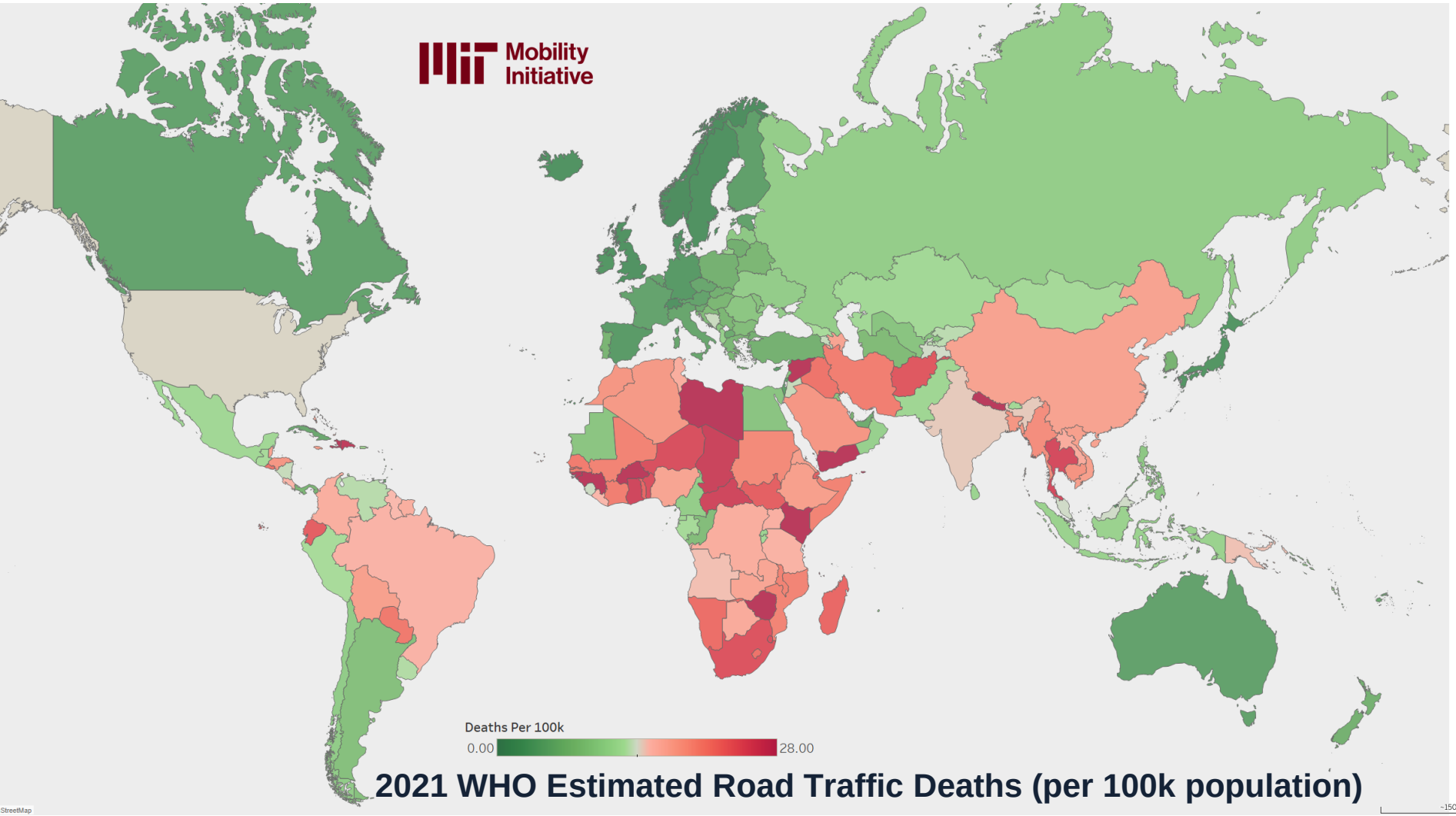
Mobility Initiative

Leading the transformation to tomorrow's mobility system

# Mobility Forum - Vehicle Performance and Safety Trends

## Cambridge, MA USA

## November 1, 2024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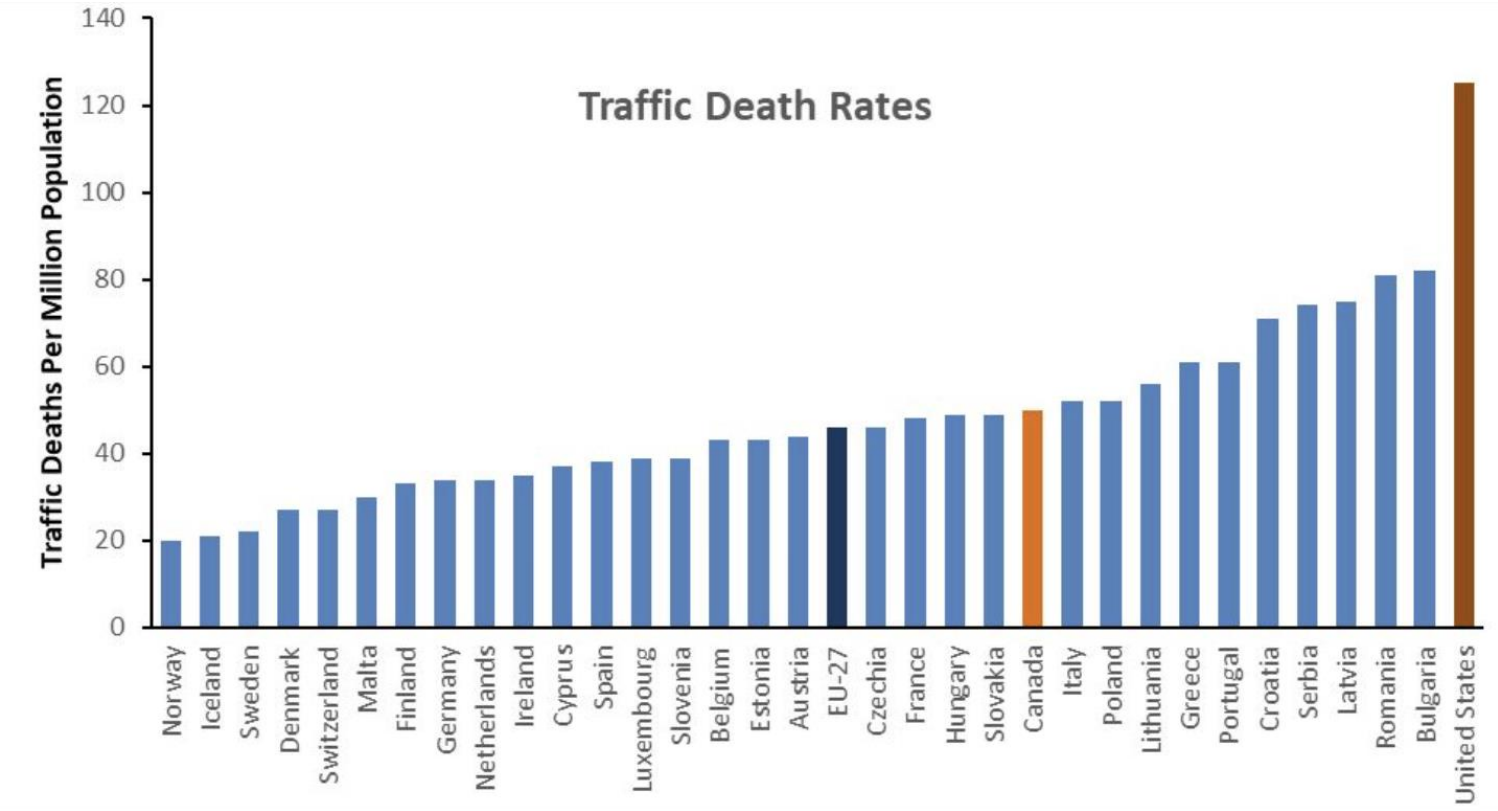
Deaths Per 100k
0.00
28.00
2021 WHO Estimated Road Traffic Deaths (per 100k population)
StreetMap
