

Review

A Review on All Terrain Vehicle Safety

Vanessa J. Fawcett ¹, Bonnie Tsang ¹, Amir Taheri ¹, Kathy Belton ² and Sandy L. Widder ^{1,*}

¹ Department of Surgery, University of Alberta, Edmonton, AB T6G 2B7, Canada; fawcett@ualberta.ca (V.J.F.); btsang@ualberta.ca (B.T.); Ataheri1@ualberta.ca (A.T.)

² Alberta Centre for Injury Control & Research, University of Alberta, Edmonton, AB T6G 2B7, Canada; Kathy.belton@ualberta.ca

* Correspondence: sandy.widder2@albertahealthservices.ca; Tel.: +1-780-407-2005; Fax: +1-780-407-2144

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Abstract: All-terrain vehicles (ATVs) have become increasingly popular in many countries around the world, both for occupational use, as well as recreational use. With an increase in popularity, and the supply of heavier and more powerful machines on the market, major traumas and deaths from ATV use are growing concerns for public health and injury prevention professionals. This review of the literature on ATVs will focus on the mechanism and patterns of ATV-related injuries, the challenges of injury prevention, and the effects of legislation and regulations regarding ATV usage. The increasing burden of injuries and the substantial economic cost from ATV-related traumas and deaths calls for intensification of injury prevention efforts. Modification of risk factors, institution of regulations and legislation, and enforcement of those rules are important steps for prevention of ATV-related harm.

Keywords: injury prevention; trauma; legislation; review

1. Background

Modern all-terrain vehicles (ATVs), also known as quad bikes, became available commercially in the early 1970s, when the Honda Motor Corporation introduced the ATC90 [1]. This three-wheeled motorized vehicle was intended for recreational use, but quickly gained popularity in agricultural and industrial settings as well; however, the three-wheel configuration proved to be unstable, and these early ATVs were deemed responsible for an estimated 105,000 injuries in the United States alone within the first 10 years of manufacturing [2]. Subsequent to a resulting lawsuit between the United States Consumer Product Safety Commission (U.S. CPSC) and ATV manufacturers, a 10-year consent decree was established in 1988 [3,4]. This ruling set specific regulations that the manufacturers of ATVs were required to follow, including the cessation of production and sale of three-wheeled ATVs. Manufacturers were also expected to offer safety/training courses, and were required to recommend engine size restrictions, the use of helmets, adult supervision for youth, and a restriction on carrying passengers [4]. In 1998, the consent decree expired, and although an agreement was reached to continue similar prevention strategies, this agreement was again voluntary and enforced only by the ATV industry [5,6].

Since the expiration of the consent decree, and particularly with the increasing popularity of ATVs as recreational and agricultural vehicles, there have been numerous studies documenting an associated increased number of injuries and deaths [4,7–10]. A study from a Level 1 trauma center in the United States (U.S.) compared the number of admissions due to ATV injuries both during the consent decree, and afterwards. They found that from 1988 to 1998, there were an average of 6.9 admissions per year, whereas from 1998 to 2004 there were 31.6 admissions per year [7]. Another U.S. study examined data from a large administrative database, including over 1000 hospitals in 37 states, and calculated ATV-associated admissions rates per 100,000 ATVs in use. These authors found that admissions

increased from 196 per 100,000 ATVs in use in 2000 to 227 per 100,000 ATVs in use in 2004, thus demonstrating that increased popularity of ATVs did not fully explain the higher number of injuries that are being seen [11].

This increase in injury has not been limited to the U.S., as demonstrated by a more recent study from Australia that found hospital admissions for ATV-related trauma increased by 41% from 2002 to 2011 [12]. Similarly, a study from Canada that included not only hospital admissions, but also emergency department visits and deaths, found that between 1998 and 2008 the incidence of severe injury from ATVs steadily increased, particularly in males. The increase in mortality that was demonstrated in this study was found to be out of proportion to the increased number of registered ATVs, again indicating that higher numbers of injuries were not just secondary to the rise in popularity of the vehicles [13].

