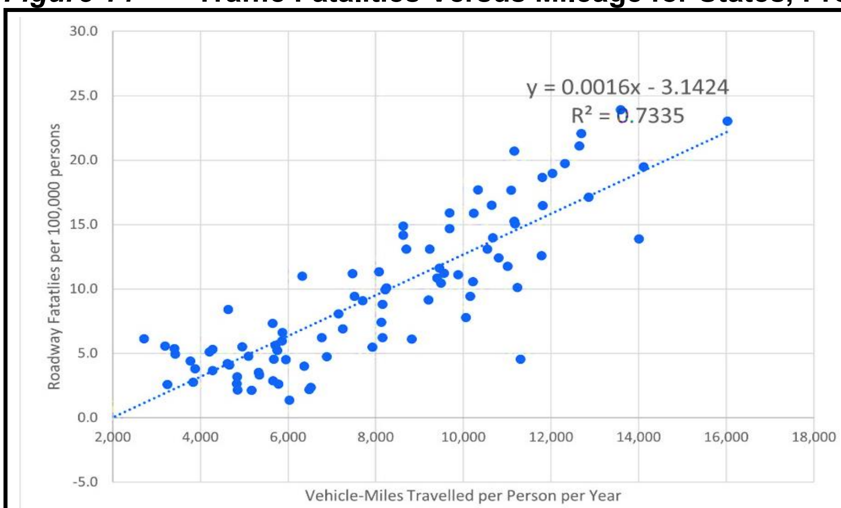
Figure 13 **Per Capita Traffic Deaths versus Vehicle-Travel** (BITRE 2018)



International data show that per capita traffic fatalities tend to increase with annual vehicle-kilometers.

These patterns occur at various geographic scales as illustrated below in the following graphs.

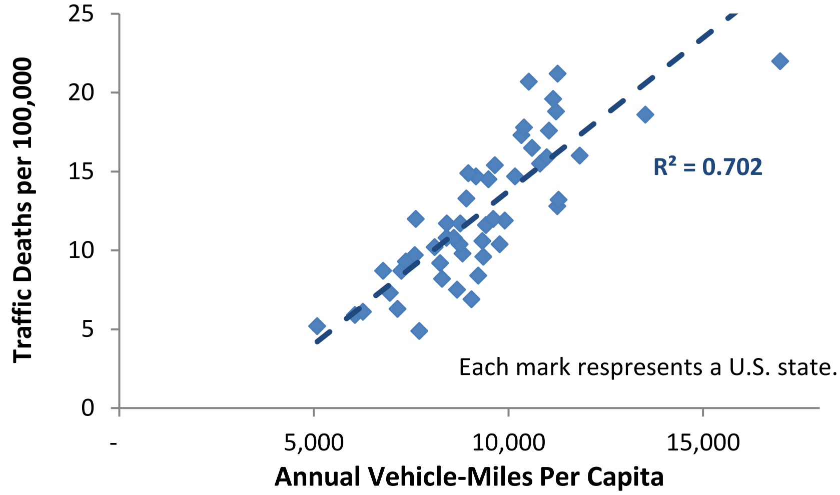
Figure 14 **Traffic Fatalities Versus Mileage for States, Provinces and Countries** (Meth 2024)



This graph shows per capita traffic fatality rates versus vehicle-miles travelled for U.S. states, Canadian provinces and 25 OECD countries in 2022. The 0.7335 R^2 value indicates that differences in per capita vehicle travel explains 73% of the variation in roadway fatality rate, a very strong statistical relationship.

The figure below shows this relationship for U.S. states.

Figure 15 **Traffic Fatalities Versus Mileage for U.S. States, 2022** (IIHS 2024)

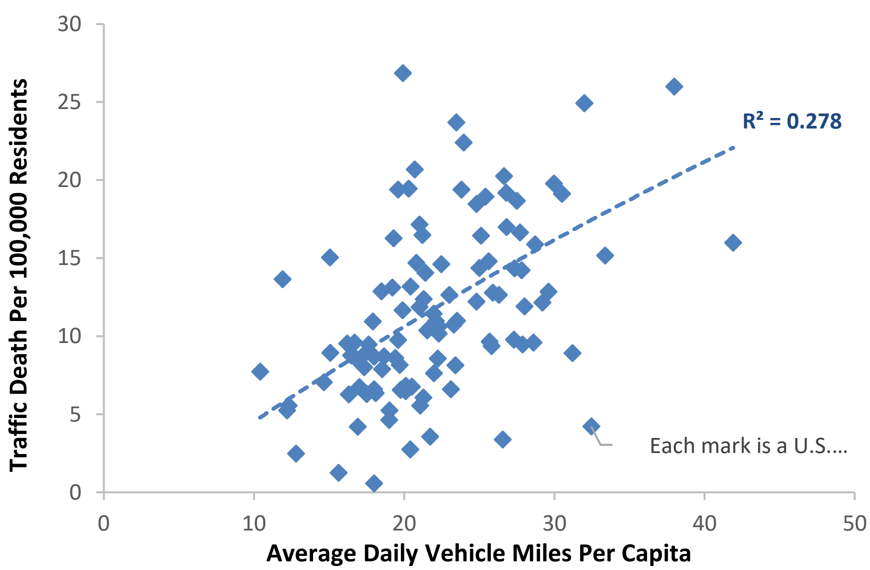


All else being equal, traffic fatality rates increase with per capita vehicle-miles. As a result, planning decisions that stimulate vehicle travel tend to increase crashes, and vehicle travel reduction policies tend to increase safety.

The 0.702 R^2 indicates a statistically strong relationship.

The figure below shows this relationship for U.S. urban regions. Other studies find similar patterns *within* regions: traffic casualty rates are much lower in compact, multi-modal neighborhoods than in sprawled, auto-dependent areas (Ewing and Dumbaugh 2009; Ewing and Hamidi 2014; Marshall, Ferenchak and Janson 2024; Welle, et al. 2018).

Figure 16 **Traffic Deaths Versus Mileage for U.S. Urban Regions** (FHWA and NHTSA 2023)



Per capita traffic fatality rates tend to increase with per capita vehicle-miles in U.S. Metropolitan regions.

Per capita vehicle travel and traffic risk vary significantly between areas. Households in compact, multimodal neighborhoods tend to drive 20-60% fewer annual miles at slower speeds, have better non-auto options, and as a result have much lower crash casualty rates than in urban fringe areas (Ewing and Hamidi 2014).

These graphs reflect simple correlations that may overlook confounding factors related to vehicle travel and risks. Of course, other factors can affect crash risk and vehicle travel reductions do not always provide proportional safety gains. For example, many developing countries have high traffic fatality rates despite low per capita vehicle travel, and the Covid pandemic caused a 15% reduction in U.S. vehicle travel in 2020 but traffic fatalities increased about 10%, although crash fatalities decline in most countries (Yasin, Grivna and Abu-Zidan 2021). This indicates that safety analysis should consider multiple risk factors.

More sophisticated analyses that account for various demographic, geographic and economic factors also show positive relationships between mileage and traffic deaths. For example, Ahangari, Atkinson-Palombo and Garrick (2017) used 1997 to 2013 data on U.S. vehicle ownership, travel behavior, socioeconomics, macroeconomics, safety policies, and mitigating factors such as health care on crash casualties. They found that per capita vehicle ownership and travel had the strongest impact. Similarly, using data that accounts for various geographic and demographic factors from 147 US urbanized areas, Yeo, Park and Jang (2015) found that each 1% increase in per capita VMT is associated with a 0.55% increase in traffic deaths. Comprehensive analysis using 2010 U.S. data, Ewing, Hamidi and Grace (2016) found that, normalizing for other factors, each 1% increase in VMT is associated with 0.3% increase in per capita traffic deaths.

A major U.S. study, *Identification of Factors Contributing to the Decline of Traffic Fatalities in the United States from 2008 to 2012* (Blower, et al. 2020), investigated reasons for crash rate declines during that period. It found that recessions tend to reduce driving by high-risk groups, particularly younger drivers, so people under age 26 accounted for almost half the safety gains. Detailed statistical analysis found that the three most significant contributors to the traffic fatality decline were increases in teen and young adult unemployment, reductions in median household income, and reduced GDP per capita. Declines in rural vehicle travel and beer consumption, plus stricter DUI laws also contributed. State highway spending and changes in safety belt use rates and fuel prices were not significant contributors because they changed little over the period.

A detailed study of 144 mid-size U.S. urban regions by Frederick, Riggs and Gilderbloom (2017) found powerful statistical evidence that living in auto-dependent American cities can have harmful health effects including higher traffic casualty rates than in cities where a greater portion of trips are by walking, bicycling and public transit. Adults living in modally diverse cities are more likely to live longer and better, and their children begin life in a better physical condition. The study, *Residential Accessibility's Relationships with Crash Rates Per Capita*, (Merlin, et al. 2020) found that in Knoxville, TN, per capita crash rates are lower in accessible neighborhoods with less per-capita vehicle miles, but this is partly offset if those areas have heavy through-traffic which tends to increase total (including pedestrian and bicyclist) crash casualty rates.

The study, "The Growing Gap in Pedestrian and Cyclist Fatality Rates Between the United States and the United Kingdom, Germany, Denmark, and the Netherlands, 1990–2018," (Buehler and Pucher 2021) found that U.S. pedestrian fatality rates per kilometer were 5-10 times higher, and bicyclist fatalities 4-7 times higher than in peer countries. The gap in fatality rates between the U.S. and the other countries grew over the time period, especially between 2010 and 2018 when pedestrian and cyclist fatality rates grew by 17% and 33% respectively, while fatality rates either fell or remained stable in the other countries. They concluded that low pedestrian and bicycle crash rates in European countries reflect better walking and cycling infrastructure, fewer vehicle km travelled, lower urban traffic speeds, better traffic law enforcement and smaller and less powerful personal motor vehicles. A major New Zealand study (Deloitte 2019) concluded that reductions in the country's crash rates from 1990 to 2012 resulted from improvements in vehicles (45%), better driver behavior (36%) and better roads (19%), but these gains were offset by increased vehicle-kilometres; it found that a 1% increase in VKTs is associated with a 2.5% increase in crashes.

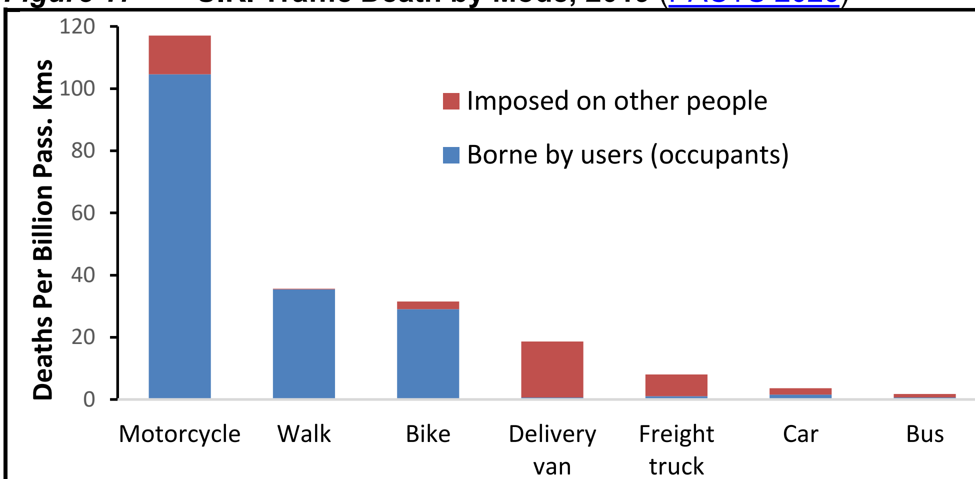
A major epidemiological study evaluated factors that affect per capita traffic casualty rates in 1,632 global cities (Thompson, et al. 2020). Taking into account demographic and urban design factors they found that crash rates were much lower in cities that have better transit, denser road networks and smaller city blocks, factors that tend to reduce vehicle travel and traffic speeds.

Since about two-thirds of casualty crashes involve multiple vehicles, and crash rates increase with traffic density (vehicles per lane-mile), changes in total vehicle travel can provide proportionately larger casualty changes, particularly in higher traffic density areas (Vickrey 1968). Hesjevoll and Elvik (2016) and Høye and Hesjevoll (2020) find that as traffic volumes increase a roadway, traffic casualties increase, particularly multi-vehicle crashes. Although high-speed grade-separated highways have low crash rates per vehicle-mile travelled, urban freeways tend to encourage sprawled development which increases total regional vehicle travel and crashes (Volker, Lee and Handy 2020). Studies that analyze these impacts on high speed highways and are likely to underestimate these effects on urban surface streets with frequent intersections. Edlin and Karaca-Mandic (2006) found that each 1% increase in total vehicle travel increases total crash costs by substantially more than 1% in virtually all U.S. states, and by 3.3- 5.4% in dense states such as California. Described differently, vehicle travel reductions can provide *external* safety benefits by reducing risk to other road users, so people become safer if their neighbors drive less.

Risk By Mode

Crash risks vary by mode, and therefore how people travel (NSC 2024). The figure below shows U.K. crash risk borne and imposed by various modes from the report, *What Kills Most on the Roads? New Analysis for the New Transport Agenda*, produced for the Parliamentary Advisory Council for Transport Safety (PACTS 2020).

Figure 17 **U.K. Traffic Death by Mode, 2019** (PACTS 2020)



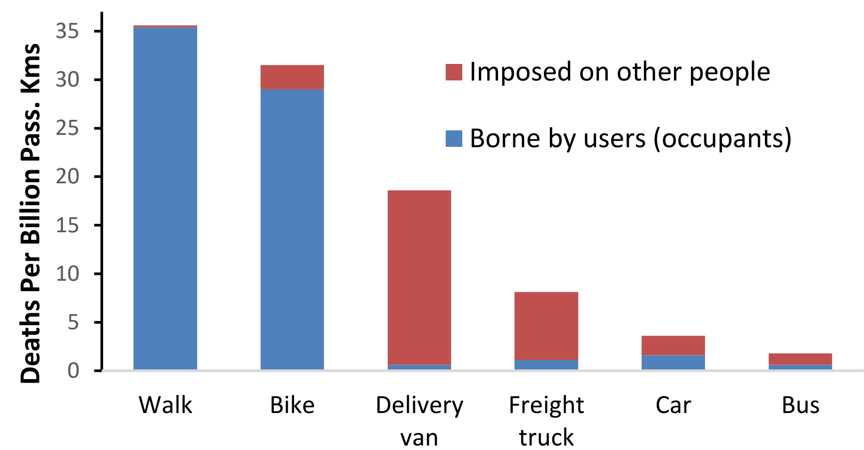
Modes vary in the risks occupants bear and impose on other people. Motorcyclists bear the highest risks because they are vulnerable and tend to risk-takers. Walking and bicycling bear high risks per kilometer but travel few annual miles so their annul risk tends to be low. Buses have very low risk.

The following factors should be considered when analyzing these statistics:

- Motorcyclists have high casualty rates due to their vulnerability and tendency to be risk takers.
- Active travellers (walkers and bicyclists) bear high risk per mile or kilometer travelled, but tend to travel fewer annual miles than motorists and impose minimal risk on others.
- Delivery vans and fright trucks impose high risks due to their large size and operation in dense traffic.
- Car travel imposes about as much risk as occupants bear.
- Public transit tends to be the safest mode.

To make comparisons easier the following graph shows the same data excluding motorcycles.