~1500 mi




Source: Analysis by Todd Lipman, Victoria Transport Policy Institute using EU, Transport Canada and NHTSA data. https://transport.ec.europa.eu/news-events/news/20400-lives-lost-eu-road-crashes-last-year-2024-10-10_en, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813561,

Safety Trend

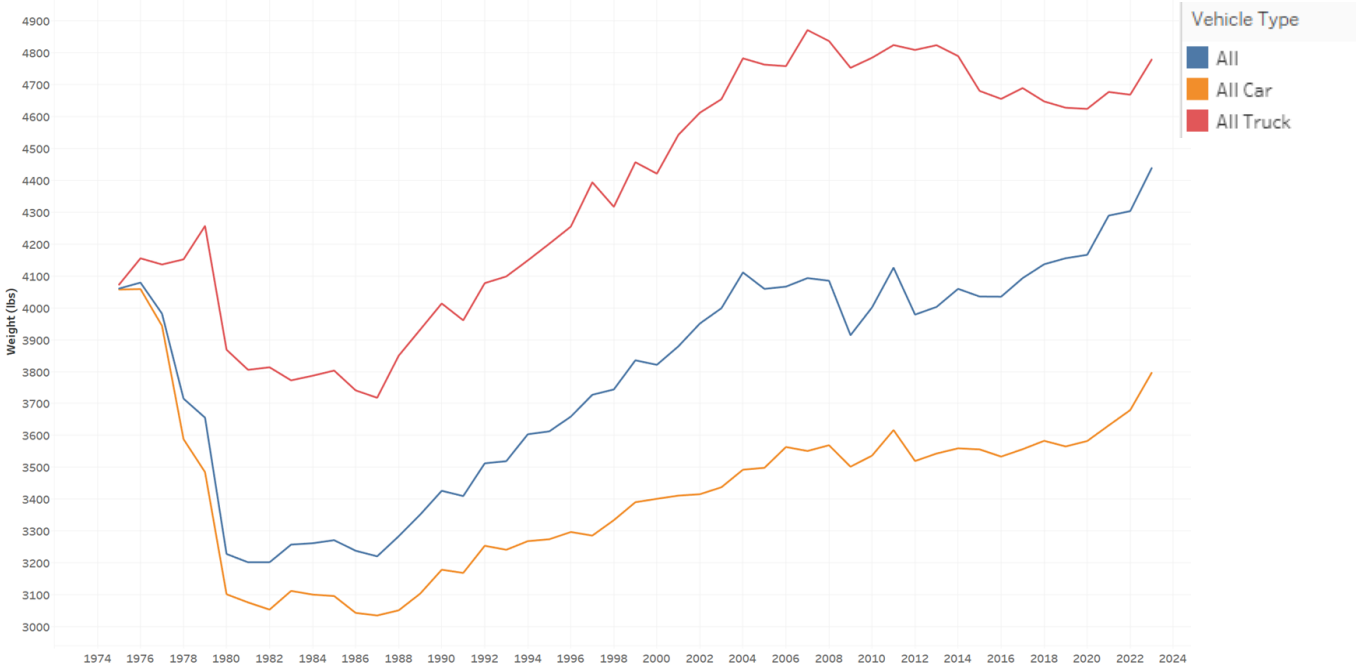
# We want safe mobility … but consumers want supersized vehicles