Over the years, ATVs have become heavier and faster. Dry weights range from 200 pounds to 1000 pounds, and speeds in excess of 75 miles per hour can be achieved depending on the model [8]. Marketing of these vehicles is directed toward a younger audience, often focusing on the adage that bigger and faster is better. Meanwhile, education and training in their proper use is not mandated and inconsistently practiced. Additionally, the settings in which ATVs are most popular are not consistent across the world. A Canadian study found that up to two-thirds of ATVs are used exclusively for recreational purposes [14], and similarly an anonymous mail study amongst rural youth in the central United States revealed that most of those surveyed used ATVs for recreation and joyriding [15]. On the other hand, in Australia and New Zealand the majority of ATVs are used occupationally, particularly in agriculture [12,16,17]. Such diverse target populations can hamper efforts at injury prevention that focus on engagement of the public.

2. Crash and Injury Characteristics

Multiple studies have described the characteristics of those involved in ATV crashes. The majority of those injured and killed while riding ATVs are male [11,14,18,19]. The age group that has the highest ATV usage is those between the ages of 16 and 40. This contributes to the observation that these older youth and young adults are most frequently harmed while riding ATVs [9,11,12]; however, there is variation in the age of the injured, depending on the characteristics of the population that is being studied. For example, a study of ATV-associated fatalities in Australia found that the median age of those who died during recreational use was 24 years, while the median age of those who died during occupational use was 59 [18].

Similar to other mechanisms of trauma, those at the extremes of age are at an increased relative risk of harm when involved in an ATV collision. This is demonstrated by a study of ATV fatalities using data from the New Zealand Department of Labour. Although deaths most frequently occurred in those aged 41–65, the patients who had the highest relative risk of death were those aged 11–15 and 66–80 [17]. The older group was likely at increased risk due to frailty and underlying medical conditions, whereas for the younger group inexperience is likely a contributing factor. Children may also lack the physical and cognitive maturity to handle such large and powerful vehicles, particularly on uneven terrain or when riding conditions change [20–25]. In a further demonstration of the increased risk that youth face when riding ATVs, other studies have shown that children less than 16 years of age have a 4.5–12 times increased risk of death from ATV use, compared to adults [26,27].

Although some studies have attempted to delineate the actual mechanisms by which ATV-related injuries occur, the variability of the studies makes it difficult to draw detailed conclusions. Crash mechanisms are inconsistently defined, for example ‘collisions’ may or may not include impact with stationary objects, other vehicles, or people [12,14,18]. Other barriers to understanding how crash mechanisms contribute to injury include the variety of sources of crash information (police reports *versus* trauma registries), as well as the knowledge that a documented mechanism may not be responsible for the rider’s injury. For example, a rider may jump off a vehicle before it rolls over, in which case the rollover does not necessarily contribute to his/her injuries.

The Transport and Road Safety (TARS) Research Centre at the University of New South Wales performed an in-depth crash analysis of 109 Australian ATV fatalities. This group found that the most frequent crash ‘initiators’ were “loss of control caused by object” (*i.e.*, running over a branch) and “loss of control due to slope”. Slope was particularly a factor for deaths that occurred during agricultural use of ATVs. Once a crash was initiated, this analysis found that a rollover occurred in 70% of the cases, most frequently a lateral roll. There was a strong association between driving on a slope and experiencing a rollover, particularly during farm work, demonstrating that ATVs are not as stable on an incline as they may be believed to be [28].

Vehicle impact also frequently causes ATV trauma [12,14]. Impact with a stationary object generally seems to be more common than impact with another moving vehicle [12,14], at least in locations where ATVs are infrequently used on public roadways. However, in some sites ATV use on roadways is frequent, even where prohibited by law, and this impacts the type of crash mechanisms that occur. A study of ATV fatalities from the Eastern United States found that those crashes that occurred on a highway more frequently involved a collision than a rollover, while crashes that occurred off a highway more frequently involved a rollover than a collision [29].