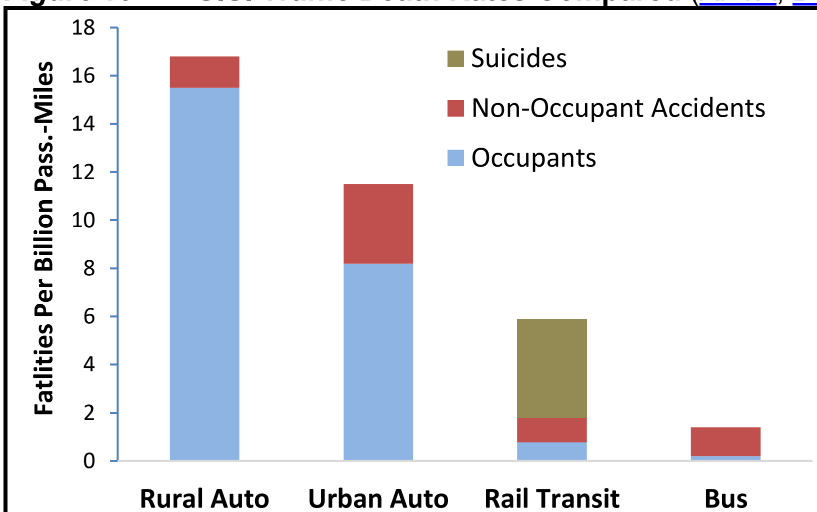
Figure 18 **U.K. Traffic Death by Mode, Excluding Motorcycles, 2019** (PACTS 2020)



This graph compares mode crash rates excluding motorcycles. Modes vary in the risks users bear and impose. Walking and bicycling bear high risks but imposes minimal risk on others and travel few annual miles so their annual risk tends to be low. Cars impose about the same risk they bear. Public transit is the safest travel mode.

The following graph compares internal and external risks by mode in the U.S. Driving is more dangerous in rural areas due to higher travel speeds and slower emergency response, and public transit is much safer than driving, even accounting for external risks.

Figure 19 **U.S. Traffic Death Rates Compared** (APTA, BTS, FTA and IIHS Data)

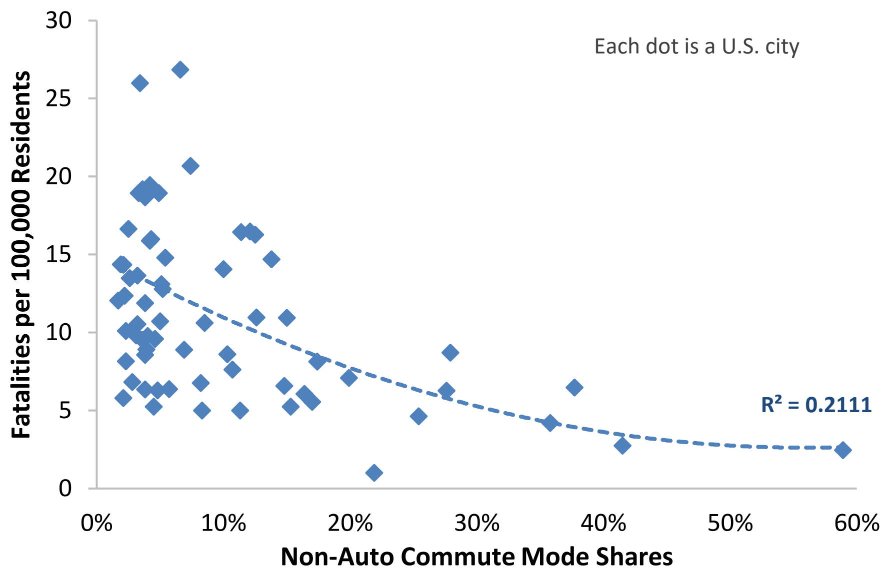


Per-mile traffic fatality rates are higher in rural than urban areas, and much higher for automobile than transit. Rail and bus passengers have very low risk, and transit imposes much less accident risk on other road users. As a result, total (all mode) crash rates tend to decline as transit travel increases in a community.

Both internal and external risks affect the total crash casualties that occur in an area. As previously described, all else being equal, that is, for a particular group or area, total (all mode) per capita traffic death rates tend to increase with more driving and decline with increased use of non-auto modes.

The following graph shows that traffic deaths tend to decline as non-auto (walking, bicycling and public transit) commute mode shares increase in a community. Only about 20% of total trips are for commuting, but commuting mode shares are often used as an indicator of non-auto travel conditions.

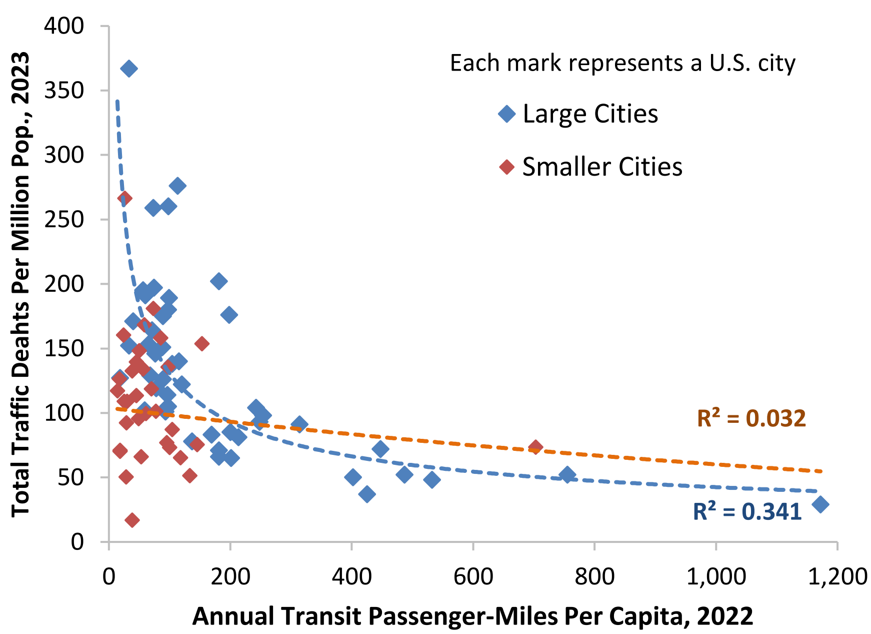
Figure 20 **Traffic Deaths Versus Non-Auto Travel Mode Shares** (ABW 2024)



As non-auto (walking, bicycling and public transit) commuting increases in a community, traffic fatality rates decline. Cities with more than 15% non-auto commute mode shares average just 6 deaths per 100,000 residents, less than half the 13 deaths per 100,000 residents in cities with less than 5% non-auto shares.

The following graphs illustrate the relationship between transit travel and traffic fatalities in U.S. cities. The effect is much stronger in larger cities where high quality transit can be a catalyst for transit-oriented development. Cities where residents average more than 200 annual passenger-miles (about 40 annual transit trips) per capita have less than half the traffic fatality rates as regions with less than 200 annual passenger-miles, indicating that small increases in transit ridership are associated with large traffic safety gains.

Figure 21 **Traffic Fatalities Versus Transit Travel** (APTA 2024, Ap. B; NHTSA 2023, T-124)

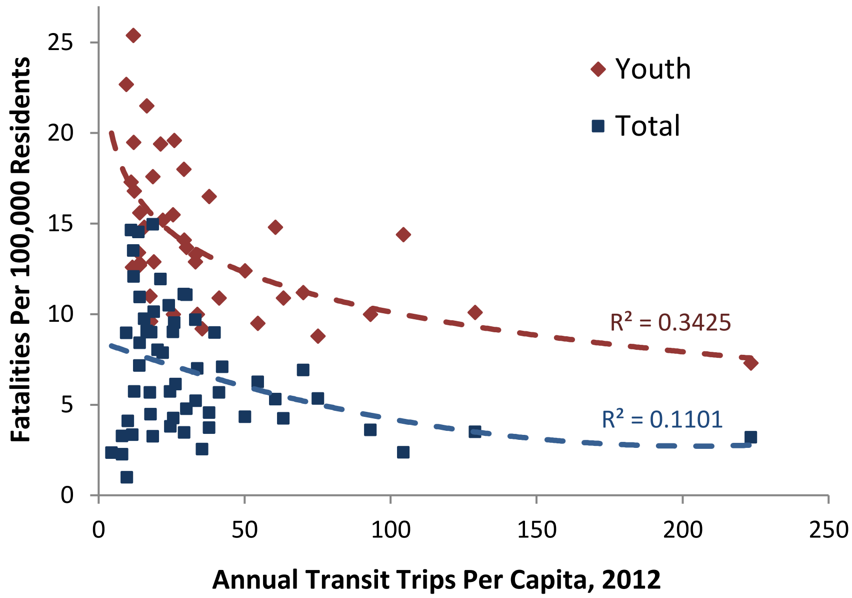


Traffic fatality rates decline with increased public transit travel, particularly in larger cities (blue marks).

Cities where residents average more than 200 annual passenger-miles (about 40 annual transit trips) per capita have less than half the traffic fatality rates as regions with less than 200 annual passenger-miles, indicating that small increases in transit mode shares are associated with large traffic safety gains.

The statistical relationship between transit ridership and traffic safety is particularly strong for youths, as illustrated below. This suggests that many young people want to reduce their driving and associated risk but can only do so if they have adequate alternatives.

Figure 22 **Youth and Total Traffic Fatality Rates Compared to Transit Travel** (CDC 2012)



Youths (15-25 years old) have about twice the traffic fatality rates as the total population average, and both youth and total fatality rates tend to decline with increased transit ridership.

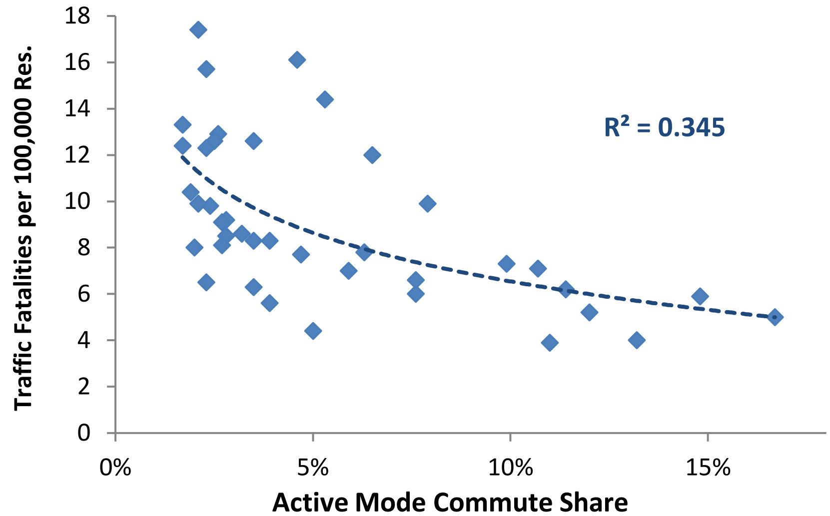
This statistical relationship is particularly strong for youths. This suggests that many young people are willing to reduce their driving and associated risk, but can only do so if they have adequate alternatives

Active modes (walking, bicycling and their variants) tend to have high casualty rates per mile or kilometer of travel. For example, in 2023 the UK had 27 pedestrian fatalities and 24 pedal bike fatalities per billion miles of travel, an order of magnitude more than the 3 fatalities per billion passenger-miles for car occupants (DfT 2024). As a result, some researchers to conclude that "a shift from passenger vehicle travel (lower risk) to nonmotorized travel (higher risk) could result in an overall increase in the numbers of people killed in traffic" (Beck, Dellinger and O'Neil 2007). However, this does not really mean that a typical traveller who shifts from driving to active modes experiences an order of magnitude increase in their individual risk, or increased walking and bicycling increases fatalities in a community; in fact the opposite generally occurs.

Numerous studies find that both active mode and total (all mode) crash casualties tend to decline as active travel increases in an area, an effect called *safety in numbers* (ABW 2016; Castro, Kahlmeier and Gotschi 2018; Ferenchak 2022; Jacobson 2003; NACTO 2016).

U.S. urban regions with active mode shares over 10% average about half the per capita traffic fatality rates as those with active mode shares under 5%, as illustrated below. Comprehensive analysis by Marshall, Ferenchak and Janson (2018) and Marshall and Ferenchak (2024) found that total traffic fatality rates in U.S. cities decline with increased bicycling mode shares. Murphy, Levinson and Owen (2017) found that in 448 Minneapolis city intersections, pedestrian crash risk declines as pedestrian traffic increases. Tasic and Porter (2018) find that sidewalk expansions tend to reduce non-motorized crash rates.

Figure 23 **Active Commute Mode Share and Traffic Deaths** (Census and CDC Data)

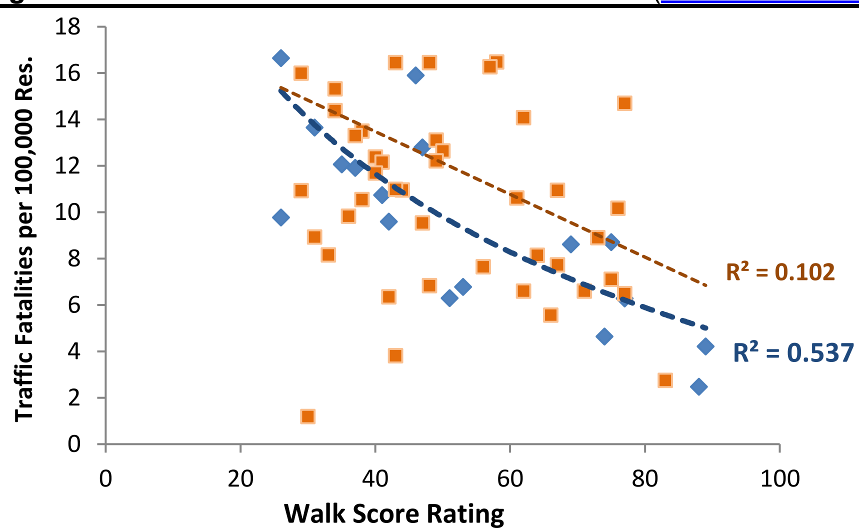


Total per capita traffic death rates tend to decline as active (walking and cycling) commute mode shares increase in U.S. urban regions.

This and other research indicates that more active travel tends to increase overall traffic safety.

The figure below shows that traffic fatality rates decline with Walk Score ratings, an indicator of neighborhood density and mix and therefore people's ability to access local services by walking. The relationship is very strong for large cities but weaker for smaller cities indicating that other factors affect their crash rates.

Figure 24 **Traffic Deaths Versus Walk Score** (Walk Score 2025)



For large cities there is a statistically strong relationship between traffic fatality rates and Walk Score, an indicator of neighborhood density and mix.

The relationship is weaker for cities with less than 750,000 residents, indicating that additional factors influence crash rates.

Relatively modest investments can increase active mode safety and travel (Krupnick 2025). For example, the U.S. Federal Highway Administration's Nonmotorized Transportation Pilot Program, which invested about $100 per capita in pedestrian and cycling improvements in four typical U.S. communities, caused walking trips to increase 23% and cycling trips to increase 48%, mostly for utilitarian purposes (FHWA 2014). Despite this increase in exposure, pedestrian fatalities declined 20% and bicycle fatalities 29%, causing per-mile fatality rates to decline 36% for pedestrians and 52% for bicyclists.

Frank, et al. (2011) found that increasing an area's sidewalk coverage ratio from 0.57 (sidewalks on both sides of approximately 30% of streets) to 1.4 (sidewalks on both sides of 70% of streets) reduces vehicle travel 3.4% and carbon emissions 4.9%. Guo and Gandavarapu (2010) found that completing a typical U.S. community's sidewalk network increases average per capita non-motorized travel 16% (from 0.6 to 0.7 miles per day) and reduce automobile travel 5% (from 22.0 to 20.9 vehicle-miles), representing about 12 miles of reduced driving for each mile of increased non-motorized travel. Similarly, Wedderburn (2013) found that in New Zealand cities, each additional daily transit trip by driving age (18+ years) residents is associated with increases of 0.95 walking trips and 1.21 walking kilometers, and two fewer daily car trips. Similarly, U.S. cities that expanded their bicycle lane networks tend to experience increased cycling activity and reduce crash rates (NACTO 2016).

