Perspective

Managing the risks of injury for operators of all-terrain vehicles (ATVs) and evaluation of the potential role of rollover protection systems (ROPS) and crush protection devices (CPDs): Creating the right incentives to improve outcomes

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Introduction

Humans currently rely heavily on motor vehicles for occupational and recreational transportation, and even societies that traditionally relied on animals now increasingly use motor vehicles. While transportation of any kind involves risks, the familiarity of operating a motor vehicle implies that most people recognize that every use of a motor vehicle involves accepting some risk of potential injury. Individuals choose to take risks depending on the benefits that they derive in exchange for accepting the risks.[1,2] Most of the time these trade-offs occur without much thought, because although over 30,000 of the approximately 300,000,000 Americans die in motor vehicle crashes each year,[3] the simple average annual risk for any individual American of approximately 1 in 10,000 seems very low. In addition, most people perceive themselves as safer and better than the average motor vehicle operator, and thus they perceive their risks as much lower than average.[4-6] Clearly this type of optimistic bias represents an issue for risk management, because if individuals do not perceive themselves as being at risk, then they perceive little to no value from prevention efforts (e.g., safety belts, defensive driving).[5]

While the risks associated with motor vehicles differ depending on the type of vehicle, manufacturers and regulators constantly seek to identify opportunities to improve safety. In the United States, Executive Order 13563 directs federal regulatory agencies "to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible" when they consider regulatory actions.[7] For any "economically significant" regulatory actions (e.g., those with an expected annual effect of $100 million or more), federal agencies submit their regulatory impact assessments to the Office of Management and Budget (OMB) for review.[8] The OMB seeks to determine whether the regulatory analysis meets the goals: "(1) to establish whether federal regulation is necessary and justified to achieve a social goal and (2) to clarify how to design regulations in the most efficient, least burdensome, and most cost-effective manner".[8, page 2]

Unfortunately, manufacturers and regulators do not control the risks of motor vehicles alone, and engineering solutions cannot prevent all bad outcomes. Factors beyond control (e.g., weather conditions) impact risks. The behavior of motor vehicle users also matters, and properly assessing the risks and benefits of motor vehicle technologies requires careful evaluation of how actual operator behaviors interface with the engineering systems. For example, the behavioral problem that on-highway motor vehicle occupants did not choose to voluntarily use safety belts led to the regulatory requirement of air bags (i.e., an engineering solution) that would provide passive protection in the case of certain types of crashes.[9-10] However, air bags did not perform as well as many people expected, in part because vehicle occupants come in various sizes and do not behave in the same manner as crash dummies, which come in standard sizes and

remain stationary once placed in the vehicle.[9-10] Tragically, soon after their widespread introduction into the vehicle fleet, the deadly interaction between air bags and children in the front seat of motor vehicles also became apparent, and this led to the need for a new behavioral solution of requiring children to sit in the rear seat in addition to redesigns of the technology.[10-11] Experience with air bags also demonstrates that safety technologies can create risks that did not exist before (e.g., new categories of upper extremity injuries associated with airbags directing limbs toward the frame of the car, children killed while in safety seats, injuries from the impact of the air bag for occupants positioned within the deployment zone that occur even in low-impact crashes).[9,10]

