The Crash Test Bias: How Male-Focused Testing Puts Female Drivers at Risk

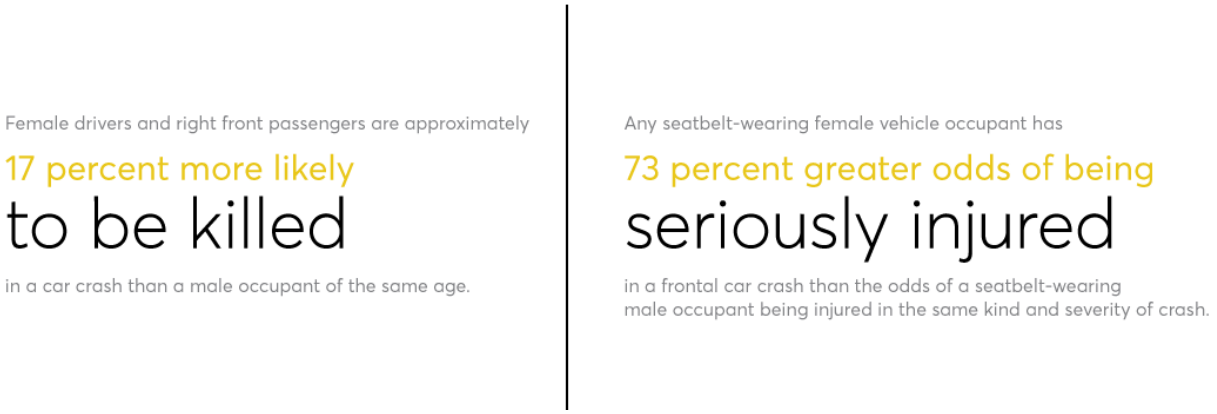
Researchers have known for decades that women are more likely to be killed or injured in a car crash. Why haven't safety regulators done anything about it?

By Keith Barry. Visualizations by Andy Bergmann.
October 23, 2019

The face of a crash test dummy looks eerily vacant. With indents instead of eyes, a pointy nose, and permanently pursed lips, it appears remarkably expressionless—especially considering it's about to hurtle toward a stationary barrier at speeds as high as 40 mph.

You might assume from its lack of distinguishing features that this crash test dummy is an avatar for all humanity. But despite those blank faces, most of the dummies used in automotive crash tests by the government and the insurance industry—the ones that determine whether a car gets a coveted five-star safety rating or is named a top safety pick—represent a very specific man.

An average adult female crash test dummy simply does not exist, despite the fact that women obviously drive to work, take road trips, and ride in cars with friends, and even though female bodies react differently from male bodies in crashes. That absence has set the course for four decades' worth of car safety design, with deadly consequences.



Sources: NHTSA and the journal Traffic Injury Prevention

Although the majority of Americans killed or injured in car crashes are male, the raw data masks the fact that females are actually at greater risk of death or injury when a crash occurs. Data from the National Highway Traffic Safety Administration and the Federal Highway Administration (FHWA) shows that males drive more miles than females, and are more likely to engage in risky behavior, such as speeding, driving under the influence of alcohol, and not wearing a seat belt. But a study from NHTSA shows that a female driver or front passenger who is wearing her seat belt is 17 percent more likely than a male to be killed when a crash takes place. And a 2019 study from the University of Virginia (UVA) shows that for a female occupant, the odds of being injured in a frontal crash are 73 percent greater than the odds for a male occupant. That's controlling for occupant age, height, and body mass index, in addition to collision severity and vehicle model year.

These alarming numbers suggest an urgent safety issue, but the problem is neither new nor unfamiliar to regulators and automakers. "These same trends have been observed in many, many studies in the past," says Jason Forman, Ph.D., who is a principal scientist with the Center for Applied Biomechanics at UVA and led that 2019 survey of injury disparities.

In fact, researchers have understood since at least the early 1980s that male and female bodies perform differently in crashes, but the vast majority of automotive safety policy and research is still designed to address the body of the so-called 50th percentile male—currently represented in crash tests by a 171-pound, 5-foot-9-inch dummy that was first standardized in the 1970s (today, the average American man is about 26 pounds heavier). This, despite the fact that cars are now routinely equipped with sophisticated safety systems, such as electronic stability control, automatic emergency braking, and blind spot detection.