Various factors help explain the large safety gains associated with increased non-auto travel:

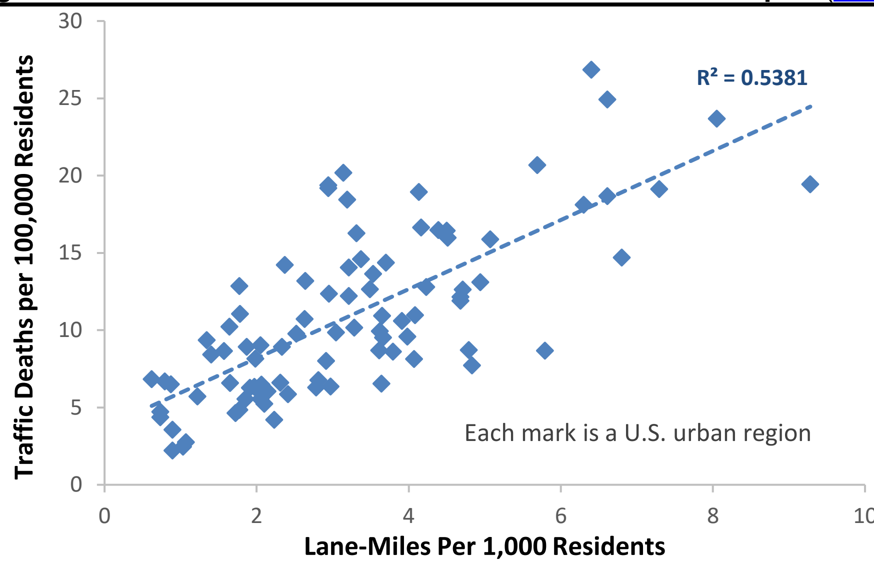
- *Safer travel conditions.* Increased non-auto travel results, in part, from safety improvements such as better sidewalks, crosswalks, bikeways, streetscaping, traffic speed control and education programs.
- *Complementary factors.* Many factors that encourage walking and bicycling, such as connected streets, higher parking and fuel prices, and compact development, also tend to increase traffic safety.
- *Reduced total travel.* Residents of more multimodal communities tend to drive less, reducing risk exposure. Shorter active mode trips often substitute for a longer automobile trip, for example, walking or biking to local shops rather than driving to regional shopping centers. Improving walking and cycling conditions reduces chauffeuring trips. A typical non-driver travels 2,000 to 4,000 annual miles by a combination of active and public transport, far lower than the 8,000 to 12,000 annual miles driven by a typical motorist.
- *Reduced risk to other road users.* Pedestrians and bicyclists impose less risk on other road users.
- *Increased driver caution.* As walking and bicycling increases in an area, drivers are likely to become more aware and cautious.
- *Less high-risk driving.* Improving non-auto modes allows young, old, impaired and distracted travellers to reduce driving, increasing the effectiveness of safety programs such as graduated licenses, senior driver testing and anti-impaired and distracted driving campaigns. For example, ride-hailing and public transit availability can help reduce post-drinking driving (Greenwood and Wattal 2015; Jackson and Owens 2011).
- *Stronger traffic enforcement*. In automobile dependent communities, courts are less likely to restrict licensure and confiscate vehicles of high-risk drivers (Wilson 2022).

Current planning tends to undercount active travel which exaggerates their crash rates (Buehler and Pucher 2024), so available statistics tend to exaggerate distance-based casualty rates. For example, transportation planners often rely on commute mode share data, which indicates that less than 5% of trips are by active modes, but more comprehensive surveys indicate that they serve about 14% of total trips, and much higher rates in cities, by lower-income travellers, and where sidewalks and bikeways are improved. As a result, conventional statistics tend to underestimate the potential to shift travel from automobile to non-auto modes and the safety benefits that result.

Urban Road Supply

Traffic engineers argued that because wider traffic lanes provide more space for vehicles to maneuver and are less stressful for drivers, crash rates increase with traffic density, and grade-separated freeways have lower crash rates, urban highways expansions increases safety. However, new research indicates that these potential safety gains are more than offset by increased traffic speeds, reduced driver caution, and more total driving which increase crash casualty rates over the long-run (Marshall 2024; Volker, Lee and Handy 2020).

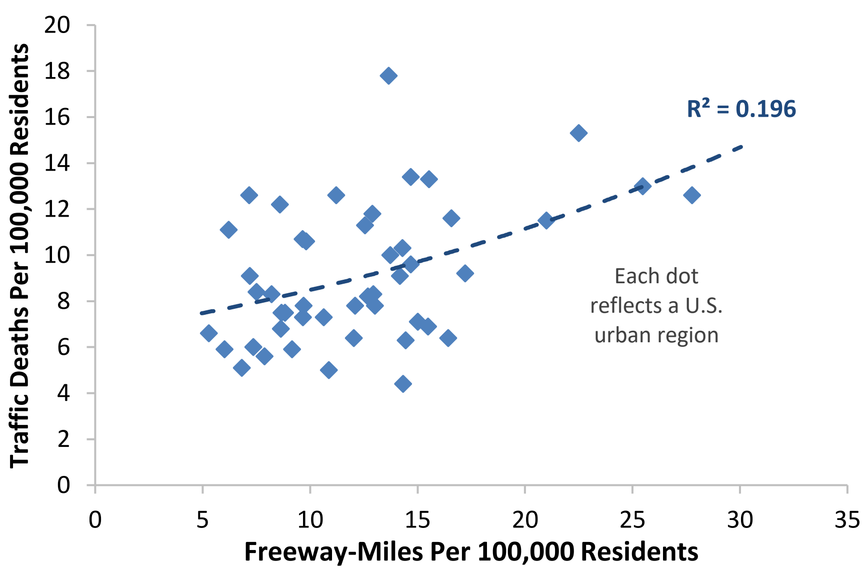
Figure 25 **Traffic Deaths Vs. Urban Lane-Miles Per Capita** (FHWA 2023)



Traffic death rates tend to increase with urban lane-miles per capita, indicating that longer and wider roads, and sprawl that increases travel distances, tends to increase traffic risk.

The figure above shows a strong positive relationship between traffic fatalities and urban lane-miles. The figure below shows a weaker positive relationship between traffic fatalities and freeway-miles per capita.

Figure 26 **Traffic Deaths Vs. Freeway Miles Per Capita** (FHWA 2018)



Although freeways have low crash rates per vehicle-mile, per capita traffic fatality rates increase with freeway supply. This occurs because urban highway expansions tend to induce more vehicle travel and sprawled development which increases total crashes, including more surface street crashes.

Traffic Speed and Congestion

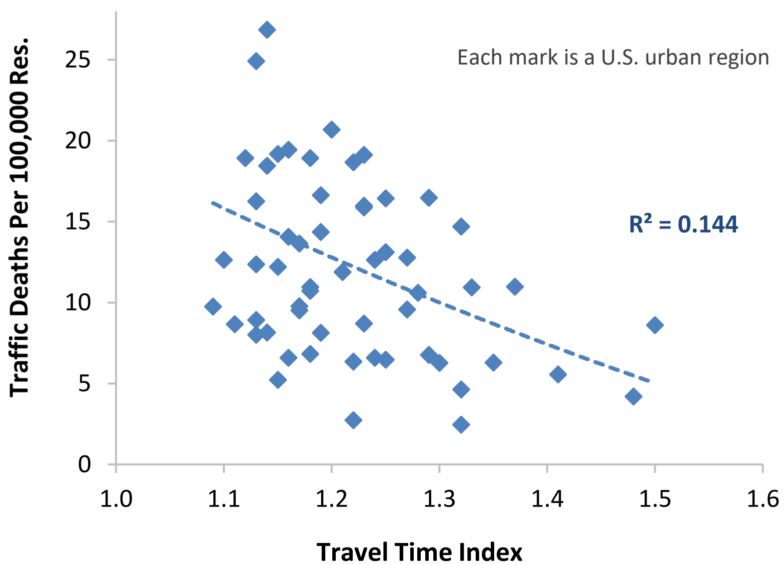
Traffic speeds affect crash risk directly, by affecting crash severity, and indirectly by affecting total distance travelled. Extensive research indicates that that higher traffic speeds increase crash frequency and severity, and speed reductions tend to reduce risk, particularly for vulnerable road users (GRSF 2021; NACTO 2020). A 1% increase in average traffic speed increases injury crash frequency about 2%, crash severity about 3% and crash fatalities about 4% (ITF 2018). Wider roads with higher traffic speeds and volumes degrade walking and bicycling conditions, called *the barrier effect*, and induce more vehicle travel.

Conventional roadway planning tends to prioritize speed. Road performance is often evaluated based on traffic speeds and delay, using indicators such as roadway Level of Service (LOS) and the Travel Time Index (TTI) which favors speed-increasing roadway projects. The *Manual on Uniform Traffic Control Devices* applies the “85th Percentile Rule,” which bases speed limits on the speeds at which 85% of vehicles travel in free-flowing conditions (Bronin and Shill 2021). These practices result in roadways optimized for traffic flow rather than safety, particularly in urban areas (Larson 2018).

The elasticity of vehicle travel with respect to travel time is –0.2 to –0.5 in the short run and –0.7 to –1.0 over the long run, so 10% higher traffic speeds increase affected vehicles’ mileage 2-5% during the first few years and up to 7-10% over the long run (Schiffer, Steinvorth and Milam 2005). As a result, higher traffic speeds increase, and speed reductions reduce, total vehicle travel and crashes. Narrower roads with fewer traffic lanes are associated with significantly lower pedestrian crash risk (AARP and CNU 2021; Ewing, et al. 2023).

Crash rates tend to be lowest on moderately congested roads (V/C=0.6) and increase with more or less congestion (Albalate and Fageda 2021; Phan and Truong 2024; Retallack and Ostendorf 2019). As a result, crash casualty rates often decline as congestion intensity increases (Potts, et al. 2014). Since traffic death rates tend to increase with per capita vehicle travel, roadway expansions that induce additional vehicle travel tend to increase traffic casualties (Wallis and Lupton 2013). The figure below shows that regional traffic death rates tend to decline with more intensive traffic congestion.

Figure 27 **Traffic Deaths Vs. Congestion Intensity** (TTI 2023)



Regional traffic death rates tend to decline with increased traffic congestion intensity measured by the Texas Transportation Institute’s Travel Time Index, which measures the additional travel time required during peak periods compared with off-peak free-flow speeds.

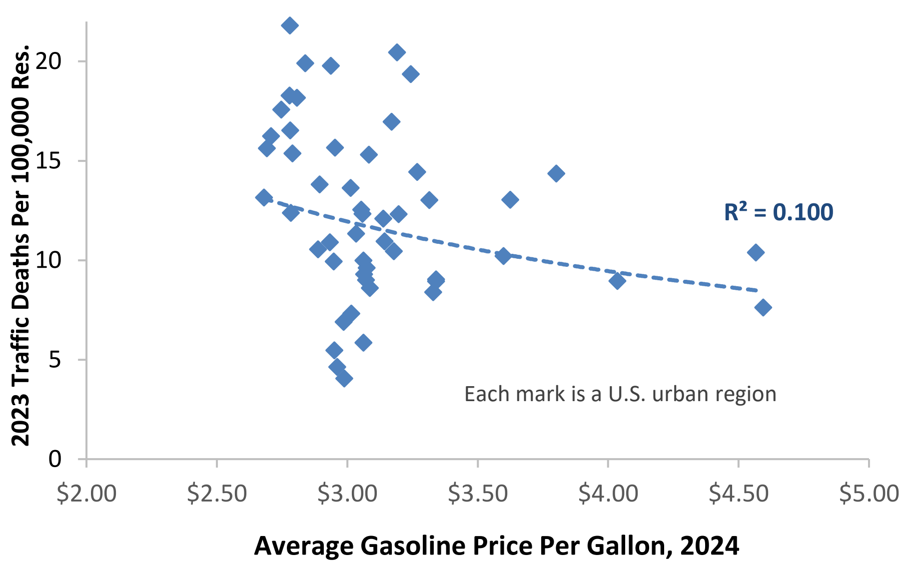
This contradicts the common assumption that urban roadway expansions increase traffic safety.

Transportation Pricing

Efficient pricing means that the prices that consumers pay for a good reflect the marginal costs of producing that good. This includes, for example, road user charges that fully fund roadway costs, road tolls and parking fees that recover facility costs with higher rates at peak demand times and locations, plus mileage-based vehicle fees and insurance premiums to reflect the costs and risks imposed by vehicle travel (Litman 2014).

Higher fuel prices encourage motorists to drive less and at slower speeds, increasing safety. A comprehensive study of 14 industrialized countries found that a 10% gasoline price decline increased road fatalities 2.19% (Ahangari, et al. 2014). Burke and Nishitateno (2015) found that a 10% fuel price increase typically reduces traffic deaths 3-6%, and estimate that removing global fuel subsidies would reduce approximately 35,000 annual road deaths worldwide. Using 2005-2018 European Union fuel price and traffic fatality data, Naqvi, Quddus and Enoch (2023) found that higher fuel prices reduce total traffic collisions, injuries and deaths due to reductions in total vehicle travel and traffic speeds, particularly by younger, riskier drivers. For every 10% increase in prices total collisions declined 1.4% for petrol and 1.2% for diesel models; fatalities declined 2.6% for petrol and 2.2% for diesel; and total casualties declined 1.6% for petrol and 1.4% for diesel. These findings suggest that policies replacing petrol and diesel vehicles with alternative fuel sources over the next 20 years could have negative repercussions for road safety if not adequately considered.

Figure 28 **State Traffic Fatality Rates Versus Fuel Prices** (NHTSA and AAA Data)

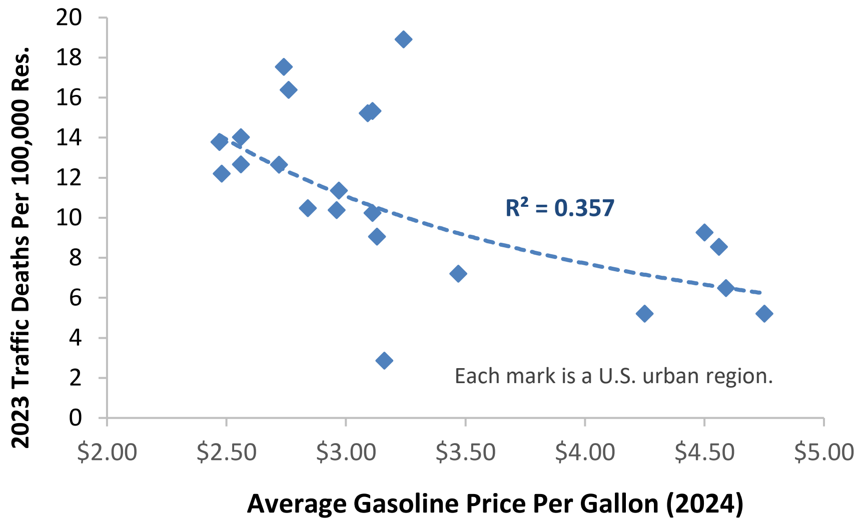


State traffic fatality rates tend to decline with higher fuel prices, although the statistical relationship is weak (R2 = 0.100).

This probably reflects the large diversity in geographic and travel conditions between states.