Although our understanding of the mechanics of ATV crashes is evolving, there are multiple studies that have documented the patterns of injuries that result. Different injury patterns are found between fatalities and survivors. Patients who are admitted to hospital most frequently sustain fractures, particularly of the lower limb [9,11,12], head injuries [9,11], as well as soft tissue injuries [9,12].

On the other hand, patients who die following ATV crashes tend to have injuries to their heads and their chests [14,17,18]. Although traumatic brain injury remains a frequent contributor to ATV fatalities, traumatic asphyxiation appears to be occurring more regularly. A Canadian study that described causes of death for ATV fatalities between 1996 and 2005 attributed 6.8% of cases to traumatic asphyxia [14], whereas an Australian study examining fatalities between 2000 and 2013 described 26.4% of deaths being caused by asphyxia [18]. Denning and colleagues studied ATV fatality data from the U.S. CPSC and found that although traumatic asphyxia was not a common cause of death, its occurrence increased more than three-fold from the period 1985–1989 to the period 2005–2009. These authors demonstrated a simultaneous increase in the proportion of ATVs with larger engines (and likely higher weights), leading them to hypothesize that these larger, more powerful vehicles are more likely to lead to death by traumatic asphyxiation than their predecessors [30].

While these design changes may be responsible for the different injury patterns seen in ATV fatalities over time, it could also relate to the study population. For example, the Australian study that reported a relatively high frequency of death from asphyxia found that agricultural workers killed while riding ATVs had a higher likelihood of traumatic asphyxia, but a lower likelihood of head injury, when compared to recreational riders. These authors described a pattern of injury for farm workers whereby an ATV rolls over and pins the rider, leading to traumatic asphyxiation (but potentially without a head injury). This is in contrast to the pattern seen in recreational drivers in their study, who frequently sustained severe injuries to the head and chest after being fully ejected from the vehicle (plus or minus impacting an object in the environment) [18].

Similarly, a study of ATV-related fatalities from the U.S. found that those who were killed while riding on highways had a high incidence of head injury, but a low incidence of compression injuries to the thorax and abdomen. In contrast, those riders killed when not on highways frequently sustained compression injuries, whereas they were less likely to suffer fatal head injuries [29]. These studies nicely demonstrate the benefit of analyzing both the crash mechanisms and the resulting patterns of injury, in order to inform potential injury prevention strategies.

One important issue regarding ATV safety that has been particularly well studied in the United States is the increase in injury and death associated with crashes that take place on roadways. Compared to driving off-road, on-road ATV use has been found to be associated with an increased risk of injury [14,17,30]. One study using U.S. CPSC ATV fatality data found that between 1985 and

2009, over 60% of fatalities occurred on roadways. Interestingly, although collisions with other vehicles occurred more commonly with the on-road fatalities, 70% of on-road deaths did not involve a collision with another vehicle, indicating that vehicle density is not the only factor that makes roads unsafe for ATVs [30]. Roads allow drivers to take advantage of the increased power and speed that modern ATVs are capable of, contributing to an increased risk of injury. The desire to harness this increased power may therefore be contributing to greater numbers of ATVs being driven on the road. A particularly troubling finding from the study above was that the rate of increase in roadway deaths was more than double the rate of increase associated with off-road fatalities. The authors speculated that this may be due to the increased number of ATVs being driven on roadways [30].

Roadway driving may be a risk factor for ATV-related harm because the machines are designed specifically for off-road use, and manufacturer guidelines state that these vehicles should not be driven on roads. Certain design features of these vehicles make them unsafe on roadways, such as thick treads and low-pressure tires that are not designed for gripping and releasing road surfaces, as well as a high center of gravity and wide turn radius that contribute to the danger of tipping [31]. Unfortunately research has shown that despite their intended use, in many circumstances the vehicles are still being driven on roadways. For example, a survey of over 4000 youth in the U.S. state of Iowa found that of those who had ridden an ATV, 80% had ridden on a public road [24]. In fact, the number of jurisdictions in the United States allowing ATVs to be used on roads is increasing, demonstrating a lack of understanding of the dangers of roadway ATV use [31].