Regulators asked for a female dummy in 1980, and a group of automakers petitioned for one in 1996, but it took until 2003 for NHTSA to put one in the car. Even then, it's just a scaled-down version of a male dummy that represents only the smallest 5 percent of women by the standards of the mid-1970s—so small that it can work double-duty as a 12- or 13-year-old child. No dummy takes into account the biological differences between male and female bodies.

In frontal crash tests performed for both NHTSA and the Insurance Institute for Highway Safety, this 5th percentile female dummy either rides as a passenger or doesn't participate in the test at all. (The female dummy sits in the driver's seat for some side-impact tests.) This, despite the fact that women now represent almost 50 percent of drivers in the U.S., according to the FHWA.

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>
> Emily Thomas, Ph.D.
> Automotive Safety Engineer
> Consumer Reports

Because automotive design is directly influenced by the results of safety testing, any bias in the way cars are crash-tested translates into the way cars are manufactured. So if safety tests don't prioritize female occupants, carmakers won't necessarily make changes to better protect them.

"The reality of progress in automotive safety is that it heavily relies on regulation," says Emily Thomas, Ph.D., automotive safety engineer at Consumer Reports' Auto Test Center. "Unless the federal motor vehicle safety standards require dynamic crash testing with average-sized female crash dummies in multiple seating positions, driver side included, the dummy industry and automakers won't make that leap themselves."

Regulators, automakers, and researchers agree that advances in automotive safety have helped all vehicle occupants—male and female, young and old, big and small—survive crashes. Still, these gains have not been equally realized, and decades of damning crash statistics and pleas from safety advocates have apparently not been enough for regulators to change the rules to make vehicles safer for women. The industry experts CR spoke with for this report gave plenty of explanations for the lack of progress—some say that developing new dummies and tests is unnecessary, or too expensive, or it would take too much time. But according to safety advocates, all the challenges are surmountable, and the arguments for inaction are far less convincing than the death and injury data that highlight the unfairness—and the danger—to women behind the wheel.

THE HUMAN CRASH

Automotive safety experts look at car crashes in three distinct stages. The first stage is the vehicle crash—the impact of a car or truck into a foreign object. Stage two is the human crash, when the bodies of the vehicle's occupants come into contact with seat belts and airbags—or worse, the dashboard, windows, or some other object. The third stage is the internal crash, which refers to the collisions of organs, bones, and soft tissue that happen within the human body.

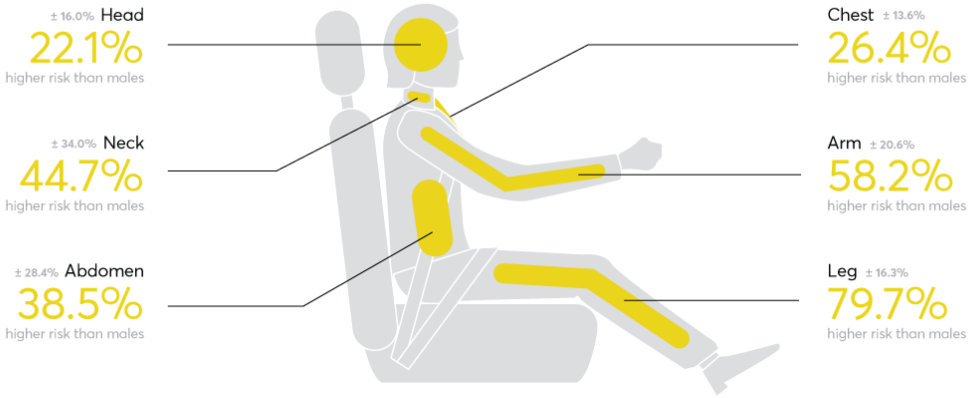
According to Consumer Reports' Thomas, the crash energy that isn't absorbed by the vehicle in that first stage is then transferred to the occupants. "Vehicle restraint systems, like seat belts and airbags, are intended to limit motion and that transfer of energy," she says. "But to do that effectively across a range of body types, carmakers and crash testers need to consider not just the size of different occupants but also the material properties of their bodies."