U.S. studies find similar results. Leigh and Geraghty (2008) estimate that a sustained 20% gasoline price increase would reduce approximately 2,000 traffic deaths and 600 air pollution deaths. Grabowski and Morrisey (2004 and 2006) estimate that each 10% fuel price increase reduces total traffic deaths 2.3%, with larger decline for drivers aged 15-21. Morrisey and Grabowski (2011) find that a 10% fuel price increase reduces traffic fatalities by 3.2–6.2%, and a 10% beer tax increase reduces motor vehicle fatalities by 17-24 year old drivers approximately 1.3%. Studies by Chi, et al. (2010, 2013 and 2015) indicate that U.S. fuel price increases reduce both per capita and per-mile crash rate, so a 1% reduction in total VMT reduces total crashes more than a 1%, with particularly large reductions in youth and drunken driving crashes. The relationship between fuel prices and safety is particularly strong for urban regions, as illustrated below.

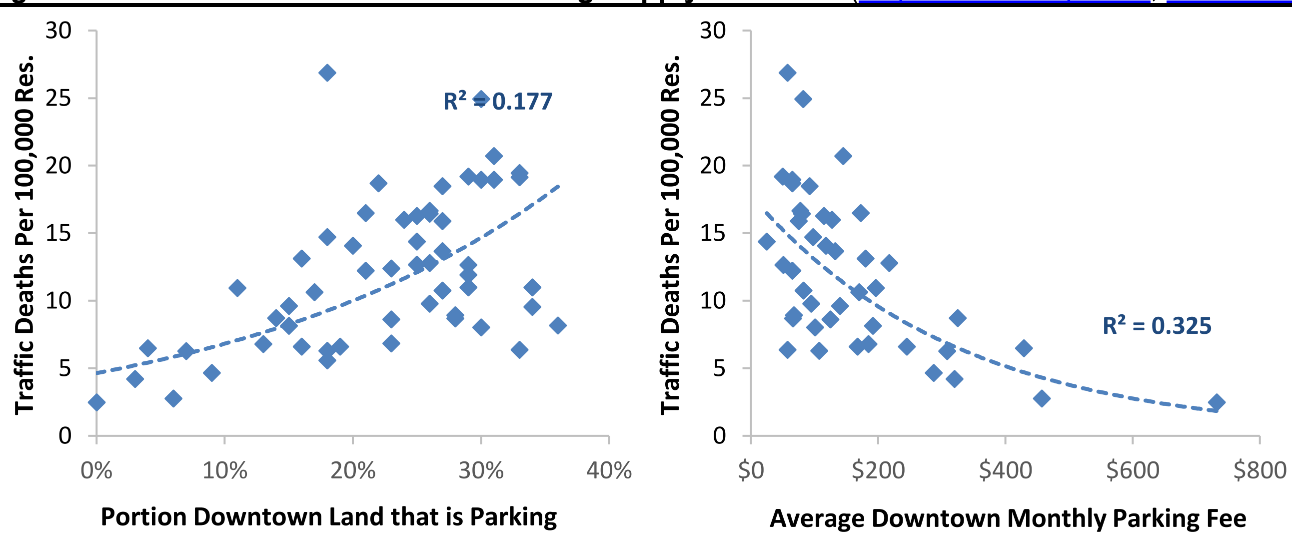
Figure 29 **Regional Traffic Fatality Rates Versus Fuel Prices** (NHTSA and AAA Data)



Large urban region traffic fatality rates tend to decline with higher fuel prices. The statistical relationship is strong (R2 = 0.537). This probably reflects the greater range of non-auto travel options in some cities which allows residents to respond to high fuel prices with reduced driving.

Other types of transportation pricing can also affect crash rates. A comprehensive review of road pricing programs found that 16 of 18 provided significant crash reductions (Singichetti, et al. 2021). These included a 46% decrease in road traffic crashes in London's charging zone plus significant decreases in adjacent non-charged areas, indicating that total traffic declined rather than shifting to other locations. During the first three months after tolls were charged for driving in southern Manhattan, crashes declined 17% and casualties 22% (Badger, et al. 2025; Braitsch 2025). London's road pricing reduced traffic 14% and casualties 25% within the charging zone, and crash rates declined 16% in nearby areas indicating that congestion pricing reduces rather than simply shifting traffic and crashes to other areas (Green, Heywood and Navarro 2020). Congestion pricing effects on pedestrian risk depends on changes in traffic volumes, speeds and vehicle types, and whether some revenues are invested in pedestrian safety improvements (Naumann, et al. 2022).

Figure 30 **Traffic Deaths Versus Parking Supply and Price** (City Observatory 2016; PRN 2025)



Urban traffic fatality rates tend to increase with more downtown land devoted to parking, decrease with higher parking fees. Abundant and cheap parking increases sprawl and encourages driving which increases crash rates.

Currently, most vehicle costs are fixed; motorists pay about the same depreciation, financing, insurance, registration fees and residential parking costs regardless of how much they drive. This encourages vehicle owners to maximize their driving to "get their money's worth" from these expenditures. Changing to distance-based pricing (called *pay as your drive* of *PAYD*), by prorating vehicle fees and premiums by average annual mileage, gives motorists a new opportunity to save money when they drive less. For example, for vehicles driven 12,000 average annual miles, a lower-risk driver with $600 annual insurance premiums would pay 5¢ per mile, and a higher-risk driver with $1,800 annual premiums would pay 15¢ per mile. Analyzing three million vehicle-years of insurance claims, Ferreira and Minike (2010) found that PAYD pricing is more actuarially accurate (premiums more accurately reflect a vehicle's claim risks), making insurance more efficient and equitable. This would typically reduce affected vehicles' mileage about 10% or more, and since higher risk motorists have a greater incentive to reduce driving, this can provide extra safety benefits, so crashes and claim costs decline more than 10%.

The table below summarizes ways that transportation pricing reforms can increase traffic safety.

Table 2 **Transportation Pricing Safety Impacts** (Litman and Fitzroy 2023)

Pricing Type	Description	Travel Impacts	Traffic Safety Impacts
Higher fuel prices	Increase fuel prices to finance roads and traffic services, and to internalize fuel economic and environmental costs.	European-level fuel prices reduce per-capita vehicle travel 30-50% compared with North America. Affects most vehicle travel.	Vehicle travel reductions provide proportionate or greater reductions in crashes (i.e., a 30% mileage reduction provides about 30%+ fatality reduction).
Road pricing	Tolls to reduce congestion and generate revenue.	Typically reduces affected vehicle travel 10-30%. Usually applies to a small portion of total travel.	Can have significant safety benefits where applied, but total impacts are generally small.
Parking pricing	User fees to finance parking facilities. Can also include parking cash out and unbundling.	Typically reduces affected vehicle trips 10-30%. Most common in city centers, campuses and hospitals.	Can have significant safety benefits where applied, but total impacts are usually moderate due to limited application.
Distance-based pricing	Prorate vehicle insurance and registration fees by mileage.	Typically reduces affected vehicle travel 8-12%.	Potentially large safety benefits. Reduces total vehicle travel, particularly higher-risk driving.

This table summarizes major pricing reform categories and their travel and safety impacts.

These pricing reforms tend to be more effective and beneficial if implemented with improvements to non-auto modes so travellers can more easily reduce driving (Litman 2014). For example, a $3.00 per day parking fee might only reduce driving 10% in an auto-dependent area but 30% in areas with good walking, bicycling, public transit and telework options.

This suggests that efficient transportation pricing can provide large traffic safety benefits. Currently these reforms tend to be proposed primarily as congestion and emission reduction strategies; their safety benefits are often overlooked or undervalued, resulting in less-than-optimal implementation. More consideration of their safety benefits can justify more efficient pricing.

Street Design and Land Use Factors

Various studies using a variety of methods and data sets indicate that traffic casualty rates decline with shorter blocks, more connected street networks, and more compact and mixed development (Ahangari, Atkinson-Palombo and Garrick 2017; Dumbaugh and Rae 2009; Ewing, Hamidi and Grace 2016; Ferenchak 2022; Marshall 2024).

Najaf, et al. (2018) find that an urban area's per capita crash rates decline with more job-housing balance, more polycentric design, increased population density and less low-density sprawl, improving transportation network connectivity and more public transit facilities. Similarly, Boeing (2020) found that increased "griddedness" is associated with less vehicle ownership and travel. They estimate that, all else being equal, a 10% increase in urban population or employment density reduces crash fatality rates more than 15%, a 10% increase in network connectivity reduces crashes 4%, and 10% more transit service reduces fatalities 8%.

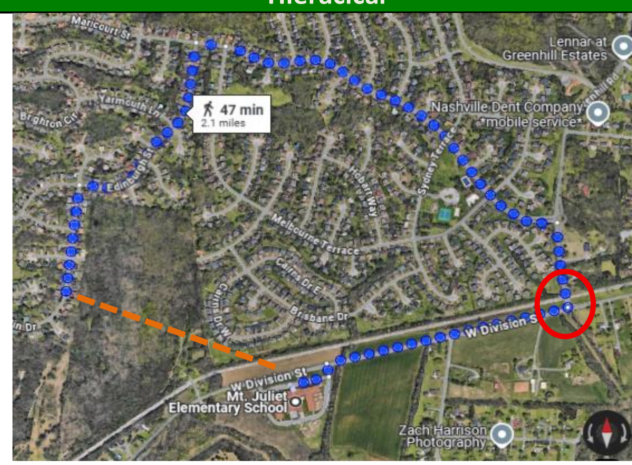
The figure below compares grid and hierarchical street networks. A dense grid provides many possible routes on lower traffic to local destinations. A hierarchical network offers few and usually circuitous route options, so even nearby destinations usually require long trips that require crossing or travelling on busy roadways. These factors discourage active travel, forcing drivers to chauffeur non-drivers for most trips, which encourages youths and seniors to drive. These factors – longer trips, poor non-auto access, more automobile travel, more crossing and turning onto busy roads, and more driving by higher risk groups – increase crash exposure. This explains why shorter blocks and increased street connectivity tend to reduce crashes.

Figure 31 **Connected Versus Hierarchical Street Network** (Google Maps)

Connected

Well-connected grid street networks offer many direct routes on low traffic streets for walking to destinations.

Hieracical

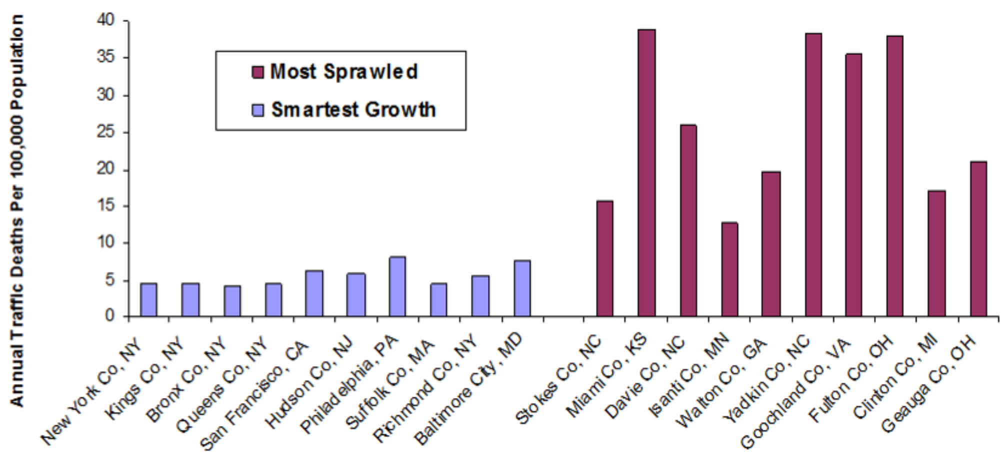


Hierarchical street networks offer limited and long routes, and requires crossing busy roads.

Garrick and Marshall (2011) found that in California, more compact, connected and multi-modal urban areas have about a third of the traffic fatality rates as those that are more sprawled, automobile dependent. These studies indicate that sprawl-inducing practices such as separated land uses, disconnected road networks, and higher roadway design speeds tend to increase crash casualty rates by increasing vehicle mileage and speeds. Accounting for demographic and geographic factors (income, fuel prices and compactness) in 147 U.S. urban regions, Yeo, Park and Jang (2015) found that per capita traffic fatality rates increase with sprawl, apparently due to a combination of increased vehicle travel, higher traffic speeds and slower emergency response. Similarly, Ahangari, Atkinson-Palombo and Garrick (2017) found that traffic death rates decline with densities.

Ewing and Hamidi (2014) found that a 10% increase in their Smart Growth index reduces per capita crash fatality rates 14%. The figure below shows the lower fatality rates in the 10 counties with the highest smart growth rating compared with the ten rated most sprawled. Ewing, Hamidi and Grace (2016) found that at the U.S. county level, accounting for various geographic and demographic factors (land use density and mix, block size, roadway connectivity, Walkscore, household size, employment and income, race fuel price and climate factors) dispersed, sprawl land use development is associated with *lower* per capita rates of minor "fender bender" crashes, but significantly *higher* rate of fatal crashes, due to the combination of more total motor vehicle travel and higher traffic speeds in dispersed, automobile-oriented areas.

Figure 32 **Annual Traffic Death Rate** (Ewing, Schieber and Zegeer 2003)



Of 280 U.S. counties analyzed, the ten with the lowest sprawl rating have about a quarter the per capita annual traffic fatality rates of the most sprawled counties.

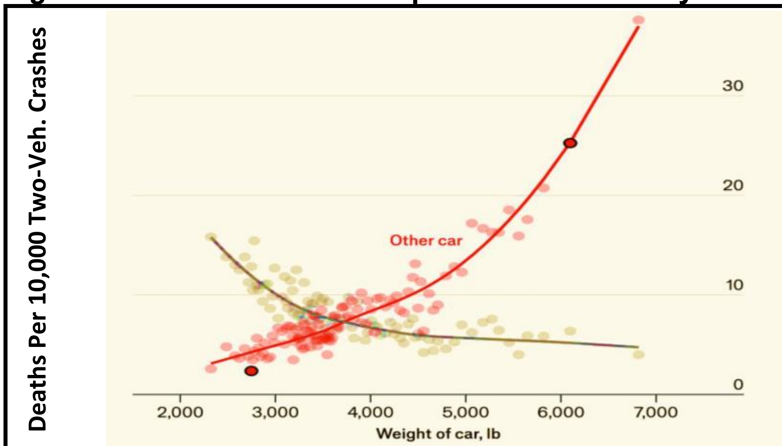
More compact development with well-connected street networks also improve emergency response by reducing travel distances between police, fire and medical services, and by providing redundant travel routes so responders are not delayed if a particular road is blocked.

These factors help explain why Smart Growth communities with compact, mixed development and well-connected street networks provides large safety benefits: they reduce total vehicle travel and traffic speeds, improve emergency response, and by improving travel options helps reduce higher-risk driving by youths, seniors and drinkers. As a result, Smart Growth complements traffic safety strategies such as graduated driver's licenses and anti-drunk-driving campaigns.

Vehicle Type

Vehicles vary in the risks occupants bear and impose on other road users. European countries have stricter vehicles safety standards designed to protect other road users (ETSC 2025). By encouraging motorists to choose larger vehicles, U.S. traffic safety programs can increase risks to other road users (Anderson and Auffhammer (2014). The Insurance Institute for Highway Safety and the National Highway Traffic Safety Administration rate vehicle occupant protection and compare fatality rates between models, which implies that safety increases with vehicle size and weight (Tucker 2023). The IIHS states, “Smaller, lighter vehicles generally offer less protection than larger, heavier ones…If safety is a major consideration, pass up very small, light vehicles.” (IIHS 2023). This encourages motorists to purchase larger vehicles to protect themselves, ignoring the additional risk they impose on others, leading to an arms race that increases total traffic risk. In fact, the increased safety to large vehicle occupants is more than offset by increased risk to others, as illustrated in the following figure.