The use of motor vehicles represents a voluntary activity, and consequently we can assume that individuals willingly accept motor vehicle risks in order to derive benefits. However, some people clearly expect the government to step in to protect Americans from themselves. Most recently, the Cameron Gulbransen Kids Transportation Safety Act of 2007 required revision of the "Rearview Mirror" standards and led the National Highway Traffic Safety Administration (NHTSA) to propose a rule on Rearview Mirrors to reduce the risk of backovers.[12] The NHTSA estimated approximately 292 fatalities and 18,000 injuries (including 3,000 incapacitating injuries) occur on average from backover incidents (i.e., vehicles unintentionally backed up into people by drivers who did not look prior to backing up) annually, with children under five years old representing approximately 44 percent of the fatalities.[12] The proposed rule tentatively concluded that manufacturers need to provide drivers with additional visual information about objects directly behind the vehicle and that this represented the only effective near-term solution to reduce the number of fatalities and injuries associated with backover collisions.[12] This proposed engineering solution to the behavioral problem of drivers not looking before they back up still requires drivers to pay attention (i.e., it will only help by providing additional visual information). The Regulatory Impact Analysis for the rule states: "We have noted that well over 40 percent of the victims of backover crashes are very young children (under the age of five), with nearly their entire life ahead of them… In addition, this regulation will, in many cases, reduce a qualitatively distinct risk, which is that of directly causing the death or injury of one's own child."[12, page 76238] This "distinct risk" apparently justifies proposing a requirement for manufacturers to install camera systems (for which they will pass on the cost to all consumers, including the vast majority of drivers who do look before they back up) at a projected cost of approximately $1.9 billion annually, in order to receive expected benefits of approximately $0.6 billion annually (i.e., a significant expected loss in net benefits).[12, page 76237] In addition, even with the new technology, driver behavior will still significantly impact the risks.

For most people, motor vehicle risks represent a part of life, and managing the risks effectively requires that all stakeholders do their part to make the best choices. Unfortunately, the legal system creates incentives for different stakeholders to blame other stakeholders when bad outcomes occur, despite the reality that bad outcomes sometimes occur due to bad luck.

All-Terrain Vehicles (ATVs)

Bad outcomes also occur in the context of using consumer products, including All-Terrain Vehicles (ATVs). Although the NHTSA does not regulate ATVs due to their primary use as off-

road vehicles, the Consumer Product Safety Commission (CPSC) regulates ATVs and it continues to collect and publicize injury statistics for ATVs and to support educational initiatives related to ATVs.[13] In the U.S., only new ATVs with 4 wheels meet regulatory requirements (i.e., manufacturers voluntarily agreed to stop the sale of 3-wheeled ATVs in the U.S. in 1988 [14]). National statistics suggest that ATV use causes several hundred fatalities to occur annually in the U.S. (approximately 400 in 2009), and children under the ages of 12 and 16 years old account for approximately 10% and 25%, respectively, of the total deaths annually based on 2009 data.[13]

All risks associated with ATVs represent preventable risks only if people choose not to use ATVs. However, we must assume that individuals who choose to ride ATVs do so because they derive benefits that exceed at least the perceived costs. We should note that if they did not choose to use ATVs, then they may substitute some other also potentially risky option (e.g., using an ATV on a farm may substitute for riding a horse, which would imply non-zero risks and costs). No matter what choice individuals make, they need to manage their risks, and for those choosing to use ATVs, the CPSC suggests: "Like other activities involving high speeds and heavy machinery, riding an ATV can be risky. To help stay safe, follow common sense safety tips. Take knowledge to the extreme and learn more about these important tips for safer riding: Get trained, Wear a helmet, No children on adult ATVs, Don't ride tandem, Don't ride on pavement, Don't ride under the influence."[13]

Although ATVs come with risks, manufacturers invest significant effort in ATV designs to do their part to improve safety. The selection of all materials and all aspects of the engineering design impacts the experiences of ATV users. Consequently, manufacturers seek to meet consumer demand for various features (e.g., ability to operate at high speed) while also making safe and reliable products that provide stability and comfort for expected uses. One challenge for ATV design arises from their potential use in a wide range of environmental and geographical conditions for diverse activities. This means that manufacturers must design for extremes of temperature (freezing snow, watery swamps, and desert heat), terrain conditions (hard, rocky and soft, muddy), humidity, and physical stress or impact. Thus, in the context of evaluating potential safety technologies, manufacturers must carefully test a wide range of potential conditions, while also accounting for the reality that users may vary in size from very large adults to small children, depending on the model. Based on their testing and prior experience with their products, as well as standardized warning labels (e.g., ANSI/SVIA 1-2010 standard labels), manufacturers provide warnings about improper use, but the responsibility for using ATVs responsibly and taking preventative measures (e.g., wearing a helmet and other protective gear) resides with the user.