That means crash-testing cars with dummies that represent a variety of body types, Thomas says, and ones that can account for the physiological differences between males and females.

"Females are not just smaller versions of males," says Kristy Arbogast, Ph.D., the co-scientific director of the Center for Injury Research and Prevention at the Children's Hospital of Philadelphia, who also sits on the board of the Association for the Advancement of Automotive Medicine. "They're put together differently. Their material properties—their structure—is different."

Female Increased Risk of Injury

Estimated increase of risk for moderate injuries in a car crash compared to a male driver or right front passenger of the same age



Source: NHTSA Injury Vulnerability and Effectiveness of Occupant Protection Technologies for Older Occupants and Women

According to the Centers for Disease Control and Prevention, today's average female is 5.4 inches shorter and 27 pounds lighter than the average male. As a result, females may sit closer to the steering wheel or wear their seatbelts differently from males. But differences aren't just about shape, size, and position. For example, the female pelvis has a geometry that's different from the male pelvis, and the male neck is stronger when it comes to forces that bend it.

Even the internal makeup of female bones can be different from that of male bones. Because crash injuries and fatalities are often related to bone fractures, this may explain some of the disparities between the sexes.

"People assume that bone is this dead, static structure in your body, but it's definitely not," says Mandy Agnew, Ph.D., a biological anthropologist and director of the Skeletal Biology Research Lab at the Ohio State University Injury Biomechanics Research Center. "It's sensing loads constantly and altering its size and shape to meet those needs, so it's quite dynamic."

Biomechanical engineers and anthropologists are still struggling to understand other biological variations between male and female bodies that determine how they will react in a car crash. Crashes are chaotic events, and even two occupants of the same height, weight, and sex may experience a crash differently. Research shows that in addition to women, elderly vehicle occupants are also more vulnerable in a crash, as are larger drivers and passengers. But there are specific differences in how male and female bodies react to crashes—and in some cases the cause is unclear.

Consider whiplash. Females are up to three times more likely to suffer whiplash injuries than males, but real-world crash data shows many vehicle seats that have been specifically designed to prevent whiplash injuries are actually less likely to help female occupants.

In the late 1990s, automakers developed two kinds of safety systems designed to protect against whiplash. One, used primarily by Volvo, is designed to absorb crash energy in the seatback and head restraint. It reduced life-altering whiplash injuries for both male and female occupants but proved to be slightly more effective for females. (Toyota uses a similar design.) The other design, used by many other manufacturers, uses only a moving head restraint to diminish the movement of the head and neck in rear impacts. While it reduces life-altering whiplash crash injuries up to 70 percent for male occupants, it has no benefit for females.

TEACHING TO THE TEST

It's an open secret in the automotive industry that automakers engineer their cars specifically to pass crash tests. That's why it's critical for tests to represent how cars are used in the real world.