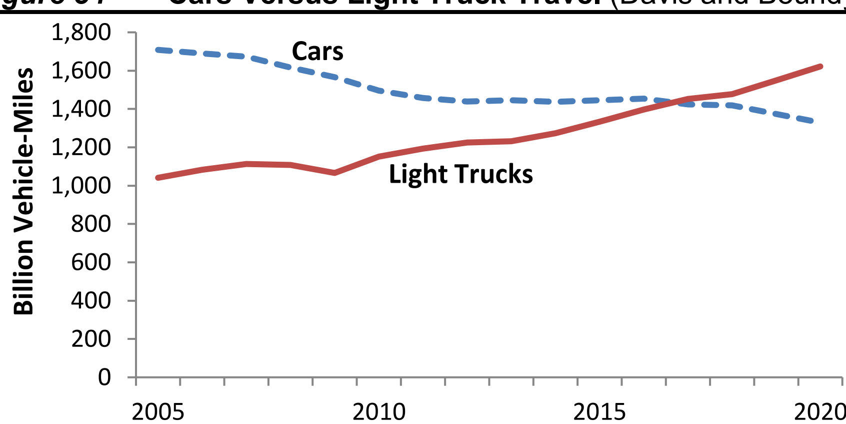
Figure 33 **Deaths to Occupants and Others by Vehicle Weight** (The Economist 2024)



As vehicle weights increase so does the risk of killing others. Researchers conclude, "For every life that the heaviest 1% of SUVs and trucks save, there are more than a dozen lives lost in other vehicles."

If larger, heavier vehicles actually increase overall safety traffic death rates should be lower in rural areas where vehicles tend to be larger, and U.S. traffic deaths should have declined as light trucks and SUVs became more common between 2008 and 2020, but that did not occur, as illustrated below. This indicates the safety that larger vehicles provide to occupants is offset by the increased risk they impose on others (Davis 2021).

Figure 34 **Cars Versus Light Truck Travel** (Davis and Boundy 2022, Tables 4.1, 4.2)



If overall safety increased with vehicle size total crashes should have declined in the U.S. between 2005 and 2020 as light trucks became more common in the vehicle fleet, but total traffic deaths increased during much of this period, indicating that safety gains to those vehicle occupants were more than offset by increased risk to others.

Many people hope that autonomous vehicles will significantly increase traffic safety. Proponents claim that since human errors contribute to 90% of crashes, they will soon reduce crashes 90% (Keeney 2017). However, these technologies introduce new risks including hardware and software failures, malicious hacking, increased risk-taking if other road users feel safer, special risks from platooning and increased total travel (Hsu 2017; Koopman and Wagner 2017; Litman 2022; Zipper 2021). The safety benefits of previous innovations were often overestimated because travellers tend to take more risks when they feel safer, called *offsetting behavior* or *risk compensation* (Chirinko and Harper 1993; Rudin-Brown and Jamson 2013).

Their net safety benefits will depend on how they are programmed, used, priced and regulated. For example, to maximize mobility they can be programmed to operate at higher speeds, take greater risks and have dedicated platooning lanes, but to maximize safety they should be programed to drive slower and be more cautious, and road pricing and high-occupant vehicle lanes can encourage autonomous vehicle trip sharing.

Transportation Demand Management Programs

Transportation Demand Management (TDM) includes various incentives for travellers to choose more efficient travel options (Peterson 2017). The table below summarizes their typical travel and safety impacts. These strategies tend to have synergistic effects: their effectiveness increases if they are implemented together, and some provide additional safety benefits by improving protections for vulnerable modes or reducing higher risk driving. As a result, comprehensive TDM programs can reduce affected vehicle travel and associated crashes 20-40%, and more if supported with large investments in non-auto modes.

Table 10 **TDM Travel and Safety Impacts** (CARB 2014; Litman and Fitzroy 2024)

Category	Travel Changes	Safety Impacts
Active mode (walking and bicycling) improvements	Shifts motorized travel to active modes	Can increase users' per-mile risks but increase safety overall by reducing external risks and VMT.
Transit improvements, HOV priority, park & ride	Shifts automobile travel to transit. Also increases active travel.	Moderate to large safety benefits. Reduces crash rates and can stimulate compact development.
Ridesharing, HOV priority	Shifts single occupant travel to ridesharing	Moderate benefits. Reduces total vehicle traffic but crashes that occur may involve more victims.
Pricing reforms (efficient fuel, road and parking prices).	Reduces vehicle mileage.	Moderate to large safety benefits. Efficient pricing reduces total vehicle travel.
Distance-based (PAYD) insurance.	Reduces mileage in proportion to risk class.	Large potential safety benefits. Reduces total traffic, particularly higher-risk drivers.
Telework, delivery services	Reduces total vehicle travel.	Modest benefits. Reduced vehicle travel reduces crashes but may increase commute vehicle travel.
Mobility marketing	Encourages mode shifts.	Can reduce affected driving 5-10%.
Streetscaping, traffic calming and speed enforcement	Reduces traffic speeds.	Large safety benefits where applied. Reduces total vehicle travel, crash frequency and severity..
Time and location driving restrictions.	Reduces vehicle travel and increases active in those areas.	Increases safety where vehicle travel is reduced, but may increase risks elsewhere if traffic is diverted.
Smart Growth (compact, multimodal development).	Reduces vehicle travel and traffic speeds, increases non-auto travel.	Large safety benefits. Reduces per capita vehicle travel.

This table summarizes the safety impacts of various transportation demand management strategies.

Education and Promotion Campaigns

Many governments sponsor traffic safety campaigns that rely primarily on education and promotion. They tend to be uncontroversial, since they are relatively inexpensive and do not require behavior change, but their effectiveness tends to be modest (Zipper 2022). The National Highway Traffic Safety Administration's *Countermeasures That Work* report gives education campaigns a minimum one-star rating indicating "limited or no high-quality evaluation evidence" of their effectiveness. To be more effective, safety campaigns can include information and encouragement to choose safer travel modes and location decisions, for example, by promoting the safety benefits of living in compact, multimodal communities.

Summary of Traffic Risk Factors

The table below summarizes key traffic risk factors and their implications for traffic safety planning.

Table 3 **Traffic Risk Factors**

Risk Factor	Typical Impacts	Implications for Safety
Total vehicle travel	All else being equal, for a given group or area, changes in vehicle-miles provide about proportionate changes in crash rates.	Planning decisions that induce more vehicle travel increase risk, and vehicle travel reductions increase safety.
Mode choice	Modes vary in the risks that user bear and impose on others. Public transit is safest. Active modes have high internal risk but impose minimal risk and reduce travel distances so total crashes tend to decline with their mode share.	Analysis should consider both internal and external risks. Safety tends to increase with shifts from driving to non-auto modes, particularly if implemented with active mode safety improvements.
Urban road supply	Crashes increase with more urban lane-miles. Although freeways have low crash rates, they induce more total vehicle travel and therefore total regional crash casualties.	Cities should limit roadway expansions and instead increase mobility and reduce congestion by improving non-auto modes and applying TDM incentives.
Traffic speed and congestion	Higher traffic speeds increase crash casualties by increasing crash severity and inducing more vehicle travel. Congestion tends to increase minor crashes but reduces crash casualties.	Urban regions should reduce traffic speeds to safe levels. Congestion reduction efforts should focus on improving non-auto modes and TDM incentives to reduce peak driving.
Transportation pricing	Higher fuel prices, road tolls, parking fees and distance-based vehicle charges tend to increase safety.	Apply fuel taxes, road tolls, parking fees and distance-based vehicle charges to increase transportation system efficiency and safety.
Land use development	Sprawl tends to increase per capita crash rates. Compact, mixed, multimodal development reduces crashes.	Recognize traffic safety impacts of land use planning decisions, including additional crashes from sprawl and safety benefits of Smart Growth.
Vehicle type	Larger and heavier vehicles tend to increase external risks.	Favor or require safer vehicles that minimize risks to occupants *and* other road users.
TDM programs	Transportation demand management can provide significant safety benefits.	Implement TDM programs to increase transportation system efficiency and safety.
Safety education and promotion	By themselves, education and promotion have limited safety benefits.	Use education and promotion to encourage mode shifting as well as safer behaviors.

This table summarizes factors that affect crash risk and how they can be applied to encourage safety.

Toward More Comprehensive Impact Analysis

The old planning paradigm was reductionist, meaning that individual problems are assigned to agencies with narrowly-defined responsibilities. For example, transportation agencies were responsible for reducing traffic congestion, public health agencies for achieving health goals, and environmental agencies for reducing pollution, with little consideration of other goals. Such planning can result in one agency implementing solutions to the problems within its responsibility that exacerbate other problems, and it tends to overlook policies that provide smaller but diverse benefits. The new paradigm supports more comprehensive analysis which considers multiple goals to identify win-win solutions, policies that help achieve multiple goals.

The table applies this concept to traffic safety. The left column identifies various planning goals. Policies that encourage safer vehicles, roads and driving may reduce crashes but achieve few other goals and contradict some. For example, larger vehicles with safety features such as air bags and antilock brakes increase occupant safety but increase user costs, fuel consumption and pollution emissions. Safer roads with wider lanes and larger clearzones increase roadway costs, and by inducing more vehicle travel increase traffic external costs. Restrictions on young and senior drivers reduce their mobility. In contrast, TDM and Smart Growth policies that reduce total vehicle travel and create compact communities help achieve many goals including safety.

Table 4 **Comparing Strategies**

Planning Goals	Safer Vehicles	Safer Roads	Safer Driving	TDM and Smart Growth
Congestion reduction				✓
Roadway cost savings		×		✓
Parking cost savings				✓
Consumer savings and affordability	×		×	✓
Traffic safety	✓	✓	✓	✓
Improved mobility options for non-drivers			×	✓
Energy conservation	×	×		✓
Pollution reduction	×	×		✓
Physical fitness and health (exercise)				✓
Land use objectives (reduced sprawl)		×		✓

(✓ = achieves goal. × = contradicts goal) Safer vehicles, roads and driving may reduce crashes achieve few other goals, and sometimes contradict them. Transportation demand management (TDM) and smart growth increase safety in addition to helping to achieve other planning goals, and so can be considered win-win solutions.

Because they feel safer, wider and straighter roads encourage drivers to take additional incremental risks, such as driving slightly faster or being distracted, called *risk compensation*. The additional vehicle travel caused by increased travel speeds is called *induced travel* (Milam, et al. 2017). As a result of these factors, roadway expansions often provide smaller safety benefits than predicted and can increase total crashes (DeRobertis, et al. 2014; Marshall 2024). For example, road widening, highways grade separation, expanded clearzones and hierarchical road systems that force traffic onto higher-speed arterials creates barriers to active travel and increases traffic speeds and total vehicle travel which tends to increase total casualties (Ewing, et al. 2023).

This is not to ignore the benefits provided by higher speed roads and more convenient parking, but it is important to account for the additional crashes they cause. This is particularly important when comparing modal alternatives, such as whether to address congestion with roadway expansions or improvements to space-efficient modes and TDM incentives; the former is likely to increase total vehicle travel and therefore crashes while the latter are likely to reduce total vehicle travel and crashes.

New Paradigm Safety Strategies

This section evaluates the safety impacts of various transportation demand management strategies. For more information see the "Guide for Road Safety Interventions" (GRSF 2021), "Sustainable & Safe" (Welle, et al. 2018), and "Road Safety in Cities" (ITF 2022).

Sustainable Traffic Safety Planning

Sustainable traffic safety planning favors crash reduction strategies that are durable and cost effective, and support other planning goals (Litman 2023). It applies seven basic principles: evaluate all traffic risks, both borne and imposed; measure risk per capita rather than using distance-based units; account for offsetting behavior that reduces long-term effectiveness; account for induced vehicle travel impacts that increase risk and resource consumption; consider TDM strategies; consider other sustainability goals; and consider safety in all planning. Most current traffic safety and emission reduction plans fail to reflect these principles which can result in safety strategies that increase emissions and emission reduction strategies that increase risks. Sustainability principles identify win-win solutions: safety strategies that help achieve other planning goals.

Establish a Safe Systems Approach (SuM4All 2023)

A Safe System approach recognizes that road transport is a complex system. Safety requires that all transport system stakeholders—the ones who plan, design, and maintain roads, manufacture vehicles, and administer safety programs—must share responsibility for traffic safety. It should take a proactive and integrated approach rather than reacting after hazards occur. It requires the following policies.

- Establish safety as the primary goal of transportation system planning, designing, and engineering.
- Articulate a clear, evidence-based vision toward the Safe System approach, with bold achievable targets and intermediate implementation milestones.
- Reform legislations, standards, and regulations to ensure accountability among all stakeholders involved in safe road infrastructures, safe vehicles, and safe road use. Allocate road safety funds.
- Build a dedicated, open-access national data repository for road safety, covering all facets from crash data, victim details, vehicle, infrastructure, and speed data to ensure evidence-based strategies.
- Flip the traditional hierarchy to prioritize active and sustainable modes of transport while making the system safer for all users.
- Reorient spatial development and urban mobility plans toward integrated transport and land use systems along with demand management measures to reduce vehicle kilometers traveled.
- Adopt citywide speed limits and low speed zones in places with high demand for walking, cycling and other activities and implement these through traffic calming and enforcement.
- Set safe speeds and speed management measures, supported by effective enforcement, along road stretches and at intersections to provide safe walking and cycling facilities.
- Raise awareness include linking climate action and public health with road safety, adopting a children-first approach, highlighting the economic and social costs of road crashes and fatalities, involving active road users, and emphasizing gender safety, security, and universal accessibility.
- Build broad-based consensus and buy-in from communities impacted by transport and road safety plans through information, public participation, and engagement during different stages of a project.

Safe Traffic Speeds

To optimize safety speed limits should be no more than 30 km/h in built up areas where vulnerable road users mix with motor vehicle traffic; 50 km/h in areas with intersections; and 70 km/h on rural roads without median barriers to prevent head-on collisions (ITF 2022; NACTO 2020). Traffic speeds can be reduced by redesigning roadways for lower speeds, with narrower traffic lanes, more traffic circles and crosswalks, and other traffic calming features (called *road diets* or *streetscaping*), reducing speed limits and increasing enforcement. Because current roadway design practices tend to favor higher traffic speeds, reforms are often required to increase the value of crash costs relative to travel time costs in project evaluation, and to change planning practices such as the 85th percentile rule which favors higher speed limits (Bronin and Shill 2021).

Table 5 **Forgiving Roadway Design Versus Slower Design Speeds** (Larson 2018)

Forgiving Roadway Design	Slower Design Speeds
Suitable for undeveloped rural areas	*Suitable for more developed urban areas and towns*
Increased safety at high speeds	Fosters the safety of low speeds
Wide travel lanes	Narrow travel lanes
Broad smooth curves	Short, tight curves
Clear zone free of fixed objects	Shoulders are used for parking, bike lanes and loading zones
Feels comfortable to drive fast	Feels dangerous to drive fast

Conventional traffic safety programs often favor "forgiving" road design. This may reduce crash severity in rural areas, but by increasing traffic speeds tends to increase crash severity, particularly for vulnerable modes.

Vehicle Safety Standards

Establish and enforce vehicle design standards that protect all road users, particularly vulnerable travellers such as pedestrians, bicyclists and motorcyclists, not just occupants (NHTSA 2024). This includes new testing procedures that simulate head-to-hood impacts and design requirements to minimize pedestrian risks.

