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# Quads, Farmers 50+ Years of Age, and Safety in Australia

**Tony Lower [1,*], Noeline Monaghan [1] and Margaret Rolfe [2]**

[1] Australian Centre for Agricultural Health and Safety, University of Sydney, Moree 2400 NSW, Australia; aghealth@health.usyd.edu.au

[2] University Centre for Rural Health North Coast, University of Sydney, Lismore 2480 NSW, Australia; Margaret.Rolfe@ucrh.edu.au

* Correspondence: tony.lower@sydney.edu.au; Tel.: +61-2-6752-8210

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**Abstract:** Quads are the leading cause of fatal non-intentional injuries on Australian farms. Due to normal age-related physiological and cognitive changes, farmers 50-years of age and above are at increased risk when using quads. This study identifies a non-statistically significant increasing trend for fatal quad incidents involving this cohort in Australia. It is contended that these vehicles are not "fit-for-purpose" for many typical agricultural tasks more broadly and that the ageing process further exacerbates these risks. Encouraging and promoting the use of more "fit-for-purpose" vehicles in the agricultural sector should be the primary focus of intervention approaches. Supplementing this, other approaches that reduce risks, specifically relating to rollovers, crush/asphyxiation and head injuries must be enacted.

**Keywords:** older farmers; injury; quads; ATV

## 1. Introduction

Agricultural production in Australia is characterized by a progressively ageing cohort of farming men and women. This is exemplified by the demographic profile for agriculture where the average age of farmers is 53 years compared to the all industry mean of 39.5 years. This represented a nine-year increase in average age between 1981 and 2011 [1].

This trend has been evolving for many years with almost a quarter (23%) of Australian farmers aged 65 years or over in 2011, compared with just 3% of people in other occupations [2]. Other Western agricultural systems also face similar demographic challenges. In New Zealand, there has been an ongoing increase in the average age of farmers since 1981 (41.9), with the average now being 47.7 years compared to the all industries mean of 42.7 years [3]. Similar age increases for farmers are also apparent in Canada (mean age 54) [4] and in the USA (mean age 57) [5]. Meanwhile, figures for the European Union illustrate that for each farmer younger than 35 years, there are nine farmers older than 55 years [6].

There are increasing concerns regarding this demographic shift within agriculture, including questions regarding the longer-term viability of the industry as a result of this workforce ageing [7]. However, there is also growing understanding regarding the impact that ageing has on health and safety for those older persons continuing to work in agriculture [8–12]. These impacts centre on normal physiological changes including reductions in strength, flexibility and balance, plus issues with sight, hearing, and memory among others.

Within the agricultural sector in Australia, there has been considerable attention paid to fatal incidents involving quads (All Terrain Vehicles) [13–15]. In Australia, quads have surpassed tractors as the leading cause of non-intentional farm related injury deaths in recent years [16–18].

Although developed as recreational vehicles, there are around 270,000 such vehicles in use in Australia, with the majority of these being used within agriculture for work-related purposes. The use of quads in this context is framed in Australia under Work Health and Safety Regulations based on application of the hierarchy of controls [19]. That is, you must first try to manage risks by eliminating the hazard where reasonably practicable and if that is not possible, then attempt to substitute the hazard for one of a lower risk (e.g., in this instance use a farm utility or side-by-side vehicle instead of a quad). Working further down the hierarchy, you can introduce engineering controls (e.g., a crush protection device), adopt administrative controls (e.g., training) and use personal protection equipment (e.g., helmet). The best results will be achieved when several of these hierarchy levels are used in conjunction. However, by law in Australia, you must first look to eliminate the risk if you can.

While there is a significant body of literature relating to children and quads [20–22], issues examining people 50 years and above have been less well addressed. The limited information available suggests that the rate of quad-related fatalities for older persons has increased in the US [23,24]. For non-fatal cases, persons over 50 years of age also incurred more severe and frequent thoracic injuries and used more hospital resources than did the younger cohort [24]. In a review assessing US occupational related fatalities, it was also observed that 43% of cases were to those over the age of 55 years [25]. These data suggest that older people do incur a significant injury burden from the use of quads.

This study reports on quad-related fatal incidents in the Australian agricultural sector between January 2001 and October 2015 involving persons 50 years of age and above. While quads are also used in off-farm scenarios for either work or recreation, the focus of this paper is those cases occurring on a farm.