3. Trauma Prevention

Prevention of ATV injuries requires a multi-faceted approach. Improved ATV design has the potential to prevent some crashes from ever occurring. Education aimed at behavioural change may prevent injuries from occurring, and may mitigate the harm that is done if a crash occurs. In addition, the use of helmets and other protective equipment will improve a person's chance of survival if they are involved in an ATV crash. Tackling ATV trauma will require concerted and consistent effort from lawmakers, public health professionals, healthcare workers, as well as others.

3.1. Vehicle Design

Engineering of ATVs and vehicle design is an important component of injury prevention. Due to inherent vehicle design, ATVs can become unstable causing rollover of the vehicle and potential serious harm to the rider. Several studies have demonstrated the frequency of ATV rollovers when these vehicles crash, up to 70% [17,18,28,32].

Strategies to improve ATV vehicle safety via increasing ATV stability, rollover resistance, and crashworthiness were highlighted by the Quad Bike Performance Project in Australia. Changes to vehicle design by manufacturers were suggested to improve vehicle safety. Potential modifications include an increase in track width, open and lockable rear differentials, and modified suspension to improve dynamic handling and stability [33].

One specific suggestion was the installment of crush protection devices (CPDs) or rollover protection systems [28]. CPDs may offer some protection to the rider in the event of a rollover, but they do not prevent rollover in the first place. In addition, injuries from ejection or pinning by the vehicle or the CPD itself can still occur. Although computer simulations and tests in the lab have shown some benefit to certain types of CPDs, clinical studies of their safety benefit are lacking.

One aspect of ATV vehicle design that may impact safety and that has received recent attention is seat design. Jennissen and colleagues studied the seat design of 67 models of adult-sized ATVs, and demonstrated significant variability with respect to key design features. The authors suggested that standardizing seat design could actually lead to increased safety-related behaviours when using ATVs. For example, ATVs that have long seats may lead riders to perceive that passengers are allowed, even though many ATVs are designed for a single rider. Another example is the distance between the front of the seat and the handlebars. When this distance is short it may facilitate children driving adult-sized

ATVs, which is also against the intended use of these machines [34]. This analysis of one aspect of ATV design demonstrates how standardization of the ATV manufacturing process could improve the uptake of safety-related behaviours.

3.2. Education and Behavioural Change

Inexperience may place ATV riders at higher risk for injury. Although experience can only be gained with time, there is some evidence that formal training in safe driving practices may decrease the risk of ATV-related injury [17]. Therefore some experts advocate for training programs to be mandatory, particularly for new riders. Such programs can focus on educating ATV users to select safe riding conditions, and to identify and avoid high-risk situations.

3.2.1. Does Education Make ATV Riders Safer?

The first issue that arises regarding ATV safety education is to determine what type of program is going to be most effective. A corollary to this is whether a given educational initiative will be effective at not only increasing knowledge, but more importantly increasing safety-related behaviour. Education related to ATV use could take the form of formal courses that are required for ownership, school-based educational sessions, and community-based awareness campaigns, as well as others. One American study used focus groups to explore which educational settings are likely to have the most impact. Suggestions included ATV safety information being part of hunter education classes or regular driver's education. An important point was raised about providing education to the parents of youth who ride ATVs, and not just to the adolescents themselves [35].

The Safety Tips for ATV Riders (STARs) program is a school-based educational initiative that was taught to over 4000 American students between 2010 and 2013. Before and after knowledge assessments demonstrated a significant improvement in the students' knowledge regarding ATV safety [36]. However, another school-based educational program in the rural U.S. demonstrated the disconnect that may exist between knowledge enhancement and behavioural change. Although the youth in this particular study demonstrated a significant increase in knowledge regarding ATV safety, there was not an associated effect on safe riding practices [22]. The authors suggested that in the future the design and implementation of a community-based multi-agency ATV injury prevention intervention should include parents in order to improve its impact, specifically on behavioural risks. Additionally it must be recognized that measuring changes in behaviour may be more complex than measuring changes in knowledge.