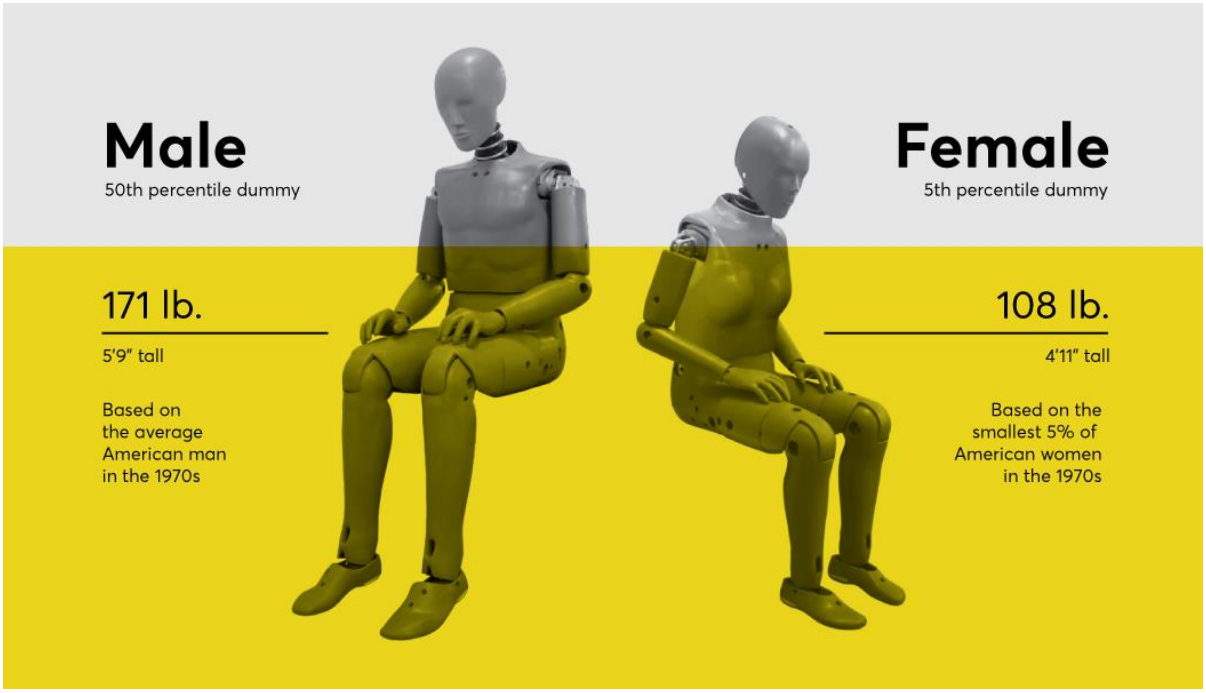
"When regulators or testing organizations set a new bar for crash safety, most automakers quickly change their designs so their cars ace the new test," says David Friedman, vice president of advocacy at Consumer Reports and a former NHTSA administrator.

That's what happened in 2012, when the IIHS, an independent crash testing agency funded by insurance companies, added a new evaluation, the small-overlap test. The test simulates a crash where the front driver-side corner of a vehicle collides with another vehicle or a tree or utility pole. As soon as the test was announced, some automakers began redesigning the next generation of vehicles to score well by improving vehicle structures and airbags. But those changes were made only to the driver's side of the vehicle, where that test was targeted. Similar improvements were not made to the passenger's side, prompting the IIHS to introduce a passenger-side version of the test in late 2017.

The results are remarkable: Only 3 out of the 11 cars initially tested in the 2012 model year received a score of Good or Acceptable. But for the current model year, every one of those cars now gets a Good or Acceptable score, thanks to redesign efforts.

According to Friedman, this incremental approach to testing and car design also demonstrates the limitations of this sort of arrangement.

"The problem today is that most car companies design to the test, and no further," he says. Friedman believes that regimented, overly predictable testing leads to engineering that simply checks boxes, rather than a more holistic approach to safety design. "That's why the next generation of crash tests needs to include more representative dummies and some randomness, putting different dummies in different seats across the tests. Then automakers would finally have to protect everyone equally."



Sources: Humanetics and CDC NHANES

Currently, there is no physical crash test dummy that represents an average adult female anywhere in the world. That doesn't appear to be changing anytime soon.

When asked why, a NHTSA spokesperson provided a written statement to CR, saying that the agency already addresses inequality in crash outcomes by requiring the use of a 5th percentile female dummy.

The agency's use of 5th percentile female and 50th percentile male dummies represents "a broad spectrum of occupant crash protection rather than merely focusing on median body types," its statement said. "Currently, NHTSA is focusing its research in new advancements in both sizes of crash test dummies, including the use of advanced instrumentation and criteria designed to better mitigate respective injury risks."

The Auto Alliance, a trade group that represents many large automakers in the U.S., told CR that the group does not believe that a 50th percentile female dummy would be useful, especially because the average American female of 2019 is actually closer in height and weight to the current 50th percentile male dummy.

"So far we've not seen any data or analysis that suggests that the addition of a new [dummy] this close in weight to the existing one used in regulations, would significantly change any real-world restraint system designs," Wade Newton, a spokesman for the group, wrote in an email.