Public Transit Service Improvements

As previously described, relatively small increases in transit travel can provide proportionately large reductions in total casualty crash rates (Duduta, Adriazola-Steil and Hidalgo 2013; GRSF 2021; Small 2018) due to reductions in total vehicle travel, traffic density, and higher risk driving by youths, seniors, and drinker. Residents of cities with more than 50 annual transit trips per capita have about half the average traffic fatality rate as regions with less than 20 annual trips per capita, indicating that relatively modest increases in transit travel are associated with large traffic safety gains. Transit service improvements include more routes, increased service speed and frequency, nicer vehicles and waiting areas, improved user information and more convenient payment systems. These tend to increase ridership, reduce automobile travel and increase safety (Peterson 2017; Walker 2015). High quality transit (urban rail and bus rapid transit) often leverages additional vehicle travel reductions by allowing some households to reduce their vehicle ownership, and by supporting more compact development, so 1% ridership increases reduces automobile travel by more than 1% (ICF 2010).

Services that target higher risk groups can provide particularly large safety gains. For example, Jackson and Owens (2010) found that extending night transit service reduced drunk driving and accidents: for each additional hour after midnight DUI *arrests* near Metro stations declined 16% and *fatal* DUI crashes declined 70%. Broyles (2014) found that Phoenix, AZ university students who live near the light rail line connecting student housing with the entertainment district are significantly less likely to drink and drive. Similarly, Lichtman-Sadot (2019) found that young driver traffic crash rates declined an average of 37%, and their crash injuries decrease 24%, after late-night buses started in Israeli cities in 2007.

HOV and Bus Priority

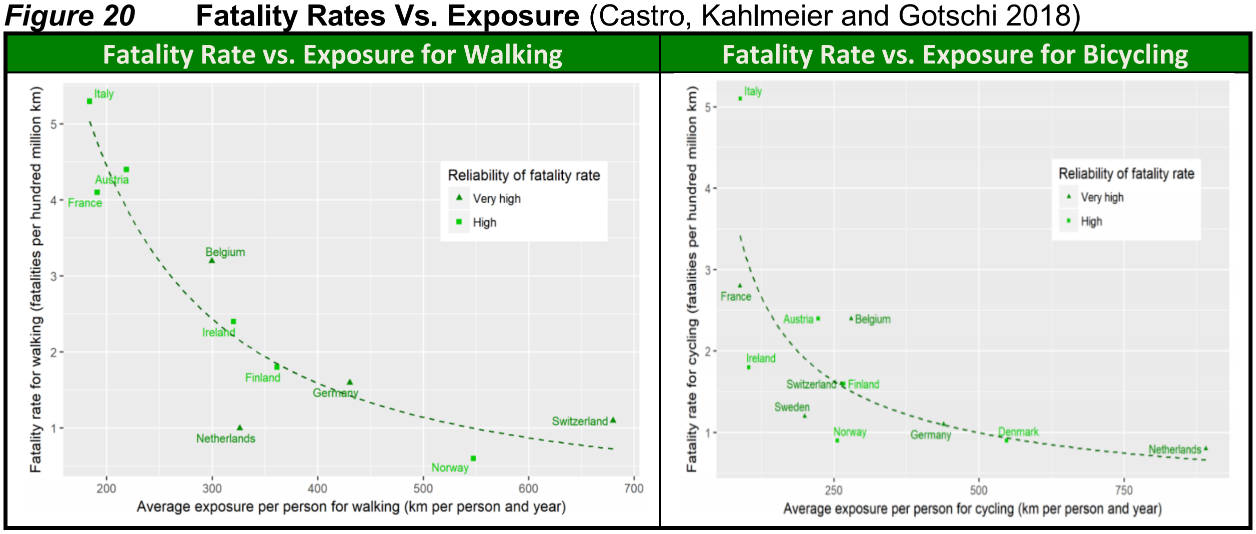
High Occupancy Vehicle (HOV) lanes, bus lanes, and bus priority traffic control systems improve transit performance (speed, reliability and operating cost efficiency) and encourage ridesharing (car- and vanpooling). HOV lanes can reduce vehicle trips on a particular roadway by 4-30% (Turnbull, Levinson and Pratt 2006). Ferenchak and Woods (2025) found that Albuquerque Rapid Transit bus rapid transit (BRT) system significantly increased safety: excessive speed crashes decreased 19% and left-turning motor vehicle crashes decreased 35%, although pedestrian injuries increased 15% apparently due to more walking. Ridesharing programs typically attract 5-15% of commute trips if they offer only information and encouragement, and 10-30% if they also offer incentives such as HOV priority and parking cash out (Evans and Pratt 2005). A single rail or BRT line is generally insufficient to significantly affect regional travel or crash rates; to be effective they require an integrated network with supportive policies including improved walking, cycling and local bus services; reduced parking requirements; policies that encourage compact development around transit stations; and commute trip reduction programs. Where those policies are effectively applied they can reduce per capita traffic fatality rates 30-60% in affected neighborhoods, and 10-30% region-wide.

Active Transport (Walking and Bicycling) Improvements

Improving sidewalks, crosswalks, bike lanes, pathways, plus traffic calming and education, can directly increase walking and cycling safety, and by reducing vehicle travel, increase overall traffic safety. As previously described, in typical North American communities, completing sidewalk and bike facility networks is predicted to reduce total personal vehicle travel about 5%, which should provide at least proportional crash reductions, and more if these improvements reduce traffic speeds or are particularly effective at reducing higher risk driving, for example, allowing drinkers to walk rather than drive home, and young men to reduce driving. This is supported by previously described evidence indicating that relatively modest increases in active mode shares are associated with large reductions in a community's per capita crash rates. This suggests that comprehensive active transport improvements can reduce resident's total crash casualty rates 5-10%. Most improvements can be implemented in a few years.

Marshall and Garrick (2011) found that U.S. cities with higher per capita bicycling rates tend to have much lower traffic fatality rates for all road users than other cities. Castro, Kahlmeier and Gotschi (2018) compared annual kilometers walked and bicycled with pedestrian and bicycle traffic death rates for various countries. The results, illustrated below show that active mode risk declines with more use.

Figure 20 **Fatality Rates Vs. Exposure** (Castro, Kahlmeier and Gotschi 2018)



Carsharing Services
Carsharing refers to vehicle rental services designed to substitute for personal vehicle ownership. They are located in residential neighborhoods, priced by the hour, and marketed to local residents. Although carsharing may increase vehicle travel by households that lack motor vehicles, they can significantly reduce household vehicle ownership, which reduces vehicle travel (ITF 2015). Carsharing members typically own 40% fewer vehicles and drive 33% fewer annual miles than average (Clewlow 2015). If 10-30% of households live in areas suitable for carsharing (typically 10 residents or more per acre), and 10-30% of area households would use carsharing if available, and carsharing reduces participating household's vehicle travel 33%, the total vehicle travel reduction and potential safety gain is 0.3-3%, with larger impacts in denser neighborhoods.

Raise Fuel Taxes to Fully Finance Roadway Costs or Internalize Externalities
A basic economic principle is that markets are most efficient and equitable if prices (what users pay for a good) reflect marginal costs (the full incremental costs of that good). This suggests that, as much as possible, motorists should pay for roads, and compensate society for external costs they impose on other people, sometimes called the *polluter pays principle*.

Road user fees (road tolls, special fuel taxes and vehicle registration fees) are often insufficient to fully finance roadway costs. For example, in 2015 U.S. government agencies spent $235 billion on roadways, of which $113 (48%) was from user fees and $122 billion from general taxes (FHWA, 2017, Table HF-10). Fuel taxes would need to increase 50¢ per gallon or more to fully finance roadways. A 50¢ per gallon fuel tax can also be justified as a $55 per tonne carbon tax. With current $2.50 per gallon fuel prices, a 50¢ per gallon tax represents a 20% increase. Previously described research indicates that each 10% fuel price increase typically reduces traffic deaths 2-6% (Ahangari, et al. 2014; Burke and Nishitateno 2015), suggesting that a 50¢ per gallon tax should reduce fatalities by 4-12%.

Efficient Parking Pricing
Motorists currently park without a fee at most destinations, due to unpriced on-street parking and off-street parking required in zoning codes. As a result, most parking costs are borne indirectly through general taxes, building rents, and higher costs for retail goods. Considering land, construction and operating costs, a typical urban parking space has an annualized cost of $500 to $3,000 (Litman 2009).

There are many possible ways to efficiently price parking. Municipal governments can expand where parking is metered; businesses can charge for off-street parking; employee parking can be priced or "cashed out" (non-drivers receive the cash equivalent of parking subsidies offered to motorists); residential parking can be unbundled (rented separately from building space); and existing parking fees can be adjusted to be more efficient, for example, with rates that reflect costs and demand (VTPI 2016). Charging users directly for parking typically reduces affected vehicle ownership and use by 10-30% (CARB 2014), which should provide comparable crash reductions. More efficient parking pricing can be implemented relatively quickly, and with new technologies, transactions costs can be minimized.

Congestion Pricing (Road Tolls that Increase Under Congested Conditions)
Congestion pricing consists of road tolls that increase under congested conditions. Research by Green, Heywood and Navarro (2015) indicates that London's congestion pricing program reduced peak-period vehicle travel by 10% and crashes by 30% in the priced area, and reduced crashes in nearby areas by 16%. Since less than a third of total vehicle travel occurs under urban-peak conditions, which suggests that congestion pricing can reduce total crash rates 5-15%, depending on how broadly it is applied.

Distance-Based Vehicle Insurance and Registration Fees

Distance-Based (also called Pay-As-You-Drive, Usage-based, Mileage-Based and Per-Mile Premiums) means that vehicle insurance premiums and registration fees are based directly on how much it is driven. Vehicle purchase taxes also be converted into distance-based fees, so a $1,000 tax becomes 1¢ per vehicle-mile. This price structure gives motorists a new opportunity to save money if they reduce their vehicle travel (Ferreira and Minike 2010; Greenberg and Evans 2017; VTPI 2016).

An average motorist who currently pays $1,200 annual insurance premiums and registration fees would pay about 10¢ per mile, approximately equivalent to a 60% fuel price increase, but this is not a new fee, simply a different way of paying existing fees. This should reduce affected vehicles' average annual mileage 10-15%. Since all existing rating factors are included in the rate structure, higher risk motorists would pay more per mile under distance-based pricing, and so should reduce their mileage more than average. For example, a lower-risk motorist who currently pays $500 annually would pay about 4¢ per mile, and so would reduce mileage 5%, but a higher-risk motorist who pays $2,400 for insurance would pay about 20¢ per mile, resulting in particularly large reductions in higher-risk driving. As a result, distance-based insurance pricing should reduce crash rates even more than mileage. This suggests that distance-based insurance and registration fees can reduce affected vehicles' crash casualties 10-20%.

There are many possible ways to implement distance-based pricing. Some systems use electronic devices to track when, where and how people drive, but this imposes significant costs and raises privacy concerns. Basic distance-based pricing only requires an annual odometer reading. If offered as a consumer option, probably 5-15% of motorists would choose electronic pricing and 30-50% (those with vehicles driven less than about 10,000 annual miles) would choose basic distance-based pricing. Incentives or mandates could result in most or all motorists having distance-based pricing. If universally applied total crashes should decline at least 15%.

Commute Trip Reduction Programs

Commute trip reduction (CTR) programs encourage workers to use resource-efficient modes. They can include financial incentives, encouragement campaigns, ridematching services, guaranteed ride home, flextime and telecommute options. Programs that only offer information and encouragement typically reduce automobile trips by 5-15% while those that include significant financial incentives can reduce automobile trips 15-30%. Commute trip reductions programs can leverage additional vehicle travel reductions, for example, if incentives to use non-auto commute modes convince households to reduce their car ownership or locate in a more multi-modal community. About 20% of personal vehicle travel is for commuting, and perhaps half of commuters are suited to such programs, so if CRPs apply to 20% of employees in an area, total vehicle travel could decline 1-6%. Safety gains are probably about proportional to vehicle travel reductions. Washington State's Commute Trip reduction law has significantly reduced vehicle travel and provided traffic safety gains in the Puget Sound region (Peterson 2017).

Mobility Management Marketing

Mobility management marketing (also called *Voluntary Travel Behavior Change Programs*) uses mass and personalized marketing strategies to encourage vehicle travel reductions. They have proven successful in many conditions including urban and suburban areas, and influence various types of trips. They typically reduce affected households' vehicle travel by 5-10% (CARB 2014). Crash reductions are likely to be about proportionate. Assuming that 60% of households are candidates for such programs, they can reduce affected households' crashes 5-10% and total crashes 3-6%. Such programs can be implemented in a few months.

More Connected and Complete Streets

Street connectivity refers to street network density, such as intersections per square mile. Increased connectivity tends to reduce vehicle travel by reducing travel distances between destinations and by supporting alternative modes, particularly where paths provide walking and bicycling shortcuts (Handy, et al. 2014). Ewing and Cervero (2010) find that intersection density and street connectivity are the second greatest land use factor affecting vehicle travel, so a 10% density increase reduces vehicle travel 1.2%. Holding other factors constant, increasing from 31.3 to 125 intersections per square kilometer is associated with a 41% decrease in vehicle travel (Marshall and Garrick 2012).

Complete streets are designed to accommodate diverse users and uses, including walking, bicycling, transit, automobile travel, plus nearby businesses and residents (SGA 2020). This tends to increase traffic safety, and by improving active and public transportation, reduce total vehicle travel and crashes. Compared with sprawled, automobile-oriented development, high street connectivity and complete streets designs can reduce local crash casualty rates 10-30% (Ewing and Cervero 2010; Marshall, Ferenchak and Janson 2018). Similarly, Mohan, Bangdiwala and Villaveces (2017) found that traffic death rates decline with more roadway junctions and fewer kilometers of arterial grade roadways.

More Comprehensive and Multi-modal Planning

Many common planning practices tend to favor automobile travel over other modes. For example, conventional transportation planning evaluates transportation system performance based primarily on roadway Level-of-Service (LOS) indicators, which reflect motor vehicle traffic speeds and delay; there are generally no indicators for other modes or other accessibility factors such as development density and mix (DeRobertis, et al. 2014). More comprehensive and multi-modal planning gives more consideration to non-auto modes and accounts for other planning goals besides vehicle travel speed (NYCDOT 2012).

Current transportation funding practices also tend to favor road and parking over investments in other modes. For example, dedicated state highway funds encourage local and regional governments to define their transportation problems in terms of inadequate roadway capacity rather inadequate mobility options or roadway underpricing (in fact, federal policies prohibit congestion pricing on most U.S. highways), and minimum parking requirements in zoning codes subsidize automobile ownership and use, discourage efficient pricing and stimulate sprawled development.

Parking Policy Reforms

Most jurisdictions require property owners to provide off-street parking which encourages automobile ownership and use, reduces non-auto travel and encourages sprawl. In typical North American communities these requirements result in the provision of 2-6 parking spaces per motor vehicle, representing a $1,000-$6,000 annual economic subsidy per motorist (Scharnhorst 2018). Reducing parking requirements does not eliminate parking, it simply allows developers to determine the number of parking spaces to provide based on market demands, which often results in unbundled parking (renting parking spaces separately from building space). As previously mentioned, charging motorists directly for parking typically reduces vehicle ownership and use by 10-30%, and more if implemented with other TDM incentives.

Although these impacts are indirect and there is little research specifically investigating how parking policies affect crash rates, reducing parking requirements can probably provide large traffic safety benefits by reducing vehicle ownership and use, increasing parking prices and allowing more compact development. This suggests that local crash casualty rates decline 5-15% if reduced parking allows a community to become compact and multi-modal. These impacts take years to occur.

Smart Growth and Transit Oriented Development

Smart Growth refers to policies and planning practices that encourage more compact, multi-modal urban development. Transit Oriented Development (TOD) refers to these policies applied specifically around transit stations. These development practices tend to reduce total vehicle travel and traffic speeds, which significantly increases traffic safety (ITF 2019).