3.2.2. Can We Improve Education Uptake?

The second broad issue regarding training and education is how to get ATV users to subscribe to educational efforts, if in fact they are effective. As was previously described, school-based ATV education is a way to target broad adolescent populations, although whether these interventions contribute to behavioural change remains to be seen. Advertisements and public media campaigns have also been used to increase awareness regarding the potential dangers of ATV riding. In terms of legislation, one proposed method would be to make training mandatory for all users of ATVs, although this is infrequent. For instance, in Canada, there are a total of ten provinces and three territories, but only three have mandated ATV rider training [37]. Unfortunately, as will be discussed below, enforcement of such mandates is challenging.

3.2.3. Are There Other Ways to Influence Behaviour?

Many authors have noted the need to promote behavioural change regarding safety not only through education, but also by using theories and frameworks, as well as empirical data, pertaining to changes in health behaviour [4,9,10]. This may involve understanding of both the incentives and barriers to the safety behaviour under consideration.

Risk-taking behaviour must also be considered. Multiple studies demonstrate the high prevalence of risk-taking behaviour among adolescents, especially 13 and 14 years old (compared to those who are younger) [23]. Adolescents in general often report behaviours that are contradictory to ATV safety recommendations, including not wearing a helmet, double or triple riding, riding without adult supervision, riding at night, and riding on paved roadways [24,26,38–40]. Therefore, focusing initiatives on these higher risk groups, or starting injury prevention initiatives at younger ages, could potentially decrease risk-taking behaviours.

As an example of attempting to affect behavioural change with respect to safety, consider initiatives to increase the use of protective equipment. Give-aways may remove financial barriers to the use of safety equipment, and positive reinforcement through incentives may contribute to ongoing use. Logan and colleagues performed an initiative in the U.S. regarding bicycle helmets, in which they combined helmet give-aways with school-based education and small financial incentives for ongoing helmet use. They demonstrated that there was an increase in bicycle helmet use when incentives were provided, but unfortunately a decrease in use once the incentives were withdrawn. This study also showed a disconnect between beliefs of helmet efficacy *versus* helmet use. The belief that a helmet “must be worn” to protect the head during a crash did not predict actual use of these helmets [41].

Barriers to the use of protective equipment are not just related to access. For example, studies have found various reasons cited for not wearing helmets, including peer pressure, appearance, comfort, as well as failure to believe in the benefits of wearing helmets [41,42]. Interestingly, one study questioned people specifically regarding helmet use on ATVs, and found that there was a general belief that ATVs are not dangerous vehicles [42]. This example of the use of protective equipment demonstrates the complexity of changing behaviour. Such analyses can and must be considered when attempting to change any behaviour as it relates to safe usage of ATVs, and changing the behaviour of ATV purchasers and drivers is integral to instituting safe driving practices.

3.3. Helmet Use

The use of helmets has been demonstrated to reduce traumatic brain injury (TBI), mortality, and short and long-term morbidity in ATV trauma patients [6,14,19,38,43,44]. A study from one Canadian province showed that unhelmeted ATV users had a 2.3 times higher likelihood of severe TBI compared to helmeted users, after controlling for other confounding variables (age, sex and blood alcohol level) [19]. The burden of head injury that results from lack of helmet use was further demonstrated by Bowman and colleagues, using nation-wide data from the United States. Unhelmeted ATV trauma patients were more likely to require admission to an intensive care unit, a neurosurgical procedure, and extensive rehabilitation prior to discharge home, compared to their counterparts who were wearing helmets [44].