## 2. Method

The Register of Quad Deaths is a database maintained by the Australian Centre for Agricultural Health and Safety at the University of Sydney, subsequently referred to as the Centre. Much of the information in the Register is sourced from the National Coroners' Information System (NCIS), which is an internet-based data storage and retrieval system for all Australian coronial cases. The NCIS contains information about all deaths reported to Australian coroners since July 2000 (January 2001 for the state of Queensland) [26]. The Centre has ethics approval to access and utilize the NCIS data.

New cases are initially added to the Register of Quad Deaths by two key methods—(1) alerts via a media monitors program and (2) coded and keyword database searches undertaken periodically by the Centre, and by the NCIS Access Liaison Officer using search terms including but not limited to: "quad bike", "all-terrain" "ATV" "four wheel & bike" and "4 wheel & bike". The electronic version of the NCIS contains some of the key documentation that is collected for each coronial cases. This can include statements by police, autopsy, toxicology and Coroners' findings reports for each case. These documents become available for review and analyses, once the Coroner hands down his/her findings for each case and the case is subsequently "closed".

Data from the NCIS are coded based on the Farm Injury Optimal Dataset, which is a coding guide developed to assist researchers to accurately describe the injury experience in relation to the agricultural sector [27]. This information is then stored in the Register of Quad Deaths allowing for detailed analysis of each case with consideration of risk factors that lead to the injury event. The Register contains all known cases involving these vehicles, irrespective of whether the incident has occurred on a farm or elsewhere. The amount of detail within the Register is limited by the information available on NCIS at the time of data retrieval. Cases on the electronic system that remain "open" have limited information available.

All fatalities involving persons 50 years and older from the total population of cases were identified. Those incidents that did not occur in a farm environment were excluded from further analyses e.g., roads, public areas, beaches *etc*.

Denominator data to ascertain estimates on the number of farmers in this age cohort were obtained from the Australian Bureau of Statistics Census data for 2006 and 2011 [28,29]. Changes in industry classification in the 2006 Census mean that previous data are not comparable. Additionally, there are no data available for the inter-census periods that specify the actual number of farmers over 50 years of age. Consequently, population estimates were applied using the trend for 2006–2011.

Data were assessed to provide a descriptive summary of the sample in regards to demographic and incident details. Chi-square analyses were completed to investigate issues regarding the mechanism of the fatal incident, primary cause of death and time to find victim post-incident. Linear regression analyses to assess trends in the rate of fatalities over time were conducted. Higher level polynomial components were also investigated with years or time centred at 2007. The trend data were calculated using SPSS Version 22 (IBM Corp, Armonk, NY, USA) with statistical significance being $p < 0.05$.

## 3. Results

The Register included a total of 218 cases covering the period 1 January 2001–31 October 2015. Of these cases, 93 (42.6%) were identified as involving persons 50 years or older. A subsequent review excluded a small number of cases that had not occurred on a farm ($n = 11$). However, at least four of these incidents involved farmers moving between paddocks and were excluded because they occurred on public roads. This left 82 cases that met the inclusion criteria for analysis. Overall, 59 of the 82 cases (72%) had been finalized and closed by a Coroner.

During the 15 year period (Figure 1), there was a slight increase in the rate of persons (0.175 per 10,000 persons per year, SE = 0.169) involved in fatal quad cases; however, this was not statistically significant ($F(1, 13) = 1.072$, $p = 0.319$), with an $R^2$ of 0.076. The addition of higher level quadratic ($F(1, 12) = 3.052$, $p = 0.106$) or cubic ($F(1, 11) = 1.863$, $p = 0.200$) components did not significantly improve the relationship.

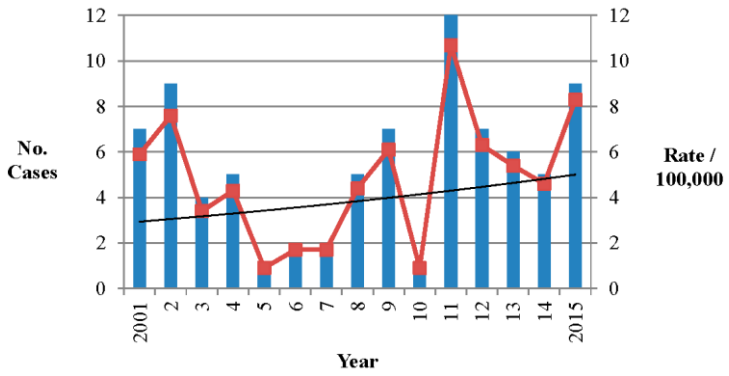


**Figure 1.** Number and rate of on-farm quad fatalities by year for person 50 years and over.

Males dominated the injury pattern accounting for 71 cases (86.5%). As Figure 2 outlines, the age distribution ranged from 51 to 94 years, with the highest proportion in those 50–59 years of age. Both the mean and median age for this sample was 67.0 years.

