

Motor Vehicle Crash Testing Regulations for More Inclusive Populations

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Executive Summary: There is a stark disparity in motor vehicle crash deaths and injuries between male and female drivers. Female drivers are 13% more likely to be killed than their male counterparts in similar motor accidents. However, vehicle safety test practices do not account for diverse body proportions when assessing safety outcomes. Vehicle crash testing standards only require testing of two variations of adult-sized crash test dummies: a 50th percentile male and a 5th percentile female. Automotive companies are not required to test safety outcomes in crash test model's representative of average female proportions or of non-average body sizes and physiological compositions. Current crash test standards are regulated by the National Highway Traffic Safety Administration (NHTSA) under the US Department of Transportation. This memo proposes three actions for the NHTSA and the Department of Transportation to address disparities in vehicle safety outcomes: 1) update safety standard requirements to include a 50th percentile female crash test dummy, 2) implement a federal tax incentive program for companies to include a greater diversity of vehicle occupant models, and 3) allocate funds for research and development of virtual crash testing models. These proposed initiatives seek to raise the minimum safety requirements and prioritize wider representation of vehicle occupants to improve parity in vehicle safety outcomes.

I. Statement of the issue

In the past few decades, vehicles have become increasingly safer, with fewer crash deaths and injuries (Kahane 2013). This is due, in part, to stricter safety regulations and technological advances in automobile safety features, such as increased safety belt use and advanced air bag installation. However, there remains a stark disparity in vehicle crash deaths and injuries when comparing male and female drivers involved in similar vehicle accidents.

Men drive more miles, are involved in more vehicle crashes, and are more likely to engage in risky behavior while driving compared to women, yet women are about 13-20% more likely to be killed than men in similar motor accidents (IIHS 2021).

These disparities in vehicle crash safety outcomes are not adequately addressed in present-day vehicle safety testing requirements. Crash testing currently uses 50th percentile male dummies (171 lb, 5 ft 9 in) but only 5th percentile female dummies (108 lb, 4 ft 11 in) to represent adult vehicle occupants (NHTSA 2021). Additionally, female

dummies are scaled-down versions of male dummies and do not account for sex differences in mass distribution, muscle and ligament strength, and bone structure and density (Linder and Svedberg 2019). Female crash test dummies do not represent average female vehicle occupants, which leads to inaccurate crash test data collection and inadequate safety features. For example, due to differences in neck musculature, women are about twice as likely to suffer from whiplash injuries than men. As a result, whiplash protection seats designed in response to crash test results are more effective for men than women (Linder and Svedberg 2019).

Physiological differences between male and female occupants are not the sole factor in risk disparity. Compared to males, female drivers are more likely to be in passenger cars than heavier vehicles like SUVs and vans, and drivers in heavier vehicles are less likely to be injured (Bose 2011). Female injury risk was reduced after accounting for differences in vehicle and crash type (Brumbelow and Jermakian 2021). However, both studies concluded that women still have a higher risk of injury compared to men, particularly extremity injury, and that sex-inclusive safety designs need to be incorporated.

Other factors beyond sex, such as age and weight, also lead to risk disparities. Fatality risk increases with age (Kahane 2013), and research groups have found that obese and underweight drivers have increased risk of death (Zhu 2006; Viano 2008). Current crash test dummies do not represent underweight, obese, elderly, nor disabled body types (Cornell Law School n.d.).

II. Current car safety standards

Vehicle safety tests are regulated by the NHTSA, which is a federal agency under the US Department of Transportation. The NHTSA implements laws from Congress by writing and enforcing the Federal Motor Vehicle Safety Standards (FMVSS), which sets requirements for vehicles that test for crash avoidance, crashworthiness, and post-crash survivability.

These standards are developed and supported by research conducted under the NHTSA through the Vehicle Research and Test Center. Their responsibilities include crash test dummy

standardization, as well as testing and research on crash avoidance and crashworthiness. In addition to crash testing performed by automotive companies to meet FMVSS guidelines, crash tests for vehicle safety ratings are also performed by the NHTSA and the Insurance Institute for Highway Safety (IIHS), a nonprofit organization. Both organizations evaluate vehicles based on crash test performance (Consumer Reports n.d.).