Hamidi, et al. (2015) found that compact communities had significantly higher transit ridership, slightly higher *total* crash rates, but much lower *fatal* crash rates than sprawled communities: each 10% increase in their compact community index is associated with a 0.4% increase in total crashes, and a 13.8% reduction in traffic fatalities. Analyzing San Antonio, Texas neighborhood crash rates, Dumbaugh and Rae (2009) found that crashes are negatively associated with *population density* (each additional person per net residential acre reduces crash incidence 0.05%); automobile oriented services (each additional arterial-oriented commercial parcel increased total crashes 1.3%, each additional big box store increased total crashes 6.6%, and pedestrian-scaled commercial or retail uses were associated with a 2.2% reduction in crashes); and higher-speed roadways (each additional freeway mile within a neighborhood is associated with a 5% increase in fatal crashes, and each additional arterial mile is associated with a 20% increase in fatal crashes).

Crash rates in the most compact, multimodal neighborhoods are an order of magnitude lower than in sprawled areas, so Smart Growth policies can reduce traffic crash rates by 70-90%, although their impacts may often be smaller. Crash rate reductions of 10-30% are probably realistic for aggressive Smart Growth and TOD programs that cause most residents to live in more compact and multi-modal neighborhoods.

Improved Traffic Law Enforcement and Driving Cession

Governments often hesitate to enforce traffic laws and revoke driving privileges even to serial offenders, and individuals with diminishing ability often hesitate to give up driving because they fear losing independence. "Taking away someone's driving privilege is no small decision. It can consign a family to poverty, affecting job prospects, child care and medical decisions." (Lewis 2025)

The new traffic safety paradigm supports traffic law enforcement and responsible driving cession by improving non-auto travel options which reduces burdens to individuals, families and society. If very high-risk drivers are responsible for 5-10% of crash casualties, and better enforcement or driving cession can reduce this by a third, this could prevent 2-5% of traffic injuries and deaths.

New Paradigm Strategy Summary

The table below summarizes the new paradigm safety strategies.

Table 6 **New Paradigm Safety Strategies**

Strategy	Travel Impacts	Crash Rate Reductions
Shorter Term (less than three years)		
Reduce traffic speeds	A 10% speed reduction typically reduces vehicle travel 2-4%.	A 10% speed reduction reduces casualties 10-30%, with larger safety gains for active modes.
Transit service improvements (more routes, frequency, etc.).	Reduces vehicle travel, particularly if it stimulates transit-oriented development.	Each 1% transit ridership gain typically reduces traffic casualties 1% or more.
HOV and bus traffic priority	Reduces automobile travel and encourages transit and ridesharing.	Can reduce affected traveler's crash rates 10-30%, and total rates 1-5%.
Active mode improvements (better sidewalks, crosswalks, bikelane, etc.).	Increases walking and bicycling, and reduces motor vehicle travel.	Increases active mode safety, and can reduce total crash casualty rates 5-10%.
Expanded carsharing services	Reduces automobile ownership and use.	Can reduce crashes 0.3-3%.
Raise fuel taxes to fully finance roadway costs, or as a carbon tax.	Reduces total vehicle travel and traffic speeds.	A 50¢ per gallon tax typically reduces crash casualty rates 4-12%.
Efficient parking pricing (motorists pay directly for using parking spaces).	Typically reduces affected trips 10-30%, and may reduce vehicle ownership.	Each 10% increase efficiently priced parking reduces crash casualties 1-3%.
Congestion pricing (road tolls that increase under congested conditions)	Reduces automobile travel, particularly in large cities.	Reduces affected area crash casualty rates 15-30%, with smaller reductions nearby.
Distance-based vehicle insurance and registration fees.	Reduces vehicle travel, especially higher risk driving.	Reduces affected vehicles' crashes by 10-20%.
Commute trip reduction programs.	Reduces affected commute trips 5-30%.	Reduces affected commuters' crash casualty rates 5-30%, and total crashes 0.5-3%.
Mobility management marketing.	Encourages use of non-auto modes.	Reduce affected households' crashes 5-10%.
Increase traffic law enforcement and driving cession programs	Less high-risk driving by serial offenders and people with diminishing ability.	Reduce crashes 2-5%.
Longer Term (more than three years)		
More comprehensive and multi-modal planning	Creates safer and more multi-modal transport systems.	Can lead to large vehicle travel and crash reductions.
More connected and complete streets.	Reduces traffic speeds, improves non-auto modes and reduces total vehicle travel.	Can reduce local crash casualty rates 10-30%.
Reduced parking requirements	Reduces crashes by reducing vehicle ownership and use.	Can reduce affected area's crash casualty rates 5-15%.
Urban rail and Bus Rapid Transit	Reduces vehicle ownership and use.	Reduces affected areas' crash rates 30-60%.
Smart Growth and Transit Oriented Development	Reduces traffic speeds, improves non-auto modes and reduces total vehicle travel.	Can reduce crash casualty rates 30-60% in affected areas and 10-30% region-wide

New paradigm safety strategies reduce total vehicle travel and traffic speeds.

Many of these strategies significantly reduce risks for affected groups or areas, so their total impacts depend on how broadly they are implemented. For example, Commute Trip Reduction programs often reduce affected vehicle travel 5-30%, so their total impacts depend on the portion of workers affected. Similarly, Smart

Growth neighborhoods have 30-60% less driving and crash rates than auto-oriented areas, so their overall impacts depends on the portion of regional households located in such communities.

Care is needed when predicting the total impacts of multiple strategies since their impacts are multiplicative not additive. For example, if transit improvements are predicted to reduce crashes by 15%, fuel price increases reduce crashes by 10%, and commute trip reduction programs are predicted to reduce crashes by 5%, the total reductions of implementing them together are calculated by multiplying their residual crash rates (85% x 90% x 95% = 73%), indicating a 27% crash reduction rather than the 30% reduction indicate by adding 15% + 10% + 5%.

Some strategies overlap. For example, increasing roadway connectivity and reducing parking requirements are both Smart Growth Strategies. While it would be true to say that reducing parking requirements can reduce crashes 5-15%, improved roadway connectivity can reduce local crashes 10-30%, and Smart Growth can reduce crashes by 10-30%, it would be double-counting to add these together to say that together they reduce crashes by 25-75%, since Smart Growth including reduced parking requirements and more connected roadways. On the other hand, many of these strategies have synergistic effects (total impacts are greater than the sum of their individual impacts), and so are most effective if implemented together. For example, public transit improvements are more effective if implemented with walkability improvements and parking pricing since together they give travellers both positive and negative incentives to shift modes.

These strategies complement existing traffic safety efforts. Many conventional traffic safety strategies attempt to reduce higher-risk driving, such as graduated licenses to reduce youth driving, special senior testing to identify high-risk drivers, and anti-impaired driving campaigns. To be effective and fair these strategies require suitable mobility options so youths, seniors and drinker have suitable alternatives to driving. Because travel demands are diverse, this requires diverse mobility options. For example, graduated licenses and senior driver testing will be more effective and less burdensome if implemented with more multi-modal planning that improves walking, bicycling, public transit and taxi/ride-hailing improvements, so youths and seniors can access services and activities without driving. Similarly, anti-impaired driving campaigns should be implemented with Smart Growth development policies that create more compact and mixed neighborhoods, so it is easier to visit a restaurant or pub by walking or public transit rather than driving. For example, conventional zoning codes often apply very high minimum parking requirements to bars, pubs and restaurants, typically 6-12 spaces per 1,000 square feet, which contradicts efforts to discourage driving after drinking, and by increasing land requirements, often prevent the development of local drinking establishments accessible by walking. Allowing more neighborhood restaurants, bars and pubs can increase public safety and health.

In these ways, multimodal planning, Smart Growth and TDM programs support both old and new paradigm traffic safety strategies.

New Paradigm Analysis Methods

This section describes how analysis methods to support the new traffic safety paradigm.

How impacts are analyzed can significantly affect planning outcomes (ITF 2022a). A solution that seems effective and beneficial evaluated one way may seem ineffective and harmful if evaluated using different metrics and perspectives. The table below compares old and new paradigm analyses frameworks. By using distance-based exposure units, focusing on internal impacts, and only considering safety, the current analysis framework ignores the additional crashes caused by increased vehicle travel, the risks the motorized travel imposes on pedestrians and cyclists, and additional benefits, besides safety, provided by vehicle travel reduction strategies. In these ways, it favors automobile-oriented solutions over multi-modal planning, Smart Growth and TDM programs.

Table 7 **Comparing Analysis Frameworks**

Factor	Old	New
Units of exposure	Distance-based units (e.g., casualties per 100 million vehicle-miles or billion vehicle-kilometers)	Per capita (e.g., casualties per 100,000 residents)
Perspective	Internal (user) impacts, such as casualties to vehicle occupants.	Internal and external impacts, such as casualties to vehicle occupants and other road users.
Scope of impacts	Traffic crash costs.	Traffic crash costs and other economic, social and environmental impacts.
Level of impacts	Direct impacts only.	Direct and indirect impacts, including short- and long-term effects on vehicle travel and risk exposure.

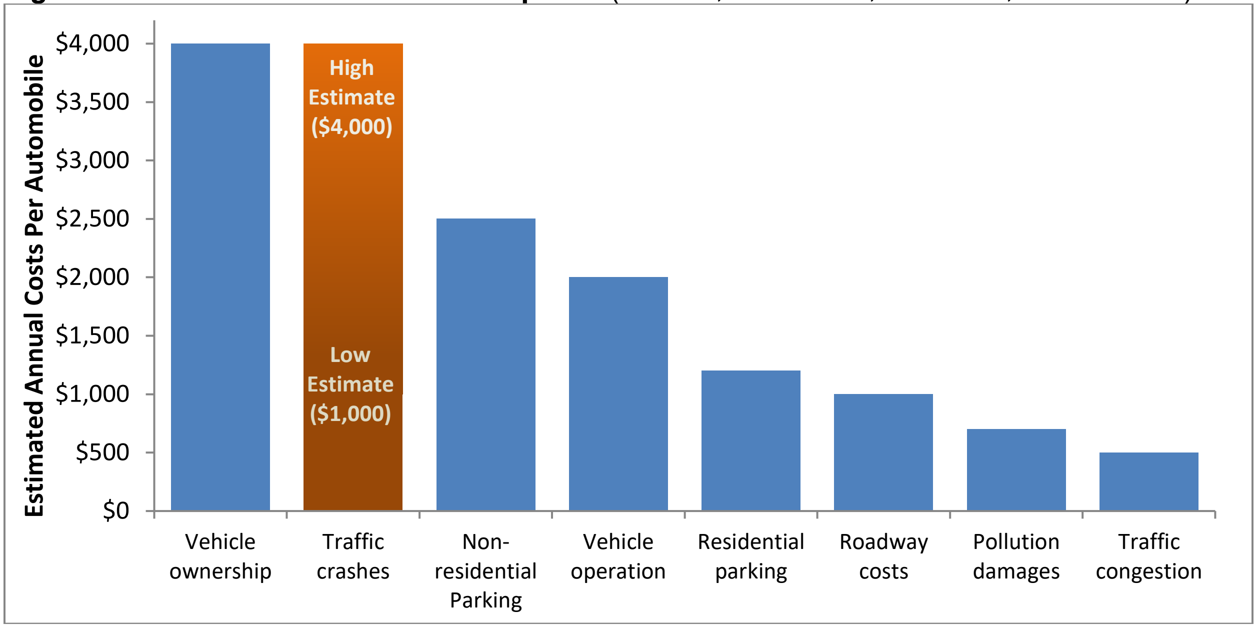
The new traffic safety paradigm is more comprehensive and integrated.

The old safety paradigm focuses on crash costs, the new paradigm considers all significant impacts. This is important because planning decisions often involve trade-offs between traffic risk and other impacts such as mobility, affordability and environmental quality. A traffic safety strategy is worth less if it conflicts with other planning goals, for example, if it increases costs to governments, consumer or businesses, or exacerbates pollution problems, but can be worth far more if it also helps achieve other planning objectives. New tools help decision-makers understand these trade-offs.

Various studies have quantified and monetized (measured in monetary units) transportation costs (Blincoe, et al. 2023; DfT 2023; Litman 2009). According to a major US Federal Highway Administration study, *The Economic and Societal Impact of Motor Vehicle Crashes* (Blincoe, et al. 2023) in 2019 the U.S. had 36,500 traffic deaths, 4.5 million injuries and 23 million damaged vehicles, with estimated costs totalling $340 billion considering just economic costs (property damages, medical care, emergency services, congestion, court and insurance administration, disability compensation and reduced productivity) or $1.4 trillion when quality-of-life losses (pain and reduced quality of life) are also considered. This averaged $1,000 to $4,000 per capita, 10¢ to 42¢ per vehicle-mile.

These costs are larger than most other transportation costs as illustrated below. Total crash damage costs are comparable in value to what households spend on motor vehicles, larger than public expenditures on roads and parking facilities, and much larger than estimated congestion and pollution damages. This suggests that a traffic safety strategy may not be cost effective if it significantly increases vehicle, infrastructure, congestion or pollution costs, but is worth far more if it reduces other costs or provide other benefits.

Figure 35 **Automobile Costs Compared** (Blincoe, et al. 2023; DfT 2023; Litman 2009)



Traffic crash damages are one of the largest costs of motor vehicle travel, less than vehicle ownership and non-residential parking, but smaller than all others. This suggests that a traffic safety program is not cost effective if it increases other costs, but can be far more beneficial overall if they reduce other costs or provide other benefits.

This is important because conventional traffic safety strategies, such as additional vehicle safety features (crash protection design, air bags, rear vision camera, etc.) and programs (sobriety checks, new driver testing, advertising campaigns, etc.) are costly and provide few benefits besides safety, while most new paradigm safety strategies provide large co-benefits. New paradigm safety strategies, such as multimodal planning, efficient pricing, Smart Growth development policies and TDM programs tend to reduce congestion, infrastructure costs, consumer costs and pollution emissions, as well as improving mobility options for non-drivers, and public fitness and health.

These factors can significantly affect planning priorities. For example, when deciding whether to expand roadways or improve public transit to reduce congestion, conventional analysis usually ignores the additional risk to pedestrians and bicyclists caused by wider roads and higher traffic speeds, and the additional crashes that result if roadway expansions induce additional vehicle travel and stimulates sprawled development; these impacts are invisible when projects are evaluated using distance-based vehicle crash rate data. The new paradigm recognizes the additional crash risks caused by induced vehicle travel and additional benefits provided by improved travel options, vehicle travel reductions, and more compact development.

Evaluating Current Traffic Safety Planning

This section evaluates whether various traffic safety planning guides consider new paradigm solutions.