Of the incidents, 68 cases (82.9%) were work-related and only nine cases (10.9%) involved recreational activity. Information was not available on the work relatedness for a further five cases. The major occupational group, were farmers with 61 cases (74.3%). Other occupations were listed in 15 cases, and no detail was available for six cases. From the 82 incidents, all deceased persons were driving the quad with only one exception, where a bystander was involved.

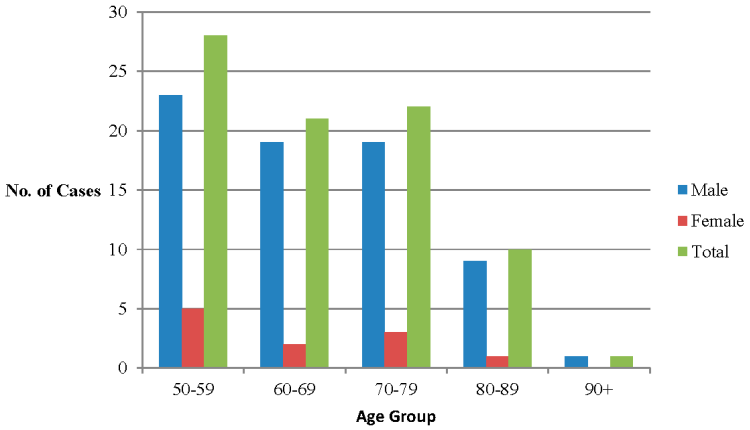


**Figure 2.** Australian quad fatalities by age group for persons 50+ years (2001–2015).

Rollovers are the major fatal injury mechanism for on-farm use of quads by this cohort, accounting for 60 cases (73.1%) of all deaths (Table 1). When comparing the prevalence of on-farm cases for those under 50 years of age (rollover = 58.7%), the older cohort is significantly more likely to incur a rollover incident ($X^2$ = 6.4, df = 1, $p$ = 0.01).

For this sample, the variation between the primary cause of death for rollovers and non-rollovers was also statistically significant ($X^2$ = 15.2, df = 5, $p$ = 0.01). Asphyxiation was the single largest cause of fatalities by a considerable margin (20.7%). Of the 17 recorded asphyxiation deaths, all resulted from traumatic/crush asphyxia, with the exception of one case involving positional asphyxia. Two further cases involved drowning after becoming entrapped under the quad. In conjunction, rollover events involving asphyxia and injuries to the thorax region (including crush injury), account for over one-third (40.2%) of all deaths. Injuries to the head also contribute considerably to fatality cases across both mechanisms, accounting for 15 cases (18.3%). Of these cases, 10 had no helmet and no information was available for the remaining five cases.

**Table 1.** Primary cause of death by mechanism of incident for persons 50+ years (2001–2015).

| Body Region | Primary Cause of Death | Rollover | | Non-Rollover | | Total | |
|---|---|---|---|---|---|---|---|
| | | *n* | % | *n* | % | *n* | % |
| Head | Intracranial | 4 | | | | 4 | 4.8 |
| | Fracture of skull & facial bones | 1 | | 2 | | 3 | 3.6 |
| | Other & unspecified | 5 | | 3 | | 8 | 9.7 |
| | **Sub-Total** | **10** | **16.6** | **5** | **33.3** | **15** | **18.3** |
| Neck | Fracture | 1 | | 2 | | 4 * | 4.8 |
| | Injury of nerves and spinal cord at neck | | | 1 | | 1 | 1.2 |
| | Other and unspecified injuries | 1 | | 1 | | 2 | 2.4 |
| | **Sub-Total** | **2** | **3.3** | **4** | **26.6** | **7 *** | **8.5** |
| Thorax | Fracture of rib(s), sternum and thoracic spine | 1 | | 1 | | 2 | 2.4 |
| | Injury of blood vessels of thorax | 1 | | | | 1 | 1.2 |
| | Injury of heart | 1 | | | | 1 | 1.2 |
| | Injury of other and unspecified intrathoracic organs | 3 | | | | 3 | 3.6 |
| | Crushing injury of thorax and traumatic amputation of part of thorax | 6 | | 2 | | 7 | 8.5 |
| | Other and unspecified injuries of thorax | 4 | | | | 4 | 4.8 |
| | **Sub-Total** | **16** | **26.6** | **3** | **20.0** | **19** | **23.1** |
| Abdomen | Injury of intra-abdominal organs | 1 | | | | 1 | 1.2 |
| | Crushing injury and traumatic amputation of part of abdomen, lower back and pelvis | | | 1 | | 1 | 1.2 |
| | **Sub-Total** | **1** | **1.6** | **1** | **6.0** | **2** | **2.4** |