1975 Ford F-150

2000 Ford F-150

2020 Ford F-150

## US Light Vehicle Average Weight (lbs): 1975 - 2022

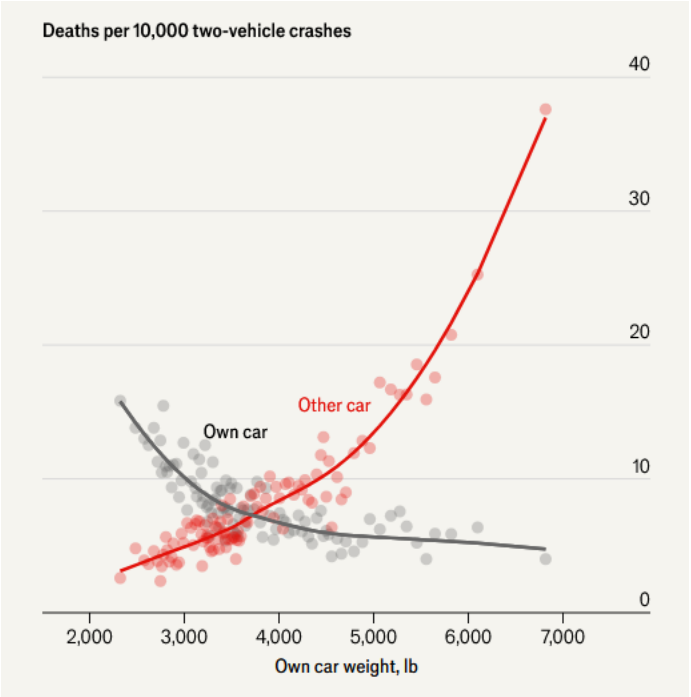



Source: EPA Data

Safety Trend

# Supersizing American Vehicles: Impact on VRU Safety

- Laws of Physics – Everything else equal, the heavier car will be safer in a two-vehicle crash
- The fatality rate is roughly seven times higher when colliding with a heavy pickup truck than with a compact car
    - As the weight of your car increases, the risk of killing others increases dramatically.
- For every life that the heaviest 1% of SUVs and trucks save, there are more than a dozen lives lost in other vehicles

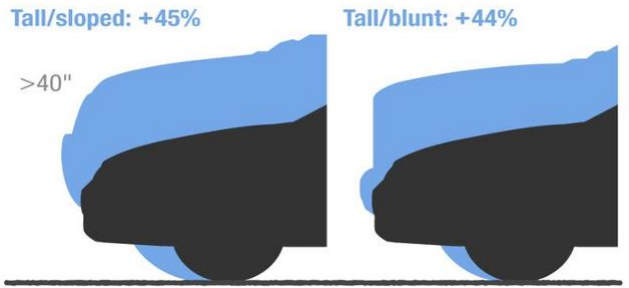



Source: The Economist - https://www.economist.com/interactive/united-states/2024/08/31/americans-love-affair-with-big-cars-is-killing-them

Safety Trend

# Supersizing American Vehicles: Impact on VRU Safety

- The average passenger vehicle in the U.S. is 4 inches wider, 10 inches longer, 8 inches taller, and 1000 pounds heavier than its counterparts of 30 years ago
- U.S. pedestrian crash deaths have risen roughly 89% since 2010: over 7500 pedestrians died after being struck by a vehicle in 2022 (GHSA and NHTSA FARS)
- 2022 IIHS Study on LDV Visibility: Pedestrian fatalities during left-hand turns roughly twice as likely for SUVs, 3x likely for vans and almost 4x likely for pickups
- 2023 IIHS Study on LDV Impact: LDVs with hood height greater than 40” are about 45 percent more likely to cause fatalities in pedestrian crashes than cars
- **A 10 cm increase in front-end height causes a 22% increase in pedestrian fatality risk** (Justin Tyndall, Univ. of Hawaii)