The actual rate of helmet use by ATV riders varies depending on the population studied, the type of study (survey *vs.* retrospective study of injured users), and the geographic location. A U.S. study using data from the National Trauma Data Bank described helmet use in injured ATV users admitted to hospital between 2000 and 2004. Only 35% of drivers and 19% of passengers were found to be wearing helmets, although information regarding helmet use was missing in a significant proportion of cases [45]. A Canadian study of ATV fatalities similarly found that 37% of ATV riders had been wearing helmets [14]. On the other hand, a survey of registered voters from the U.S. state of Ohio found that amongst ATV users, only 26% always wore a helmet [46]. And one study from Australia that analyzed 106 ATV fatalities found that only 21% were wearing helmets at the time of injury, and amongst the riders who were using ATVs for agricultural purposes, only one out of 53 were wearing a helmet [18].

A voluntary, anonymous and self-reported survey of ATV and motorcycle users regarding their helmet use found that helmet use was lower in younger riders as well as those from a rural location. Interestingly, personal history of ATV or motorcycle injury was associated with lower current usage of

helmets [47]. This persistence of high-risk behaviour despite prior harm is particularly concerning, and remains a major factor in recidivism.

With regards to additional protective equipment (such as boots, gloves, chest protectors), the lack of use by ATV riders may be related to perceptions that the equipment is cumbersome, has limited flexibility, and causes overheating [47]. There have been improvements made in protective equipment to make it lighter and more flexible, while at the same time offering adequate padding to protect riders from life-threatening injuries [19]. Upgrades in the design of the equipment, legislation and enforcement of use, and continuing targeted education in schools, outdoor clubs, and by ATV manufacturers are some strategies for increased usage of helmets and other protective gear when using ATVs.

3.4. Alcohol and Drugs

Limiting drug and alcohol use while riding ATVs is another important injury prevention strategy. Ethanol can significantly impair judgment, and can promote reckless or irresponsible behaviours. Unfortunately studies have found alcohol use to be frequent in people who sustain ATV-related injuries. A Canadian study found that 48% of adult and 12% of pediatric patients had positive alcohol levels at the time of admission to hospital for ATV-related injuries [48]. Similarly, a provincial injury prevention center in Canada found that of ATV fatalities between 2002 and 2013, 55% of individuals tested positive for alcohol. Of those who tested positive, 76% had blood alcohol concentrations above 0.08%, the legal driving limit in Canada [48].

Although less is known about the frequency of drug use with ATV crashes, one U.S. study reported coroner findings from 112 ATV-related fatalities. Over 20% tested positive for drugs, most frequently marijuana (10.6%). Although positive tests for opioids and benzodiazepines were relatively frequent (6.7% and 5.8%, respectively), the study did not distinguish cases that might have involved pre-death therapeutic interventions using these drugs. In this study, use of methamphetamines and cocaine was found to be low [29].

Several studies have shown a higher degree of non-compliance with the use of helmets and other protective gear in those individuals who are using alcohol at the time of a crash [19,43]. For example, a study of U.S. emergency department visits related to ATVs found that 40.6% of the patients who had positive alcohol levels did not use protective equipment, in comparison to just 18.5% of those individuals who were not under the influence at the time of the crash [43]. Overall the literature on drug and alcohol use while driving ATVs points to the need for serious insight regarding the added dangers that come from using ATVs while under the influence. As was noted in the previous section, how these messages are best transmitted remains unclear.

Other injury prevention initiatives that have been suggested include engaging primary care physicians to screen and counsel patients at check-ups [25], building off-highway vehicle parks where safe riding can be promoted [20], and mandating safe usage practices such as helmet use, driving training and licensing, age restrictions, and a ban on passengers. As will be discussed below, such mandates may not produce all of the results that are hoped for.

4. Legislation and Regulations

Legislation would improve the impact of the majority of the injury prevention strategies discussed. The aim of legislation is not to eliminate the use of ATVs, but rather to reduce the needless injuries and fatalities that are becoming too common with the use of ATVs in many countries. However, several difficulties exist with legislation, including questions surrounding its efficacy and difficulties with enforcement.