A BRIEF HISTORY OF DUMMIES

The first crash tests were performed on men—not dummies, but actual, living men. In the 1960s and early '70s in Detroit, Wayne State University professor Lawrence Patrick was subjecting himself to crashes at speeds as high as 45 mph. Patrick and his students also studied the effects of vehicle car crashes on cadavers and animals.

That research led directly to the development of some of the first crash test dummies. One of Patrick's students, Harold Mertz, led the team at General Motors that created the first version of the average male automotive crash test dummy we still use today, which originally debuted in 1976. The modern version, called the Hybrid III, is used in crash tests currently conducted by NHTSA and the IIHS.

Two years after that first dummy debuted, NHTSA started its New Car Assessment Program (NCAP) during the Carter administration. Although similar programs now exist worldwide, the program was revolutionary when it first began. It was the first time a government agency had ever crash-tested cars, rated them for safety, and released those ratings to the public. According to Joan Claybrook, who was NHTSA's administrator at the time, the agency started with male crash test dummies because the agency had limited funds and because men were the ones dying in crashes. "It was just that men were in the workplace, and they were more likely to be in car crashes," she says.

At the time, the agency took an expansive approach to regulation. Under Claybrook, who had worked previously with consumer advocate Ralph Nader, NHTSA proposed a number of safety rules, including mandatory airbags and tire pressure monitoring sensors. (From 1982 to 2006, Claybrook also served on the board of Consumers Union, as CR's publisher was then known.)

Lawrence Patrick, Human Crash Test Dummy

A professor at Wayne State University, Patrick subjected his own body to crash tests

Source: Walter P. Reuther Library, Wayne State University.

In 1980, NHTSA tried to expand its selection of crash test dummies to better represent the driving public. A team of researchers at the University of Michigan recommended augmenting and updating the existing male dummy, while also creating a "family" with three additional dummies—a small female, a large male, and an average female.

In 1981, however, the Reagan administration took over, and brought with it a very different attitude toward regulation. Many existing rules were scrapped, deadlines were delayed, and proposals were shelved. NHTSA's budget was cut from $259 million in 1979 to $211 million in 1987.

One of the casualties was the average female crash test dummy. Although the agency accepted the University of Michigan team's proposal in 1983, NHTSA later dropped the female dummy because of funding constraints. The other three dummies were built, but only the small female—the 5th percentile female used in side-impact tests and as passengers in front-impact tests—ended up part of NHTSA's crash test program, and even that addition took decades.

Claybrook blames shifting attitudes toward regulation and the role of government for the stalling of many automotive safety efforts, including the development of new crash test dummies, in the early 1980s.

"The male dummy was the first one developed, and nothing happened in the 10 years after I left," she says. "I think it had to do, in part, with an anti-regulatory bias, if you would, and not wanting to undertake anything that involves issuing more rules."

AN AVERAGE MAN IS NOT AN AVERAGE HUMAN

According to the writer and feminist activist Caroline Criado-Perez, the lack of an average female crash test dummy is one of many examples of design that uses the average male as the stand-in for all humans.

In her book, "Invisible Women: Data Bias in a World Designed for Men," Criado-Perez offers numerous examples: Doctors refer to female heart attack symptoms as "atypical." Workplace safety equipment is designed for the average male and might not properly fit a female. Offices are usually kept at temperatures that are comfortable for the metabolic resting rate of the average male but too cold for the average female.

The reason, Criado-Perez told CR, is that "we are so used to thinking of the average male as the average human. As soon as you say it like that—well, obviously, the average male is not the average human—you realize how ridiculous it is to suggest that it's inevitable that half of humanity would be left out."

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> Center for Injury Research and Prevention
> Children's Hospital of Philadelphia

Today, researchers sometimes refer to females as "outliers," and their crash injuries are spoken of as "unintended consequences"—which Criado-Perez says is "clearly nonsense from a statistical perspective," considering that women make up about half of the population, and half of drivers. (Although several states currently issue licenses with a nonbinary gender option, federal data classifies drivers only as male or female.)

Almost all the researchers that CR spoke with went out of their way to say they didn't view the lack of an average female crash dummy as evidence of intentional bias. But the difficulty is recognizing and acknowledging that bias, Criado-Perez says.