Table 8 **Review of Traffic Safety Planning Guides**

Program	VMT Reduction Safety Strategies
Countermeasures That Work, NHTSA (https://bit.ly/48B43dx)	None
Desktop Reference for Crash Reduction Factors, FHWA (tinyurl.com/4dv8kpzr)	None
Developing Safety Plans for Rural Road Owners, FHWA (http://bit.ly/2px3hIA)	None
Getting to Zero Alcohol-impaired Driving Fatalities, National Academy Press (www.nap.edu/download/24951)	Recommends improving public transit and ridehailing that serves alcohol drinkers
Integrating Road Safety into Existing Systems and Policy, Global Transport Knowledge Practice (www.gtkp.com/themepage.php&themepgid=376).	Recommends integrated approaches, including multi-modal transport planning.
Highway Safety Manual, AASHTO (http://bit.ly/2oF4Xix)	None
Highway Safety Program Guidelines, GHSA (www.ghsa.org)	None
Motor Vehicle PICCS, CDC (www.cdc.gov/motorvehiclesafety)	None
Roadway Safety Guide, Road Safety Foundation (www.roadwaysafety.org)	None
Safe Ride Programs, Mothers Against Drunk Driving (www.madd.org)	None
The Injury Research Foundation (www.tirf.ca)	None
Toward Zero Deaths (www.towardzerodeaths.org)	None
*Canada's Road Safety Strategy (*http://roadsafetystrategy.ca)	None
Tackling the Road Safety Crisis (TRB 2024)	None
Toolbox for Road Safety (https://doi.org/10.1186/s40621-016-0098-z)	None
Traffic Safety Fundamentals Handbook, MDOT (https://bit.ly/48ESke3)	None
Transportation and Health Tool, USDOT and CDC (www.transportation.gov/transportation-health-tool)	Recommends multi-modal planning for safety and health.
Transportation Planner's Safety Desk Reference, USDOT (http://bit.ly/2oFbz0j)	Recommends VMT reduction strategies.
Vision, Strategies, Action: Guidelines (https://bit.ly/2ImGuum)	None
Vision Zero: Toolkit for Road Safety in the Modern Era (https://bit.ly/2VN2Blh)	None
Guide for Road Safety Interventions: Evidence of What Works and What Does Not (https://tinyurl.com/4ur4espj)	Rates the effectiveness of road safety strategies. Recommends multimodal planning.
Global Status Report on Road Safety 2023, World Health Organization (http://tinyurl.com/pxfupc)	Recommends multimodal planning and traffic speed reductions.
Enhancing Policy and Action for Safe Mobility, Sustainable Mobility for All (https://bit.ly/3XxWwXL)	Recommends sustainable modes, compact development and vehicle travel reductions.
World Report on Road Traffic Injury Prevention, GRSP (www.grsproadsafety.org)	Recommends demand management strategies.
Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System, (http://bit.ly/2nQZJmP)	Recommends some vehicle travel reduction strategies.

Of 25 major traffic safety programs reviewed, only nine mention multimodal planning or vehicle travel reduction strategies, and few provide guidance on their evaluation or implementation.

Most traffic safety programs reflect the old paradigm (Sung, Mizenko and Coleman 2017). For example, the *2015 Traffic Safety Facts Report* (NHTSA 2017) shows casualties per 100 million vehicle-miles but not per capita, and the USDOT's safety performance indicators are all distance-based (USDOT 2017). Of nineteen major traffic safety programs considered in Table 6, only seven mention vehicle miles of travel (VMT) reduction strategies, and none provide guidance on evaluating or implementing them. When these programs support multimodal planning, it is often limited in scope. For example, a recent report by the U.S. National Academy of Sciences, *Getting to Zero Alcohol-impaired Driving Fatalities: A Comprehensive Approach to a Persistent Problem*, includes the following recommendation:

> Recommendation 4-4: Municipalities should support policies and programs that increase the availability, convenience, affordability, and safety of transportation alternatives for drinkers who might otherwise drive. This includes permitting transportation network company ridesharing, enhancing public transportation options (especially during nighttime and weekend hours), and boosting or incentivizing transportation alternatives in rural areas.

Although this recognizes the possibility that improving non-auto travel can reduce impaired driving, it implies that such programs should target specific conditions rather than supporting public transit and transit-oriented development overall. It also fails to evaluate the costs and co-benefits of anti-impaired-driving campaigns, which could justify more integrated solutions.

The World Bank's *Guide for Road Safety Interventions: Evidence of What Works and What Does Not Work* (GRSF 2021) rates traffic safety strategy effectiveness. The best include:

- Integrated public transport
- Roadside barriers and medians
- Safe traffic speeds and traffic calming
- Pedestrian footpaths and crossings
- Roundabouts and grade-separated intersections
- Seatbelt and helmet requirements.

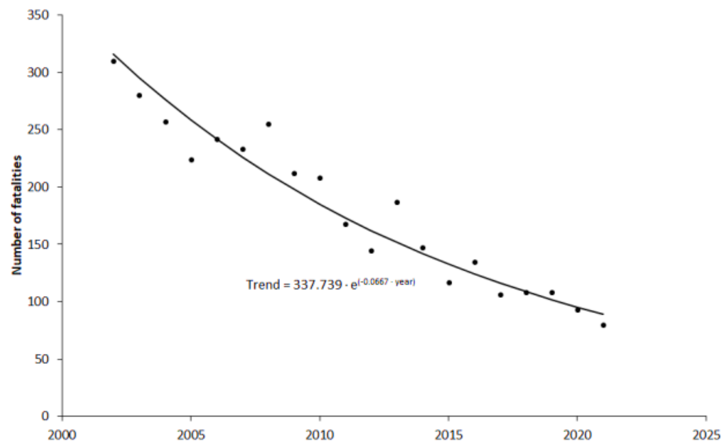
The Sustainable Mobility for All report, *Enhancing Policy and Action for Safe Mobility* (SuM4All 2023) proposes a safe systems approach to traffic safety, which recognizes the safety benefits of multimodal transportation and land use planning which reduces total vehicle travel and traffic speeds, and it supports transportation demand management strategies that reduce vehicle travel, although it provides little guidance for evaluating their safety benefits.

Many jurisdictions apply more multimodal planning, transportation demand management incentives, and Smart Growth policies, and some have established vehicle travel reduction targets (Litman 2021). These are justified for various reasons including reducing traffic congestion, public infrastructure savings, consumer savings, social equity, public health, emission reductions and habitat preservation; although they can also provide substantial traffic safety benefits these often receive little priority.

New tools, such as California's *Vehicle Miles Traveled-Focused Transportation Impact Study Guide* (Caltrans 2020) and the *Handbook for Analyzing Greenhouse Gas Emission Reductions* (CAPCOA 2021) can help policy makers and practitioners estimate the impacts that transportation and land use projects will have on total vehicle travel and therefore crashes. Traffic safety programs can incorporate this type of information into traffic safety planning.

Some jurisdictions apply the new safety paradigm in various ways. Since 2002 Norway has established four-year national road safety action plans with ambitious Vision Zero goals ("Vision Zero embodies an ambition to continuously and markedly reduce the number of killed or seriously injured road users"), consensus and commitment to improving road safety, more integrated and comprehensive safety policies, and more stakeholder involvement (Elvik, et al 2023). Traffic death rates subsequently declined about 75%, as illustrated below, with particularly large safety gains in cities.

Figure 36 **Norwegian Traffic Fatality Tends** (Elvik, et al. 2023)



Norwegian traffic death and serious injury rates declined more than 70% between 2002, when nation road safety action plans were first established, and 2021. This demonstrates that integrated traffic safety programs can achieve large traffic safety gains.

Similarly, since 2013 the European Union has required all urban areas to implement Sustainable Urban Transportation Plans (SUMPs) which are designed to satisfy mobility needs in ways that enhance urban quality of life, including safety (EU 2024). SUMPs include many policies that improve non-auto travel and reduce total vehicle travel and traffic speeds. European cities have experienced substantial declines in crash rate, suggesting that these policies increase safety.

Traffic impact analysis (TIA) studies are often used to predict how a particular project or policy will affect travel activity, traffic congestion, parking problems and pollution emissions, and therefore the need for mitigation strategies which include road and parking facility expansions, and TDM incentives to reduce vehicle travel. LaJeunesse, et al. (2025) argue that TIAs should explicitly incorporate traffic risk analysis and safety goals, which is likely to increase support for congestion mitigation strategies that also support safety goals.

Obstacles and Criticisms

This section describes various obstacles facing new paradigm traffic safety strategy implementation.

This new traffic safety paradigm faces various obstacles. Many stakeholders are unfamiliar with these concepts: transportation professionals seldom consider the additional crashes caused by planning decisions that stimulate vehicle traffic, or the potential safety benefits of vehicle travel reduction strategies. Multi-modal planning and TDM programs are generally intended to reduce congestion and emissions, safety benefits are often overlooked. Few guidance documents or modelling tools provide guidance for evaluating TDM and Smart Growth traffic safety impacts, or support their implementation.

Transportation professionals often emphasize that most crashes result from special risk factors, such as youth, senior, impaired or distracted driving, and so favor targeted safety strategies. From this perspective it seems inefficient and unfair to reduce total driving for safety sake, since that would punish all drivers for errors made by an irresponsible minority. However, even a perfect driver who never errors increases safety by reducing mileage and therefore their chance of being the victim of other drivers' mistakes, and most drivers make small errors that can contribute to a crash, such as driving a little faster than optimal for safety. Since most casualty crashes involve multiple vehicles, travel reductions tend to provide proportionately larger crash reductions, particularly in urban areas (Edlin and Karaca-Mandic 2006). As a result, mileage reductions by lower-risk drivers increase traffic safety.

It is also wrong to assume that vehicle travel reduction strategies "punish" drivers: many improve travel options or provide positive incentives that benefit travellers who drive less. Critics argue that these are ineffective safety strategies. It is true that many TDM strategies individually only affect a small portion of total travel so their safety benefits seem modest, but their impacts tend to be synergistic, so an integrated program can provide significant crash reductions and other benefits. Surveys indicate that many travellers would shift from driving to safer modes, such as public transport, provided it is convenient and attractive (Ibrahim, et al. 2024). Some strategies, such as new urban rail systems, may seem costly considering just their traffic safety impacts, but provide other important benefits including reduced traffic and parking congestion, infrastructure savings, user savings and affordability, improved mobility for non-drivers, improved public fitness and health, energy conservation and emission reductions. Considering all impacts new paradigm safety strategies are often very cost effective.

Critics could argue that these strategies' safety impacts are difficult to predict, but research described in this report can be used to model how policy and planning decisions affect travel activity and crash rates. Such models are no less accurate than those used to predict conventional safety strategy impacts; in fact, current models often exaggerate conventional strategies' net safety gains by ignoring induced travel and offsetting behavior effects (Rudin-Brown and Jamson 2013). More research is justified, but sufficient information is available to make reasonable predictions of new safety strategy impacts.

Conventional planning tends to overlook or undervalue policies and programs that provide traffic safety co-benefits. For example, detailed analysis by Oldham and Mills (2020) found that some public programs that are primarily intended to reduce crime or pollution emissions also increase traffic safety, but these impacts were overlooked or undervalued in the program evaluations, leading to their underinvestment. Similarly, public transit service improvements are generally intended to reduce traffic and parking congestion, and improve mobility for non-drivers, and Smart Growth development policies are generally intended to reduce the costs of providing public infrastructure and reduce environmental impacts, but these also provide significant traffic safety gains. Table 7 lists various multi-modal planning strategies that also tend to provide traffic safety co-benefits.

Table 9 **Multi-Modal Planning**

Improved Mobility Options	Mode Shift Incentives	More Accessible Land Use
Improved walking and cycling conditions	Efficient road and parking pricing	Compact and mixed development
High quality public transit services	Fuel price increases	More connected road networks
Ridesharing, ride-hailing and taxi services	HOV priority	Complete streets policies
Car- and bikesharing	Commute trip reduction programs	Reduced parking requirements

Various policies can create multi-modal communities where residents drive less and rely more on non-automobile modes, reducing traffic fatality rates. Their effects are synergistic and so should be evaluated together.

New paradigm safety strategies may seem outside traffic safety programs' scope, but this is an arbitrary distinction. Traffic safety programs now include road and vehicle design standards, law enforcement, business regulations, and social marketing; there is nothing inherently different about multi-modal planning, TDM and Smart Growth. These strategies are sometimes criticized as *social engineering*, with the implication that they force travelers to use undesirable mobility options, but such arguments that are generally false. In fact, multi-modal planning, TDM and Smart Growth tend to respond to consumer demands for non-auto modes, and remove existing market distortions, such as reducing parking minimize that subsidized automobile travel. Surveys indicate that many people would prefer to drive less and rely on alternative modes, provided they are convenient and affordable. For example, the National Association of Realtor's *National Community and Transportation Preference Survey* (NAR 2017), indicates that a growing majority of home buyers prefer living in a walkable urban neighborhood over a detached house that requires a longer commute and driving to shops, and most respondents like walking (80%), about half like bicycling, more than a third (38%) like public transit travel. More multi-modal planning responds to these demands, which increases safety among other benefits.

Another criticism is that new paradigm strategies are too slow, but as Table 4 indicates, many can be implemented in a few years. Experience indicates that communities can achieve significant safety gains within a few years by applying more multi-modal planning, TDM and Smart Growth policies. As Figure 18 showed, during a ten-year period, the cities with multi-modal planning and Smart Growth policies reduced their traffic fatality rates 2.5 times more than in cities with conventional planning and development policies (PBOT 2016; SDOT 2015), which suggests that new paradigm strategies can more than double the safety gains achieved by conventional safety programs alone.

Another obstacle is stakeholder (policy makers, practitioners, citizens, etc.) bias. Most stakeholders are themselves motorists, who tend to be proud of their skills (surveys indicate that most drivers consider themselves safer than average, called *illusory superiority*), and so are often offended by the idea that their driving is dangerous and should be reduced for safety sake. In addition, many stakeholders consider travel reduction a defeatist solution that denigrates conventional transportation planning and traffic safety programs. These responses misrepresent the issues. The new safety paradigm acknowledges that most drivers are responsible and cautious, and past traffic safety programs successfully reduced crash rates, but recognizes that new strategies can provide additional safety gains that will not otherwise occur, plus other important benefits, and so should be implemented.

Conclusions and Recommendations

After a century of decline, U.S. traffic casualty rates have started to increase indicating that new approaches are needed to achieve ambitious safety goals. Recent research improves our understanding of factors that affect traffic risks and identifies new safety strategies. Numerous studies using various methods and data sets indicate that *exposure*, total vehicle travel, is a significant risk factor. Although other factors affect crash risks, for a given group or area, changes in per-capita vehicle travel generally cause comparable changes in per capita crash casualty rates. Since most casualty crashes involve multiple vehicles, even error-free drivers become safer by reducing mileage which reduces their chance of being a victim of other drivers' mistakes. A paradigm shift is needed to apply this knowledge.

The old paradigm assumed that most crashes result from special risks, such as youth, senior, impaired and distracted driving, and so favored targetted safety programs. The new paradigm recognizes that all vehicle travel incurs risk, so policies that induce more vehicle travel increase crashes, and vehicle travel reductions increase safety. This expands the scope of potential safety strategies, as summarized below.

Table 10 **Scope of Traffic Safety Programs**

Old	New
• Targeted speed reductions. • Anti-impaired and distracted driving campaigns. • Special testing for youth and senior drivers. • Roadway design improvements. • Vehicle design improvements. • Vehicle occupant crash protection.	• Safe traffic speeds. • More multi-modal planning. • Complete streets roadway design. • Vehicle safety standards that protect other road users. • Efficient transport pricing (fuel tax increases, road tolls, parking fees, distance-based pricing). • Smart Growth development and complete streets policies. • TDM programs (commute and school travel management).

The New Paradigm expands traffic safety programs to include traffic reduction strategies that reduce exposure.

How risks are measured can significantly affect safety analysis. The old paradigm relied on distance-based risk indicators which ignored the additional crashes caused by policies which increase total vehicle travel and the safety provided by vehicle travel reductions. The new paradigm measures casualties per capita. Because vehicle travel reduction strategies provide co-benefits besides safety, the new paradigm supports comprehensive impact evaluation.

The new paradigm faces various obstacles, including many stakeholders' preferences for targeted safety programs and aversion to vehicle travel reduction strategies. However, new paradigm strategies actually complement existing programs, which become more effective, equitable and acceptable if implemented with improved mobility options that help higher-risk travellers reduce their driving.

This is not to suggest that traffic safety requires totally eliminating automobile travel, but surveys indicate that many people would prefer to drive less and rely more on alternatives, provided they are convenient, comfortable and affordable. In response, many communities are implementing more multi-modal planning, Smart Growth policies, and TDM programs. This research suggests that, in addition to their other benefits, these are also excellent traffic safety strategies.

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