Automotive companies must test several different crash conditions in order to meet FMVSS, using both front and side impacts at different speeds (NHTSA 1999). In these tests, the effectiveness of the safety equipment is determined by measurements of acceleration, force, and deflection of a representative crash test dummy (Hollowell n.d.). After a vehicle meets minimum requirements of the FMVSS, the NHTSA may perform additional testing to give the vehicle a rating out of five stars for its performance in various types of accidents (Consumer Reports 2014). These tests determine injury severity based on the Abbreviated Injury Scale and use the results from all types of crashes to give a vehicle an overall rating. Unlike the compliance testing of FMVSS, which uses the 5th percentile female dummy in a variety of positions, the NHTSA star ratings only procure data with the female dummy as a passenger on the driver's side. This is notable since the NHTSA star ratings are made available to the public while FMVSS compliance testing remains private. Separate ratings are used for the passenger and driver side dummies, but in NHTSA testing, a 50th percentile male dummy is used as the driver while the 5th percentile female and children dummies are put in passenger positions (Consumer Reports 2014). Additionally, the FMVSS requires maximum measurements of force and acceleration, but excludes considerations for differences in bone density, mass distribution, and other physiological differences between men and women in the injury calculations (Cornell Law School n.d.; Linder and Svedberg 2019). Current vehicle safety standards do not account for diverse body types, and publicly available data on female or representatively sized crash test dummies are severely lacking.

While regulations for crash tests are often updated to improve vehicle safety, standards for crash test

dummies have been slow to change. Efforts by the NHTSA to expand its crash test dummy repertoire in the 1980s were hindered by budget cuts and shifts in government attitudes towards regulation. The cost and time needed to develop new dummies continue to be key factors in maintaining the status quo. According to a senior research engineer at the IIHS, crash test dummies can take over twenty years to develop (Barry 2019). In support of the current standards, an NHTSA representative explained that using a wider range of crash test dummies (50th percentile male and 5th percentile female) allows for better protection for a greater range of occupants (Putka 2021).

One example of regulatory success in improving car safety is the response to airbag deaths in low-speed crashes that were not expected to be fatal. Airbag deployment was designed to protect 50th percentile males in crashes. However, the force of these airbags was too strong for children and smaller women, leading to 179 deaths between 1996 and 2000 (Barry 2019). The NHTSA responded by implementing new airbag regulations, relaxing testing requirements to quickly promote life-saving improvements (Hollowell n.d.), and requiring advanced airbags that deploy with a force relative to the weight of the vehicle occupant. These measures significantly reduced airbag fatalities, demonstrating that regulation can mitigate vehicle injury and fatalities. Despite regulatory success in improving airbag design for a wider range of vehicle operators, most safety measures are still designed and tested primarily using 50th percentile male dummies, which puts female drivers at higher risk of injury (Bose 2011).

III. Car safety research and development

A crash test dummy representing the 50th percentile female body has yet to be commercially produced or used in US automotive testing, despite there being a physical prototype model, the BioRID 50F, and a computer model called EvarID. However, due to cost and the absence of regulatory incentive to incorporate these models in vehicular safety testing, they are not yet fully developed nor widely used in crash testing (Gendered Innovations n.d.). Some individual automotive companies are implementing additional safety testing to improve safety measures for a wider

diversity of drivers and passengers. For example, in 2019 Volvo launched the Equal Vehicles for All initiative with the aim to expand crash testing research for a greater variety of body types and has shared more than forty years' worth of their data and research (Gendered Innovations n.d.). However, these additional safety measures vary in scope and efficacy across brands and vehicle models. Unless FMVSS requirements are updated to reflect updated proportions, many present-day vehicle operators will continue to experience poor safety outcomes in automobile accidents.

Considering the cost, labor, and time of developing diverse crash test dummies and running multiple crash tests per dummy, some companies have turned to virtual models. As of 2021, Toyota has made its virtual human-modeling software, Total Human Model of Safety, free access, without a government incentive to do so. This system digitizes crash testing and performs computer simulations and injury analyses for vehicle collisions. The system can replicate vehicle impacts on the muscle tissue, skeleton, and internal organs of several sexes, age groups, and body types in greater detail (Autovista Group 2020). Virtual crash testing has the potential to gather crash data and inform safer vehicle designs, especially since Toyota can continue to improve the software when it is more widely available to users (Toyota Motor Corporation 2020).