"This isn't about bad people," she says. "We're all sort of conditioned to think this way."

NEW GENERATION, SAME PROBLEM

NHTSA and the IIHS are both evaluating a new set of dummies, called THOR (for Test device for Human Occupant Restraint). They have been in development since the 1980s and may be used in European crash tests as soon as 2020. They'll be able to collect more data than the Hybrid III, and the 5th percentile female version of the THOR dummy has been designed to better mimic an actual human female body.

However, there are currently no plans for an average female THOR. Even if regulators demanded one today, researchers would first need to collect real-world injury data from female occupants to identify patterns first—which injuries happen most often? Which are the most severe? Then they would have to recreate those specific patterns and mechanisms in the laboratory with animals or human cadavers.

Hybrid III Dummy. Every part of a crash test dummy is designed to show how a real human body handles a crash.

Whether it's the THOR of tomorrow or the Hybrid III of today, all dummies are remarkably complex—which explains why it would be impossible to build a one-size-fits-all dummy, or a dummy that can be changed to represent all humanity. Far from a plastic mannequin or life-size doll, every part of every dummy is designed to be representative of that same part of an actual human body.

"Dummies can take 20 years or more to develop," says Becky Mueller, a senior research engineer at the IIHS. "Building the dummy doesn't necessarily take that long, but to be able to relate what the dummy is measuring back to real-world injuries takes years and years of real world data collection."

Astrid Linder, Ph.D., a professor at Chalmers University in Sweden and the research director of traffic safety at the Swedish National Road and Transport Institute, agrees that the length of time it could take to build a new female dummy is frustrating, but she says that is not an excuse for delaying the work further.

"This was the answer I got 20 years ago when I did a review as a Ph.D. student," she says. "There is no data that isn't possible to collect. Go ahead and do it. We know how to do it."

Linder has been leading efforts in Europe to address differences in crash outcomes between male and female vehicle occupants. She says that we need to start work on an average female dummy to determine what information we don't know. "If you wait for all data to be available, then we will wait forever," she said.

Astrid Linder, Ph.D., Professor and Safety Researcher

Helped create a virtual model of a female crash test dummy

Source: Hejdlösa Bilder AB/VTI

One way that automakers and safety advocates are addressing inequality in the short term is by developing computer models that can simulate how human bodies of different shapes, sizes, or sexes react in a crash. This approach is already in use by some automakers, including Toyota and

Volvo. Volvo developed a computer model of a midsized pregnant female in the early 2000s, and worked with Chalmers University to create a computer model of an average-sized female to develop its whiplash protection system—the very same one that protects males and females equally.

"If you want to run a crash test, you have to build a car first, then you have to spend the time to instrument it, and of course you put the dummy in and run the test," said Jason Hallman, Ph.D., a principal engineer in Toyota's research and development department. "If you want to, say, shift the posture or put in a different-sized dummy, you have to do the process over again." By comparison, Hallman says that running a test with a computer model of a human body can take about a week, although the underlying research behind that model often took years of work.

Linder says she expects computer models to become more prevalent, but she emphasizes that a virtual human is no substitute for an actual dummy. "As long as we humans are the ones using the cars, then we need to confirm in physical testing that this is actually representing the physical world." Therefore, those physical tests must also include female dummies. "If you exclude half of [occupants], you can only confirm for half of them what you have done in the computer world what corresponds in the physical world," she says.

THE AIRBAG LESSON

Collecting the data and re-engineering America's crash tests to better represent female occupants could take decades, but with the right motivation, there's a chance that change could be accelerated. That's what happened in the late 1990s, when safety regulators and researchers took just two years to fix an airbag issue that was killing children and smaller women.

Between 1996 and 2000, 179 people—including 118 children—were killed by airbags in low-speed crashes that shouldn't have been fatal. Physicians, automakers, and safety advocates realized they had a problem, and they suspected it had to do with airbags designed to be powerful enough to keep a 50th percentile male in his seat in a crash even if he wasn't wearing a seatbelt, per federal safety regulations.