Evaluation of Potential New Safety Devices for ATVs

ATV manufacturers continuously explore a wide range of risk management strategies, including:

- Elimination of some risks (e.g., offering vehicles that comply with existing safety standards)
- Substitution or replacement of ATVs with alternative vehicles (e.g., side-by-side vehicles)

- Engineering controls (e.g., approximately 30 safety-related equipment and performance provisions in the ANSI/SVIA Standard, plus various active and passive safety design features)
- Administrative controls (e.g., Training recommendations and warnings, model state legislation for mandatory safety measures like helmet laws, no children on adult ATV laws, no operation on public roads laws, public information and education)

Manufacturers maintain responsibility for designing equipment that performs according to mandatory and voluntary standards, for communicating proper use, and for warning users about the risks. They constantly evaluate design options that might improve safety using risk assessment, which quantitatively characterizes the probabilities of different types of injuries associated with different types of crashes and evaluates the impact of the new technologies on the injuries potentially prevented AND caused. Essentially all technologies come with trade-offs, and the risk assessments must characterize these in such a way that both the good and bad outcomes become clear.[15] Some technologies appear to prevent significantly more injuries and provide more benefits than the injuries they cause and other costs they impose. For example, while operators may experience some risks associated with heat stress or perhaps perceived less visibility or hearing capacity while wearing a helmet, the benefits of the helmet with respect to providing protection from head trauma in the event of a crash far outweigh the risks and costs. In on-highway motor vehicles, the use of safety belts that keep occupants contained within the vehicle in the event of a crash or rollover provide significant injury prevention benefits, but their live-saving benefits come with some costs of discomfort and they can in some cases cause injuries to the body when crashes lead to high forces at the interface between the human body and the safety belt.

For ATVs, rollovers can represent an important mechanism with respect to injuries.[16] Not surprisingly, engineers continue to explore numerous potential ATV Rollover Protection Systems (ROPS) and Crush Protection Devices (CPDs). The challenge to designing effective ROPS and CPDs arises from the reality that adding structures to the top of the vehicle can increase the probability of a rollover event by increasing the height of the center of gravity. In addition, for motor vehicles that contain occupants inside a closed frame (note that even convertibles provide a partially closed frame) the benefits of restraints that keep occupants inside the vehicle are well documented. However, for open, straddle-seat, handlebar vehicles, the benefits of adding a restraint system remain unclear. To date, no single design for ROPS or CPDs for ATVs exists that does not pose substantial risks of causing new injuries, and studies demonstrate that poorly designed systems can cause more harm than good.[16]

Despite the lack of evidence of effective designs, demands for manufacturers to install ROPS and CPDs continue to occur. Unfortunately, the demands focus on the promise of benefits of the devices, without considering the risks or costs. While it may seem reasonable to suggest that a theoretical system would have prevented a horrible tragedy, manufacturers must consider the overall impacts of systems that they design. First, in the context of their risk assessments, manufacturers must assess both the engineering and the behavioral aspects of the system, and they must estimate both the positive and negative impacts of changes that they make (i.e., injuries prevented AND caused). Manufacturers must particularly consider the nature and impact of any injuries that the proposed changes create. Second, they need to weigh the trade-

offs associated with the injuries with full consideration of the nature, severity, and numbers of injuries. Risk assessments help in this process because they provide information about both the net impacts, including the total numbers of injuries prevented on net (i.e., the numbers of injuries prevented minus the number of injuries caused, or the net injury benefit), the total costs saved (i.e., the economic values of the costs saved due to the net injuries prevented minus the costs paid to install the technology, or the net economic benefit), and the number of injuries caused divided by the number of injuries prevented (or the risk-benefit ratio, sometimes expressed as a percentage).[15] All of these metrics provide critical information, and decision makers should consider all of them. One of the largest challenges associated with quantifying these metrics arises from the need to explicitly value the relative importance of injuries of different levels of severity. For example, how many serious non-fatal head injuries are equivalent to one death? Typically analysts account for both mortality and morbidity in their metrics, but this requires judgment and implies value trade-offs. However, the alternative to consideration of both mortality and morbidity in these metrics is to ignore one, which provides an incomplete assessment of the impacts.