Source: Insurance Institute for Highway Safety and Governors Highway Safety Institute: https://www.iihs.org/news/detail/vehicles-with-higher-more-vertical-front-ends-pose-greater-risk-to-pedestrians, https://www.iihs.org/news/detail/suvs-other-large-vehicles-often-hit-pedestrians-while-turning, https://www.ghsa.org/sites/default/files/2023-06/GHSA%20-%20Pedestrian%20Traffic%20Fatalities%20by%20State%2C%202022%20Preliminary%20Data%20%28January-December%29.pdf, https://www.sciencedirect.com/science/article/pii/S2212012224000017#:~:text=of%20vehicle%20height.-,The%20effect%20of%20front%2Dend%20vehicle%20height%20on%20pedestrian%20death,seniors%20are%20more%20strongly%20affected.

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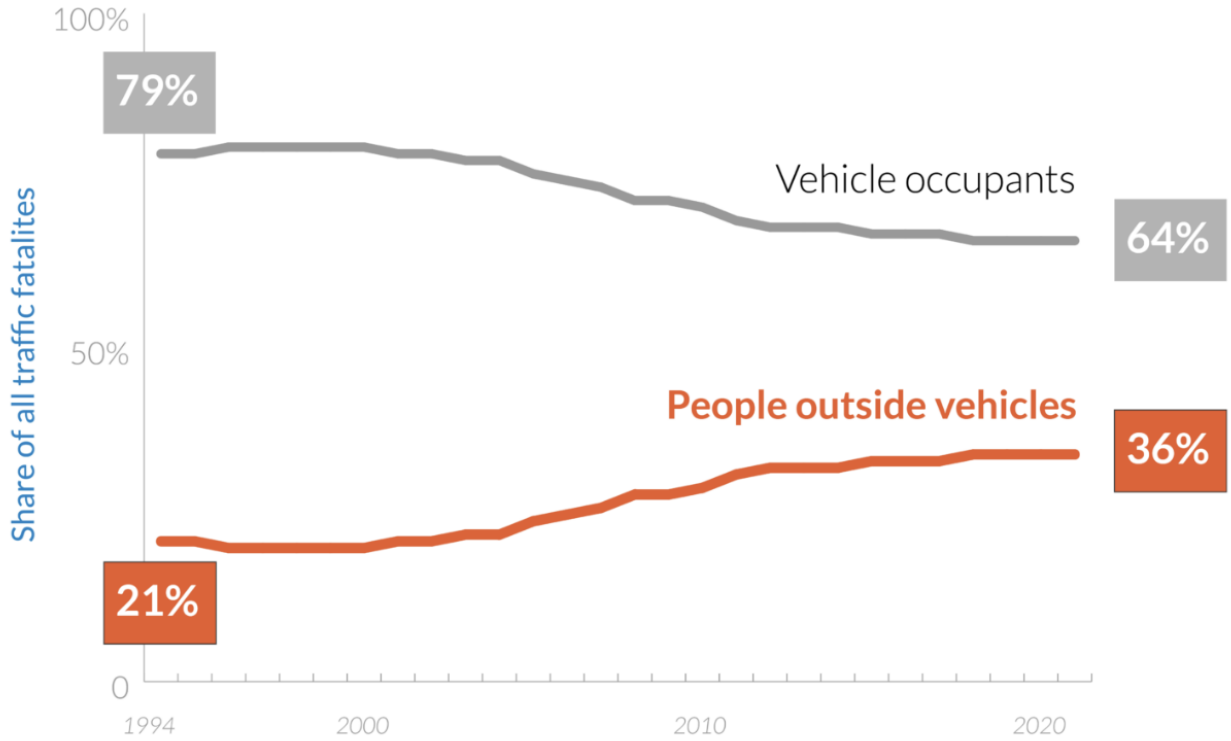
# A growing share of all traffic deaths are people outside of vehicles




Source: Pedestrian Fatalities at Historic High, Smart Growth America, April 2024: https://smartgrowthamerica.org/pedestrian-fatalities-at-historic-high/#:~:text=Injuries%20and%20deaths%20are%20up,more%20than%2046%2C000%20(thousand!).

# Creating the US Light Duty Vehicle (LDV) Database

| Source | Method | Data Points |
|---|---|---|
| **CarSheet.io** | Web Scraping | Model Year/Trim, Price, Body Style/Type, Dimensions, Weight, Powertrain type, Capacities, Features, Range, Warranty |
| **Car & Driver** | Manual | 70 mph - 0 Braking in feet<br>0 - 60 mph in seconds |
| **Motor Trend** | Manual | 0 - 60 mph in seconds |
| **0-60 Spec** | Web Scraping | 0 - 60 mph in seconds |
| **NHTSA Safer Car Data** | CSV Sheet | Rollover Ratings |

Database of over 300 US LDV models, 600+ trim levels from Model Year 2020 onwards

# Light Duty Vehicle (LDV) <8500 pounds

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Passenger Cars:

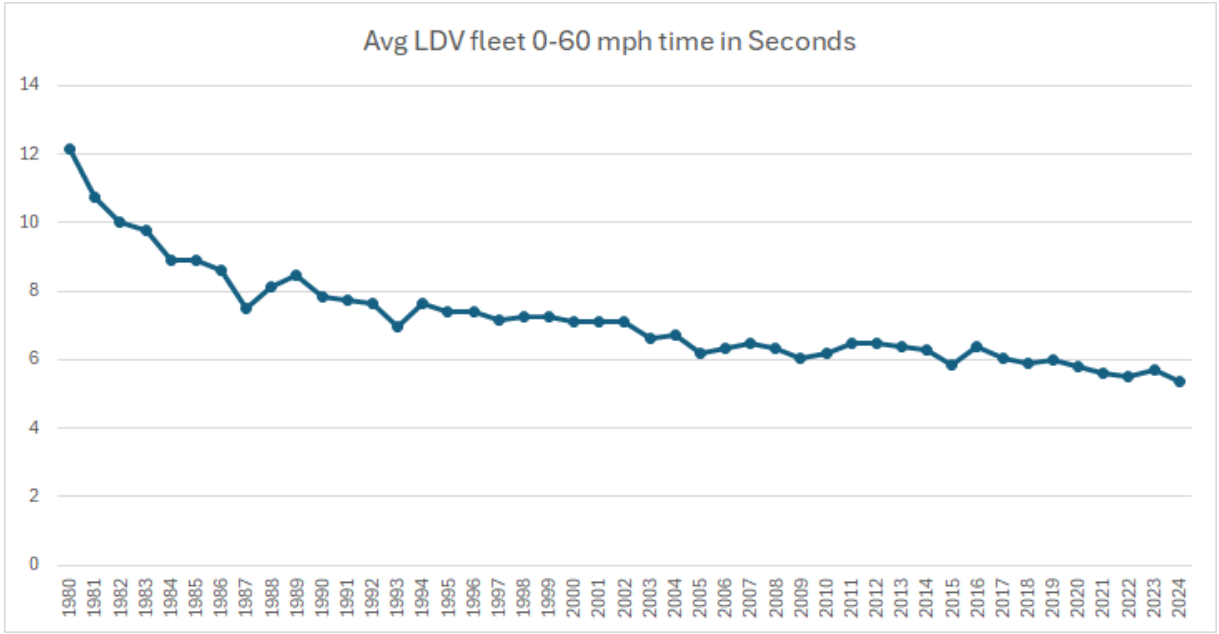
- Sedans
- Station Wagons
- Coupes
- Hatchbacks
- Convertibles

Light Trucks:

- Pickup Trucks
- SUVs
- Minivans
- Vans

# Increasing Vehicular Speed and Acceleration

- Vehicular Speed is directly proportional to acceleration - v = u + a*t
- Current LDV fleet 0-60mph acceleration time is around 6 seconds - 50% reduction since 1980




Source: Car & Driver, Motor Trend, 0-60 Spec

# Why is this important?

- Modern cars make accessing this quick, seamless & strong acceleration much easier and quieter
- Modern cars also mask speed (reduced NVH) very well
- A few seconds of additional throttle pressure can have the car doing unsafe speeds 20 - 30 mph over the limit without the driver noticing
- Increased probability of encountering scenarios where the vehicle needs to shed speed quickly
- Hypothesis - Faster accelerating cars (irrespective of shape, size, drivetrain type) should have better braking performance
    - Usually true - Manufacturers have put better braking hardware on faster accelerating cars (BMW M, Audi RS, Mercedes AMG, Hyundai N, Honda Type-R) compared to the slower accelerating ones of the same model type
    - However, fast accelerating models are now available across many different model types, vehicle classes and weight - more VMT
- Does the hypothesis hold?

# Why is this important?

What this is NOT:

- Not anti-car
- Not anti-technology

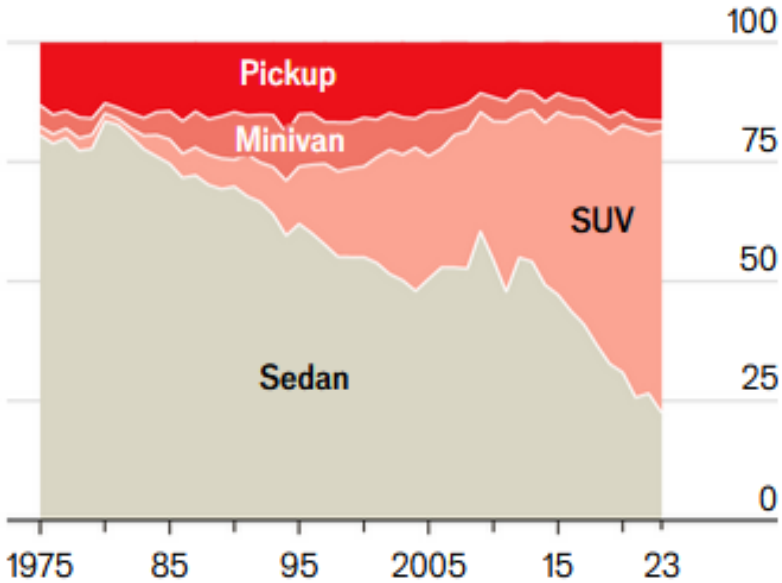
What this is:

- Data driven look at LDV performance (braking, acceleration) versus other vehicle characteristics (Weight, Cost, Vehicle Type, Drivetrain)
- A potential guide for consumers, regulators and policy makers

# SUVs & Pickup Trucks

- 80% of new LDV sales are SUVs and Pickup Trucks-
  - Share of full-size SUVs & Pickup Trucks are gaining share
  - 2023 – 3.5%, 2019 – 2.6%, 2013 – 1.9%
- NHTSA Rollover ratings -
  - 80%+ of non-SUV/Pickup LDVs have a 5/5 score
  - 95% of SUVs/Pickups score 3 or lower
- Rollover fatalities for SUV/Pickups are 1.6 - 1.9 times higher than cars

**US Light Duty Vehicle Market by Type 1975 - 2023**




Source: EPA, Economist, https://www.spglobal.com/mobility/en/research-analysis/us-consumers-going-big-as-fullsize-suvs-gain-share.html

# Battery Electric Vehicles

- Due to the heavy battery pack BEVs are typically around 800 - 1200 pounds heavier than their ICE equivalents/counterparts – e.g F-150 BEV is around 40% heavier than the ICE F-150 equivalent

- They are excellent from an efficiency standpoint
  - 15 - 20% BEV energy loss versus 64 - 75% ICE energy loss
  - Electric motors develop maximum torque from standstill, delivering fast, stealthy acceleration
    - BEV median 0-60mph time = 4.3s
    - non-BEV median 0-60mph time = 6+s

- Regenerative Braking helps in less brake use for everyday driving
  - But it is proportional to the speed of the car
  - You need physical brakes for hard/emergency braking

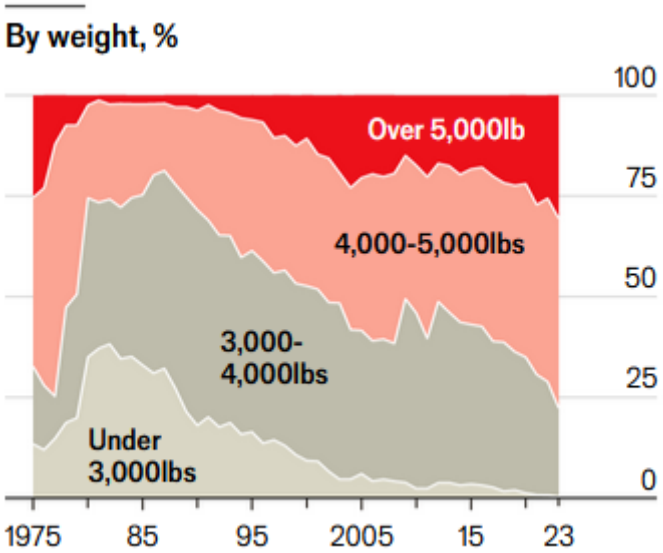
- How does the added weight impact braking performance for these extremely fast accelerating BEVs?

Source : https://fueleconomy.gov/feg/atv-ev.shtml

# Weight

- Being hit by a 1,000 pound heavier vehicle results in a 47% increase in fatality
- Heavier cars carry more momentum and need bigger and more resilient braking hardware
- How does the added weight impact braking performance for different vehicle types?

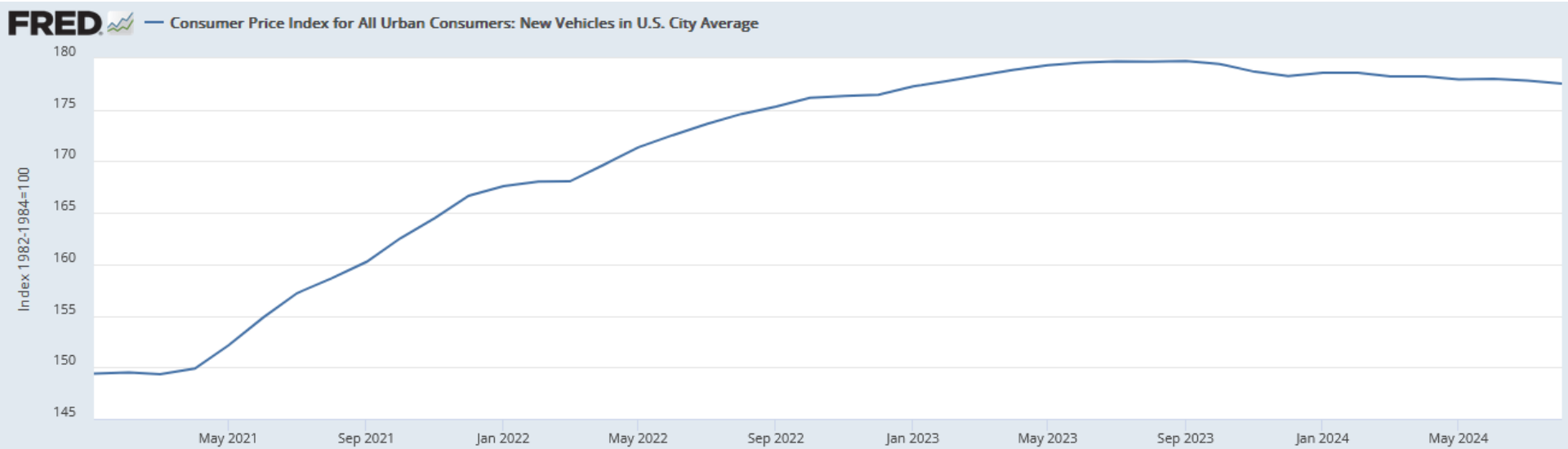
Average new car weight:
1. USA – 4400 pounds
2. EU – 3300 pounds
3. Japan – 2600 pounds