**Table 1.** *Cont.*

| Body Region | Primary Cause of Death | Rollover | | Non-Rollover | | Total | |
|---|---|---|---|---|---|---|---|
| | | *n* | % | *n* | % | *n* | % |
| Multiple | Other injuries involving multiple body regions, not elsewhere classified | 1 | | | | 1 | 1.2 |
| | Unspecified multiple injuries | 3 | | 1 | | 4 * | 4.8 |
| | **Sub-Total** | **4** | **6.6** | **1** | **6.0** | **6 *** | **7.3** |
| Other | Asphyxiation | 17 | | | | 17 | 20.7 |
| | Effects of other external causes | 2 | | | | 2 | 2.4 |
| | **Sub-Total** | **19** | **31.6** | | **-** | **19** | **23.4** |
| Unknown | | 8 | | 1 | | 14 * | 17.0 |
| | **Sub-Total** | **8** | **13.3** | **1** | **6.0** | **14 *** | **17.0** |
| **Total** | | **60** | **73.1** | **15** | **18.3** | **82 *** | **100** |

* Data unavailable for some variables.

For 38 of the 60 rollover cases (63.3%), there was a protracted period exceeding one hour in duration between the occurrence of the event and the individual being found. This definition for a "protracted period" was consistent with a large Australian study [30]. Data for this variable could not be determined in 15 cases, and there were seven cases where the victim was located within the first hour post-incident. There was no statistical difference for this variable between rollover and non-rollover cases ($X^2 = 4.4$, df = 2, $p = 0.1$).

Most commonly, fatal incidents involved activities such as general transport ($n = 18$), herding livestock ($n = 17$), weed control ($n = 15$), other ($n = 4$), and a further 28 cases did not have sufficient detail on the case files. Of the 60 cases that involved a rollover, some form of load was present in 22 cases (36.6%). Typically, these were spray units ($n = 15$), toolboxes ($n = 3$), towed trailers/equipment ($n = 2$) and passengers ($n = 2$).

Toxicology results were electronically available for 34 cases. Of these cases, three identified the presence of drugs (prescription medications), and one had an alcohol reading above 0.05 mg/L.

## 4. Discussion

These data reinforce increasing safety concerns for farmers aged 50 years and above. Over a 15 year period, quads have been responsible for an average of 5–6 deaths to those 50+ in on-farm events each year. The rate of persons involved in fatal quad cases increased over this time. However, unlike associations identified in the US [23,24], this increase in the Australian data was not statistically significant. While the proportion of farmers over 50 years of age increased in this period, there was an overall reduction in total numbers by 8.52% (approximately 0.57% per annum) [8]. Hence, the increase in rates is unlikely to be simply attributed to larger numbers of farmers 50 years of age and over being exposed.

The majority of cases involved rollover incidents during work activities, which raises issues relating to both the design of quads and their operation for work purposes. While developed primarily as recreational products, quads have found a niche within agriculture in many countries. However, increasing evidence is mounting that quads are indeed not "fit-for-purpose" for many of the agricultural tasks performed and that correct vehicle selection to match such tasks is vital [13,14,31]. Quads do not have a lateral stability standard [32] with the industry preferring to focus on the contribution of "active-riding" which entails shifting body weight to maintain vehicle control [33] Although "active riding" is a central platform of the quad industries training and advice, there is a lack of robust objective data validating its effectiveness and reliability as a risk control measure to enhance safety [13].

In broad terms, the ageing process can impact the capacity of individuals to undertake a range of activities, with changes in physical strength, sight, balance, flexibility and memory all interacting.

Farmers are no exception to this pattern. Notwithstanding concerns regarding the validity of "active riding", quad operation necessitates that the rider is agile, can move and is willing to move their body to maintain control of the vehicle. Given the ageing-related physiological changes and the clearly significant burden of rollover related cases in our study, farmers in this age cohort appear to be at significant risk from the use of quads.