Stakeholders and Incentives

All stakeholders want safe ATVs, but they face different incentives and constraints. Manufacturers face clear incentives in the market to provide the best products that they can, and they collectively share interests in improving safety. Regulators play a role with respect to developing safety standards, and they face incentives to demonstrate the effectiveness of their actions, although they do not incur any liability associated with their actions. Regulators must also deal with competing demands from manufacturers, consumers, physicians, and other stakeholders. Some consumers and trial lawyers face incentives to make manufacturers responsible for all injuries, regardless of actual causation, and this can create major issues for manufacturers. Unfortunately, the mismatch of incentives leads to mistrust, and mistrust creates a climate in which misinformation can easily spread. Given this, manufacturers may want to explore opportunities to communicate more openly about how they design for safety and how they make decisions, because they cannot assume that other stakeholders will be aware of the risk assessment processes and requirements for evidence that they use.

From a societal perspective, we face difficult questions about how much to protect people from themselves and whom to protect. Consider for example, a device that can save 10 lives. If the device will save those lives while taking no lives (with all else being equal), then it would represent an easy solution. However, what if the device saves 10 lives but causes 1 death or 5 deaths or 10 deaths or 20 deaths? Most rational people will instantly reject a device that implies accepting 20 deaths to save 10 lives, and trading 10 lives for 10 lives results in a net gain of zero, so this would also not look like a good option. However, from an expected value perspective, losing 5 lives to save 10 might seem like a good option, but what if the trade-off is 10 adult lives saved and 5 lives of children lost. Thus, while safety advocates may focus on the net 5 lives saved by a device that saves 10 lives while causing 5 deaths, the types of lives saved might also matter. For example, how many children did air bags put at risk to save large unbelted adult men? Should we value the lives of people who put themselves at risk differently from the lives of innocent bystanders? None of these choices are easy, and making real progress on safety will require open discussions about these types of trade-offs.

Prior experience demonstrates the importance of considering the incentives of various stakeholders and ensuring their alignment to achieve overall improvement in the system. For example, vaccines provide enormous benefits, but the lawsuits associated with the rare adverse effects associated with vaccines are sufficiently damaging to keep manufacturers out of the market, and this led the U.S. government to create the National Vaccine Injury Compensation Program.[17] No comparable mechanism exists for vehicle occupant safety. In the context of ATVs, it appears that stakeholders need to appreciate the different incentives that they may face and seek a strategy that will improve ATV safety overall. Determining the acceptable level of injuries caused by the devices will most likely depend on both the absolute number of injuries caused (for which manufacturers might get sued and face large reputational risks) and the relative number caused when compared with the numbers of injuries prevented. Manufacturers should find it in their interest to lead the efforts to improve safety, since better and safer products will most likely perform better in the market. Manufacturers may also find it worthwhile to consider segmentation of the market to address specific needs. For example, if farmers use ATVs in ways that increase their relative risks of rollovers (e.g., by adding weight to the ATV to carry equipment), then manufacturers may find it useful to consider introducing new products specifically for farm use. Prior to developing new segments of ATVs, manufacturers will need to conduct appropriate market research to ensure sufficient demand for specialized designs, but greater segmentation may help to alleviate issues that arise with respect to large market segments that face particular types of risks.

Conclusion

While opportunities may exist to improve ATV safety, many challenges also exist. All stakeholders will need to engage in a process that will develop a cooperative strategy to achieve the shared goal of cost-effectively reducing bad outcomes on net, and currently, appropriate consideration of the incentives faced by the various stakeholders represents an important hurdle to overcome. Demands from consumers, researchers, and safety advocates for manufacturers to install ROPS and CPDs may not appropriately consider the trade-offs implied by the devices and they tend to ignore the shift in the liability introduced by creating an expectation that the manufacturer and device are responsible for preventing every bad outcome. Manufacturers should do their part to improve safety and promote good outcomes, but they also need to communicate effectively about the risks imposed by new devices.

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