IV. Policy recommendations

Vehicle safety can be improved through federal regulation and support. This memo recommends the following measures:

i. Update FMVSS to require a 50th percentile female crash test dummy in vehicle crash testing

Update the FMVSS to include a female crash test dummy proportioned for the 50th percentile of adult American women in automotive crash testing. Additionally, this crash test dummy must be tested in driver and passenger positions.

Advantages

Requiring the inclusion of a 50th percentile female crash test dummy in vehicle safety testing will ensure that crash test data incorporates average female proportions. Testing updated female crash test dummies in both driver and passenger

placements will improve representation of actual vehicle operators. Inclusion of a female crash test dummy in vehicle crash testing is a promising first step to address disparities in vehicle occupant safety outcomes.

Disadvantages

Changes in safety testing requirements will require significant administrative and financial investment by automotive companies for compliance with new guidelines. While 50th percentile female crash test dummies have already undergone significant research and development, additional research may be required to ensure standardized implementation for safety testing across companies. Finally, this requirement still only represents a limited subset of vehicle operators.

ii. Incentivize automotive companies to incorporate additional safety testing for diverse vehicle occupants

Inclusion of an updated female crash test dummy improves the representation of diverse vehicle occupants in safety testing protocols, but it still provides only a limited scope of occupants. Therefore, we propose the use of federal tax incentives to encourage automotive companies to incorporate additional diversity in vehicle safety testing. While the NHTSA or IIHS issue industry-wide safety ratings based on testing at their affiliated sites, automotive companies also conduct their own crash testing to ensure compliance with FMVSS in the United States. The NHTSA can recommend and incentivize the inclusion of additional standardized crash test dummy specifications for automotive companies to incorporate in company-specific car safety testing to represent a wider diversity of vehicle occupants. These can include models representing higher and lower size percentiles, weakened bone density or joint strength, internal or external implants, etc. In addition, virtual crash testing presents promising opportunities for cost-effective testing of diverse occupant safety outcomes.

Advantages

The utilization of a tax incentive approach for the incorporation of additional vehicle safety testing will encourage automotive companies to consider vehicle safety data from a wider diversity of vehicle occupants. The automotive industry will retain the

option to consider which safety measures beyond the basic FMVSS requirements will be valued by their consumers. Incentivizing the inclusion of diverse crash test models, whether physical or virtual, may promote further development of safety models which represent a wider range of vehicle occupants to improve overall safety outcomes.

Disadvantages

An incentive model does not require additional safety testing of diverse vehicle occupancy. Safety testing will still vary between vehicle brands and models, which may not be clearly communicated to consumers. In addition, more research may be required to set national standards for diverse crash test dummies. Finally, inclusion of tax incentives for companies to incorporate improved diversity in crash test dummies may result in reduced federal tax revenue received from the automotive sector.

iii. Fund vehicle research and development for virtual crash testing and analysis

The NHTSA requests a total of \$32,805,000 for Vehicle Safety Research and Analysis in their Fiscal Year 2021 budget estimate. This budget focuses on improving research for driving automation, advanced vehicle safety technologies, and crash survivability, including the development of innovative physical and virtual testing tools for crashworthiness (NHTSA 2021). We recommend that the Appropriations Committee approve this investment in technology to make vehicles safer.

Advantages

Virtual crash testing allows for a greater number of crash test simulations on a greater variety of vehicles and body types. This allows for more data and analyses without the costs and time of physical crash testing and dummies. Approving this budget to fund the development and access of virtual crash test systems, like Toyota's system, would lead to more vehicle manufactures having the resources and data to improve car safety for more people.

Disadvantages

Virtual crash testing can never completely replace physical crash testing, as virtual models are based on the physical world. There will always be a need to confirm and validate virtual models with physical testing, which will still need better

representative dummies to create safety features (Barry 2019).

V. Conclusions

Despite increased safety measures in vehicle development and testing, there remain significant demographic disparities in safety outcomes following vehicular accidents. Federal agencies can

help prevent unnecessary injury and fatalities by updating crash test dummy requirements to be more representative, incentivizing automotive companies to be more inclusive and extensive in their crash testing research, and by investing in virtual crash testing technology. Implementing these recommendations can help make vehicles safer for more people.

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