The capacity to control a quad is also compromised if carrying or towing a load [13]. In this sample, over one-third of rollover cases included a load, most commonly a spray tank. Cognitive distraction such as looking at areas being sprayed or chasing livestock during mustering will also add to the inherent risks in controlling the vehicle and were common incident factors. Such findings are in keeping with other recent information from New Zealand farmers [34]. Either singularly or in tandem with physiological changes, the issues of loads impacting stability and cognitive distraction further accentuate risks for these riders.

Medication use has been raised as a potential contributing factor to injuries in older farmers [8]. For this sample, it appeared to have a limited impact with only three cases reporting the presence of prescription medication. However, further pharmacological assessment is required to discern if indeed these medications were at levels that may have increased the risk of injury. Similarly, while alcohol is often noted as a prominent factor within quad cases in the US [35], it is certainly not the case for this sample of on-farm riders.

The typical incident in this case series involves an individual farmer working in isolation, rolling the quad and becoming entrapped under or crushed by the vehicle. In around two-thirds of cases, there was a significant period (>1 h) between the incident occurring and location of the victim. With an average quad weighing around 300 kg, entrapment or crushing quickly becomes a life and death scenario. A recent Australian review drawing on hard copy coronial records, indicated that many of the fatalities involving asphyxia (approximately 20), would have survived if someone was present to extract the individual as no other injuries were present [30]. Additionally, riders would undoubtedly benefit from the use of helmets, as in the 10 cases involving head injury where helmet status was known, no helmets were worn.

While others have suggested improvements in training and education to better manage risks [25], this is at the lower end of the hierarchy of controls. Moreover, there is little to no evidence that improvements in knowledge and training actually lead to reductions in injury occurrence or severity [36,37]. While it is not possible to ascertain fully the years of quad riding experience that those fatally injured in this sample had, it is evident from the text available in the records that many had considerable experience and were far from novice riders. Additionally, many of the normal ageing process changes are not amenable to rider training e.g., reductions in strength, balance and vision. As such, the utility of rider training as the key strategy to reduce quad fatalities for persons 50+ years (which constitute over 50% of the farming population), is critically flawed. Further, reliance on such approaches does not take account of the hierarchy of controls. Indeed, moving farmers of all ages but particularly those 50 years of age and above, to safer and more "fit for purpose" vehicles, will be pivotal to reducing this burden [38]. Depending on the task being undertaken, a tractor, utility, side-by-side vehicle, two-wheel motorbike or horse, could be a more appropriate choice.

This study is limited by the information that is available within the electronic coronial database, with some gaps in detail. Population estimates were also required as data for inter-census periods specifying the actual number of farmers 50+ years of age, are not available. Furthermore, while we are able to calculate rates of death/100,000 for those 50 years of age and above, there is no actual exposure data available in regards to hours of quad use. Hence, while rates/100,000 in this cohort have risen, it is not possible to validate this with more detailed exposure data. Additionally, while there is a reasonable study sample ($n$ = 82), the incident details available are aggregated so any individual changes related to the ageing process that may influence injury causation cannot be specifically defined. Consequently, only general inferences on the impact of the ageing process on injury risk can be

drawn from the results. Notwithstanding this limitation, there is no reason to expect that the typical age-related changes that occur across the population, do not apply equally to this cohort.

## 5. Conclusions

The evidence strongly suggests that the normal changes associated with ageing compromise the safety of farmers 50+ years of age. Maintaining participation in agriculture for older farmers is likely to be of personal and societal benefit. While we cannot "turn back the clock" on many of these physical and cognitive changes, it is possible for farmers 50 years and above to continue to be actively and safely involved in agriculture. In the case of quads, it is contended that these vehicles are not "fit-for-purpose" for many typical agricultural tasks more broadly and that the ageing process further exacerbates these risks.

In accordance with the hierarchy of controls, encouraging and promoting the use of more "fit-for-purpose" vehicles in the agricultural sector should be the primary focus of intervention approaches. Supplementing this approach for this cohort, it will be necessary to also draw on the hierarchy to enact approaches that will reduce risks, specifically related to rollovers, of crush/asphyxiation and head injuries.

**Author Contributions:** T.L. and N.M. developed the study design and collated the fatality data. M.F. provided statistical advice and undertook data analyses. All authors contributed to writing the manuscript and its completion.

**Conflicts of Interest:** The authors declare no conflict of interest.

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