Source : https://www.nber.org/papers/w17170, EPA, Economist

# Cost

- Cars are costlier than ever - up 21% since 2021 from $40,000 to $48,389
- Consumers may stretch their budget to buy a more expensive variant, expecting better overall performance (acceleration and braking)
- How does braking performance vary with cost for different vehicle types?




Source : https://www.kbb.com/car-advice/when-will-car-prices-drop/

# NHTSA

Feb 2022 – Issues final rule allowing adapting driving beam headlights

- Improve VRU safety
- Reduce nighttime fatalities that have been increasing

April 2024 – Issued mandate for AEB from MY 2029

- Improve Pedestrian safety
- Reduce frontal crashes

September 2024 – Proposes new vehicle standard to better protect pedestrians

- Introduce testing procedures to assess the safety of those outside the vehicle

Source: NHTSA.gov, https://www.nytimes.com/interactive/2023/12/11/upshot/nighttime-deaths.html

**Vehicle Performance Trends and their Safety Implications**

Bhuvan Atluri & John Moavenzadeh, Massachusetts Institute of Technology, November 1, 2024

## Part I. Literature


1. Anderson, M., & Auffhammer, M. (with National Bureau of Economic Research). (2011). *Pounds that Kill: The External Costs of Vehicle Weight*. National Bureau of Economic Research. https://www.nber.org/papers/w17170
2. Botzoris, G., Profillidis, V., Galanis, A., Lemonakis, P., Argyropoulos, G. (2023). *An Investigation of Distraction Factors on Road Safety*. In: Nathanail, E.G., Gavanas, N., Adamos, G. (eds) *Smart Energy for Smart Transport*. CSUM 2022. Lecture Notes in Intelligent Transportation and Infrastructure. Springer, Cham. https://doi.org/10.1007/978-3-031-23721-8_92
3. Governors Highway Safety Association (2023). *Pedestrian Traffic Fatalities by State: 2022 Preliminary Data*. https://www.ghsa.org/sites/default/files/2023-06/GHSA%20-%20Pedestrian%20Traffic%20Fatalities%20by%20State%2C%202022%20Preliminary%20Data%20%28January-December%29.pdf
4. National Highway Traffic Safety Administration. (2024). *Early Estimates of Motor Vehicle Traffic Fatalities in 2023*. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813561
5. Nikolaou, P., Dimitriou, L., (2018). *Evaluation of road safety policies performance across Europe: Results from benchmark analysis for a decade*. *Transportation Research Part A: Policy and Practice*, 116, 232-246. https://doi.org/10.1016/j.tra.2018.06.026
6. Wang, X., Atiyya Shaw, F., Mokhtarian, P. L. (2022). *Latent vehicle type propensity segments: Considering the influence of household vehicle fleet structure*. *Travel Behaviour and Society*, 26, 41-56. https://doi.org/10.1016/j.tbs.2021.08.002


## Part II. Recent News


1. Badger, E., Blatt, B., Katz, J. (2023, December 11). *Why are so many American pedestrians dying at night? The New York Times*. https://www.nytimes.com/interactive/2023/12/11/upshot/nighttime-deaths.html
2. European Commission. (2024; October 10). *20,400 Lives lost in EU road crashes last year*. https://transport.ec.europa.eu/news-events/news/20400-lives-lost-eu-road-crashes-last-year-2024-10-10_en
3. Insurance Institute for Highway Safety (2023; November 14). *Vehicles with higher, more vertical front ends pose greater risk to pedestrians*. https://www.iihs.org/news/detail/vehicles-with-higher-more-vertical-front-ends-pose-greater-risk-to-pedestrians
4. S&P Global Mobility (2023; October 17). *US consumers going big as full-size SUVs gain share*. https://www.spglobal.com/mobility/en/research-analysis/us-consumers-going-big-as-fullsize-suvs-gain-share.html

**Part III. Questions and Answers**

Question: There seems to be a tendency for compensating behaviour, where people seek heavier and bigger vehicles in search of perceived safety that they provide, or as a response to poor infrastructure (a larger vehicle can supposedly make potholes feel less noticeable). However, once in a larger vehicle, they are inclined to drive faster and more aggressively because they can.