Legislation regarding ATV use varies across the world, but for the most part, there are few mandatory regulations. In Canada, there are only three out of thirteen provinces and territories that mandate driver safety training and helmet use. Regulations across the United States vary widely by state. For example, as of 2012 31 U.S. states had helmet requirements for ATV riders; however, in

19 states helmets were only required for those below age 16 or 18, and 5 of those states exempt riders who are using ATVs for agricultural work [49]. Regulations concerning broader issues (such as vehicle design, use of ATVs on public *versus* private property, and age-appropriate use) are even more varied. Europe is more aggressive with its legislation, and all countries except for two explicitly ban children from riding on ATVs [50].

A study by Keenan and Bratton investigated the efficacy of legislation regarding ATV safety by comparing U.S. states with legislation and those without. They found that those states with mandatory helmet laws had lower ATV-associated fatality rates (0.08 per 100,000 person), compared to states without mandatory helmet laws (0.17 per 100,000 persons) [51].

In contrast, McBride and colleagues did not find significant benefit in terms of pattern of injury, disability or mortality when comparing pediatric ATV trauma before and after state legislation on ATV safety in one U.S. state. Importantly however, they did not show an increased uptake of safety-related behaviour in those presenting with ATV-related injuries with the change in laws, which would be prerequisite to demonstrating changes in injury patterns. In addition, the study included only 88 patients, again limiting the capacity of this study to show meaningful impact of legislation [52].

One of the most likely reasons why legislation may have limited effect on ATV safety in some jurisdictions is the lack of enforcement (an example being the McBride study previously mentioned, where ATV safety behaviours did not change with introduction of legislation [52]). Although the use of ATVs on private property is cited as one reason why enforcement is challenging, several studies have shown that enforcement does not occur on public lands either. One retrospective study found that nearly 40% of ATV-related non-fatal injuries in the U.S. state of Iowa occurred on public roadways, despite the majority of roadway use being prohibited in that state [53]. Enforcement must take a higher priority if laws are to be effective.

Legislation may also have limited effect when it is not accompanied by education and training, as well as other efforts to change safety behaviour. A survey from the U.S. seems to indicate that attitudes towards ATV safety legislation are not such a barrier. This study found the adult population in one state to be broadly supportive of laws regarding helmet use, safety classes, and banning of passengers on ATVs. When asked about their helmet use and their opinions regarding mandatory helmet use, 26.3% of the ATV riders reported always wearing a helmet, and 44% stated that they would always wear a helmet if a law were in place. However, these results must be interpreted with caution, because only 20% of the study participants had used an ATV in the preceding year [46]. It is possible that those who use ATVs and those who do not have different opinions regarding safety practices.

Finally, one of the aspects of ATV safety that may be the most amenable to legislative changes is the design and production of the vehicles. There are currently voluntary standards that have been adopted by ATV manufacturers, such as placing safety messages and warning labels on their products and the prohibition of selling adult size vehicles for use by youth [14]. However, as these standards are voluntary, there are few incentives to comply. Australia has created a safety rating system that may be applied to all ATVs. By allowing consumers to choose vehicles based on their safety rating, they hope to apply pressure to the manufacturers to produce safer vehicles [28].

Additionally, ATV manufacturers and retailers must also take social responsibility if we are to make any changes in the current culture and attitudes that exist amongst ATV users. ATV manufacturers should place funding into further research so that they can assess the safety of vehicle design, and continue to improve it.

5. Conclusions

The burden of injuries and deaths caused by ATVs is significant in many parts of the world. ATVs continue to increase in popularity, and as such the associated morbidity is likely to grow. Despite the efforts of many experts in the injury prevention field, more work is needed to mitigate the harm associated with these vehicles. Not only should there be a focus on primary injury prevention, but mandatory education and training programs must be in place to target those who are at risk, and

interventions designed to reduce such risks. Governmental support and changes to existing laws and regulations are also key in improving ATV-related harm. Concerted efforts from lawmakers and law enforcement agencies, ATV manufacturers and retailers, as well as educators and concerned citizens groups, are required if the heavy toll that ATV injuries take is to be diminished.

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