"I think that really highlighted how far behind we were and how inadequate the testing had been for them to just assume that a 50th percentile male would be sitting there," Jackie Gillan says. Today, she's the president emeritus of Advocates for Highway and Auto Safety, a group that lobbies for safer roads and better safety regulations. But in 1996, Gillan was the vice president of the organization, and she worked with automakers, legislators, regulators, and the families of those killed in crashes to help create safer airbags.

In November 1996, NHTSA announced that it would make changes to airbag rules in response to the deaths. Four months later, the agency relaxed testing requirements to allow automakers to rapidly redesign their airbags using a crash sled—which simulates a car crash—instead of costly, time-consuming crash tests of actual vehicles.

Nearly half of automakers reduced the power of their airbags between the 1997 and 1998 model years. By September of 1998, NHTSA required automakers to install advanced airbags, which would deploy with a force proportional to the weight of the vehicle occupant. The strategy worked: Starting in 1998, fatalities due to airbags began decreasing appreciably.

Although fixing an airbag is no easy task, it's not nearly as complex and nuanced as addressing the multiple factors that make females less safe in crashes. But according to Ohio State's Mandy Agnew, many of the mechanisms behind different injury outcomes between males and females remain unexplored, as are injury risks for other vulnerable groups, such as the elderly and larger drivers and passengers.

"We have to do the basic science; we have to go back to the fundamentals," she says. "At the same time, we can't wait for all of the answers to do anything. I think we need to do both in parallel."

According to Gillan, part of the reason for the swift action on airbags was a clear, perceptible harm.

"When all of a sudden you saw these people being injured by a safety technology that was supposed to save their lives, I think there was just so much public outcry," she says. "You have all the elements coming together where you had a problem of children being injured, public opinion, congressional interest, and a legal system that was not going to let this continue. You had all the elements for action."

By comparison, even though more than 10 thousand women were killed and over 1.4 million women were injured in car crashes in 2017, Gillan says that the issue of higher injury and fatality risks for women is difficult to publicize. That may explain why studies like Forman's grab headlines every few years before fading away.

THE CASE FOR CHANGE

Already, the auto industry itself has made some moves to protect female vehicle occupants. In 1996, it was a group of U.S.-based automakers who petitioned NHTSA to add a 5th percentile female dummy to crash tests because real-world crash data shows that females are more likely to suffer head injuries in side impacts. Currently, a 5th percentile female is allowed to "drive" for one of

NHTSA's side-impact tests, and the IIHS puts small female dummies in the driver and rear seats for side-impact tests.

Some automakers have gone even further to address inequality. Many of the computer models that researchers use for virtual crash tests are only possible thanks to software partially developed by Toyota and shared with universities and other automakers.

"We try to make these results public and try to compare them to our current crash test dummies," says Toyota's Hallman.

Volvo has worked with Chalmers University and other organizations in Europe to further develop computer models that can represent a wider variety of vehicle occupants, including average females.

While these advances are welcome, CR's Friedman says that targeted improvements are no substitute for testing programs that standardize safety expectations for everyone in the car. "It's great to see some automakers taking this seriously, and many more should step up," he says. "But better testing has—and will—drive big changes on occupant protection across the industry."

Gillan believes that NHTSA isn't proactive enough to force further action on inequality, and getting a safety regulation changed or a rule enacted often requires a literal Act of Congress. "If you look back at all the major safety advances, whether it's been airbags, ejection prevention, rollover prevention, tire pressure monitoring—more recently rearview cameras—those have all required us going to Congress to force the agency to act," Gillan says.

If regulators do decide to make a change, Chalmers University's Astrid Linder estimates that we could have an average female crash test dummy included in official crash tests by 2030, assuming it would take between two and three years to formulate a new regulation and about five years to change test protocol. "And the industry will take action and society will take action," she says. "But the starting point is those decisions made by regulatory bodies."

Getting to that starting point could be difficult, especially for a complex and costly issue that isn't tailor-made to grab headlines.

But, as activist Caroline Criado-Perez says, policymakers have an imperative to fix a problem that has the potential to disproportionately kill or cause injury to half the population. "This is a case of justice and this is a case of saving lives, and there's just no acceptable argument against addressing this."