Another interesting avenue for research is to look at the 0 to 60 speeds which have fluctuated over the years. The 'malaise era' which lasted between 1974 and 1978 saw the number go up and horsepower go down, in response to the energy crisis of the era. It is also interesting in the light of how different vehicles (e.g. motorcycles and passenger cars) respond to the driver breaking when at different speeds and the driving knowledge and behaviour they elicit because of it.

Finally, it would be worth considering how vehicle dynamics have changed, for example in electric cars which are going to have a very low centre of gravity compared to ICE vehicles, which will see their centre of gravity increase as they get bigger.

Answer: Exactly. We have seen that the 0 to 60 has been going up in leaps and bounds, however, the breaking capacity is nowhere near to match that performance. However, having grown up outside the US, it does feel that the roads here are quite good – SUVs with their spring design and solid axle rears may not be the best in terms of ride comfort – a Mercedes S class will provide a more comfortable ride compared to a SUV or a pick-up truck. And so, I think it is just a way for people to justify the desire to buy a larger car.

Q (follow-up): In the early 2000s we have conducted a study where we drove people around the freeways in Seattle and asked them to rate the pavement. Those who rode in a larger vehicles rated the quality as significantly smoother than those who rode smaller vehicles.

Q: SUVs are popular in Europe where the safety record is much better than in the US. What causes the difference?

A: For several months now something called ' intelligent speed assistance' has been required for all vehicles sold in Europe – this is effectively a monitoring system that buzzes or otherwise indicates if the vehicle goes above the speed limit. It also still comes down to weight – SUVs in Europe are still much smaller in Europe than in the US. The SUV category is broad, so the type of SUVs sold in Europe might be much smaller than those purchased in the US. Further, anecdotally, US vehicles focus on the ride while German vehicles focus on handling.

Another potential explanation is the presence of manual transmission which limits the propensity to look at the phone, and be distracted. Also road design may affect road safety – Europe has narrower roads than the US – wider roads are more dangerous for pedestrians to cross; narrow European roads make you feel as if you're driving fast when going 20 miles per hour, while American roads lull you to sleep. Further, people driving in the US drive larger distances – can we with time change land use patterns and through planning encourage mode shift?

For more information regarding the Intelligent Speed Assistance see: https://etsc.eu/intelligent-speed-assistance-isa/

Q: What do you think about the amount of screens in cars nowadays, against more analog controls in older cars from a safety perspective?

A: That definitely has a part to play; screens are another distraction point. Having screens is less expensive for the manufacturer. However, between customer preference and regulations, there is push towards keeping or reintroducing physical controls; there are examples of manufacturer reintroducing physical controls, so that drivers do not have to take eyes of the road. The lighting level might also be worth looking at – bright screen light impairs vision of the driver, particularly at night.

Q: What about headlights – positioning, driving at night?

A: Intelligent headlights are a good step; headlights on the roof level or higher up as on SUVs might blind drivers. The riskiest time to drive is at dusk.

**Part IV. Summary of Memos**

*Themes from other memos:*

1. There are four key pillars of research into road safety: 1) infrastructure and road design; 2) vehicle design; 3) policy and enforcement; and 4) driving behaviour.
2. Current research and policy priorities focus on infrastructure and vehicle design. More time should be spent on policing driving behaviour and ensuring appropriate training and traffic enforcement of those disregarding rules.
3. Reflections on differences between car culture across the globe, in particular contrasting the American and European preferences in car and urban design, and the resulting diverging road traffic accident statistics
4. Considerations of the optimal way to curb car bloat and improving road safety with or without infringing on personal freedom

*My reflection:*

Last week's Mobility Initiative lecture was presented by Bhuvan Atluri and John Moavenzadeh, both from Massachusetts Institute of Technology. The talk focused on vehicle performance trends and their safety implications, examining how vehicles changed over the years and how the automobile design may be impacting road safety.

The talk started with a very poignant reminder – 1.9 million people are killed in road accidents each year, and another 20 to 50 million are injured. The following statistic was even more shocking – road accidents are the leading cause of death for children and young adults, an unfortunate truth in most countries across the globe. While discussing these numbers, the presenters displayed a map showing the estimated road traffic deaths by country. There, one thing stood out – US was marked as a country with a death rate notably higher than European countries.

Having only recently moved from Europe to the US, the talk was very much a neatly evidenced and summarised embodiment of the car culture shock I have experienced over the last few months. The presenters pointed out that cars in the US are notably bigger and heavier than those in Europe; that the city and road design favours smaller carriageways on the old continent than it does across

the pond; that having a manual transmission provides fewer opportunities to get distracted and may influence the user to pay more attention to the their environment. All of these points ring true – seldom have I seen SUVs towering over me back home – it is now a daily occurrence; I grew accustomed to vehicles being obliged to stop to let me cross the road – here I stopped counting near-misses as drivers zoom past, utterly distracted.

This intersection of regional differences and the scale and severity of the problem very much at the forefront of my mind leaves me with just one question – why?

**Part V. Other Information**

N/A