



# Farm injury resulting in hospital admission: a review of farm work and non-farm work-related injury

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## ABSTRACT

**INTRODUCTION:** Occupational health on farms is important because farms are not only workplaces where agriculture workers are vulnerable to high injury and fatality rates, they are also homes where families and visitors undertake a variety of activities that can result in injury.

**AIM:** To profile and describe injuries requiring hospital admission that occurred on farms, both for injuries related to farming activities and injuries unrelated to farm work in the Midland region of New Zealand.

**METHODS:** A review of anonymised prospectively collected Midland trauma registry data from 1 July 2012 to 30 June 2018 was undertaken. Cases include unintentional injuries occurring on a farm. Non-major injuries are included to better quantify the trauma burden.

**RESULTS:** In total, 2303 hospital admissions met the study criteria. Non-major injury accounted for 93.1% of events and 45.0% of injuries occurred during farming activities. Five people died in hospital; all injured while undertaking farm work. Males made up 84.8% of farm work and 70.9% of non-farm work injuries. Horse riding had the highest number of injuries, with off-road motorcycles, livestock, falls and quad bike injuries comprising the most common injury activities and mechanisms. Farming-related major injuries commonly involved quad bikes, non-traffic vehicles and motorcycles. Farmers in the Districts of Waitomo, Rotorua, Waipa and Taupō had the highest standardised hospitalisation rates.

**DISCUSSION:** The nature of farms and farming exposes people to different risks from the risks people in urban areas are exposed to. Injury prevention efforts should remain on work-related farming injuries, but also encompass the high number of injuries that are not related to farm work but happening on farms.

**KEYWORDS:** Trauma; major injury; non-major injury; farm; New Zealand

## Introduction

Across the Midland region (population 950,000), agricultural and equestrian businesses are important sources of employment and contribute strongly to the regional and national economy.<sup>1,2</sup> In New Zealand, as elsewhere, farming is recognised as an inherently dangerous occupation, being

overrepresented in injury statistics.<sup>3,4</sup> However, farms are usually both a workplace and a home, bringing particular challenges for safety in terms of the physical and social environment of a farm.<sup>3,5</sup> Health and safety improvement in the agricultural sector is a high priority for WorkSafe New Zealand (Worksafe), as the national regulator of health and

safety at work, as well as national and regional industry groups.<sup>6</sup>

Australia, Ireland, Canada and the United Kingdom all report agriculture as one of their most hazardous industries, with considerable costs to individuals, their families and farms due to injury.<sup>7–12</sup> Australian estimates suggest that farm injuries account for 17% of all worker deaths, and farm injuries occur at a rate of 56.4 per 1000 workers.<sup>3</sup> Six percent of the Irish workforce is employed in agriculture, but the sector accounts for 40% of workplace fatalities.<sup>11</sup> Data for New Zealand tell a similar tale, with the agriculture, forestry and fishing industries having a high injury claim rate of 190 claims per 1000 full-time equivalent workers (FTE) in 2018.<sup>6,13</sup> Work-Safe data show there were 28 agricultural fatalities during the 2012–18 year period in the Midland region. Of these fatalities, nine involved a quad bike (with six deaths being of people aged >65 years).<sup>14</sup>

Our study examines all injuries occurring on farms that resulted in a hospital admission, separating injury events into the type of activity that was being undertaken at the time of injury; that is, ‘farming’ or ‘non-farming’-related activities. Our key objective was to review the major and non-major (Injury Severity Score  $\leq 12$ ) injury events happening on farms and establish the mechanisms of injury.

## Methods

A retrospective review of anonymised, prospectively collected trauma data from the Midland Trauma System (MTS) trauma registry was conducted. The Midland region covers the five District Health Boards (DHBs) of Taranaki, Lakes, Tairāwhiti, Waikato and Bay of Plenty. Data from Tairāwhiti DHB are included from 1 July 2014 (4.6% of all events). We identified all patients admitted to any hospital in the Midland region within the 6-year period, 1 July 2012–30 June 2018, as a direct result of trauma occurring on a farm.

Intentional injuries were excluded. Consistent with trauma registries internationally and best practice standards, patients were excluded if they sustained hanging, drowning or asphyxiation without evidence of external force, insufficiency or periprosthetic fractures, exertional injuries, poisoning, ingested foreign body, injury as a direct result of pre-

## WHAT GAP THIS FILLS

**What is already known:** Farming is a high-risk occupation in terms of serious injury and fatalities. While there is much research on farming-related fatalities and major injuries, there is somewhat less on non-major farming injuries and injuries occurring on farms that are not related to undertaking farm work.

**What this study adds:** The collection of non-major injury data is a unique feature of the Midland Trauma System. This study found that 55% of injuries happening on farms occurred during activities that were not related to farming, with 93% of all injuries being non-major. There was a wide variety of injury activities and mechanisms, differing by age and gender.

existing medical conditions or late effects of injury, or the injury occurred >7 days before admission.

Injury severity and pattern of injury diagnoses were quantified using the Abbreviated Injury Scale (AIS), an anatomical scoring system that ranks injuries from ‘1’ (minor) to ‘6’ (non-survivable).<sup>15</sup> The Injury Severity Score (ISS) is also an anatomical scoring system using a 0–75 scale. The highest AIS scores in each body region are the basis of the ISS, with injuries then categorised as non-major (ISS  $\leq 12$ ) and major (ISS  $\geq 13$ ).<sup>16</sup>

For patient ethnicity, we used the ethnicity recorded on the patient’s National Health Index record and categorised ethnicity according to the 2005 Ethnicity New Zealand Standard Classification.<sup>16</sup> A network of trauma clinicians across the Midland Trauma System collect the trauma data, with qualified staff coding to International Classification of Disease (ICD10) and AIS standards.

Age standardisation to establish hospitalisation rates for farmers used Statistics New Zealand 2013 Census data for people aged  $\geq 15$  years and employed in the agriculture industry (ANZSIC06) as the denominator. The reference population was the Midland region population (supplied to DHBs by the Ministry of Health).

Chi-square tests for independence were calculated to compare observed and expected frequencies of major and non-major injury between farming and non-farming-related activities.

Table 1. Injury events by the type of activity being undertaken and the severity of injury

		Farming-related activity		Non-farming activity	
		Major <i>n</i> (%) 79 (7.6)	Non-major <i>n</i> (%) 957 (92.4)	Major <i>n</i> (%) 79 (6.2)	Non-major <i>n</i> (%) 1188 (93.8)
<b>Gender</b>	Female	12 (6.1)	184 (93.9)	23 (4.4)	505 (95.6)
	Male	67 (8.0)	773 (92.0)	56 (7.6)	683 (92.4)
<b>Age group (years)</b>	0–9	0 (–)	1 (100.0)	5 (3.9)	123 (96.1)
	10–19	2 (3.5)	55 (96.5)	8 (3.0)	263 (97.0)
	20–29	7 (3.1)	216 (96.9)	2 (1.1)	184 (98.9)
	30–39	13 (7.3)	164 (92.7)	8 (6.2)	122 (93.8)
	40–49	17 (10.1)	152 (89.9)	15 (8.3)	165 (91.7)
	50–59	17 (8.4)	186 (91.6)	18 (9.2)	178 (90.8)
	60–69	12 (9.6)	113 (90.4)	9 (8.8)	93 (91.2)
	70–79	9 (15.0)	51 (85.0)	13 (20.3)	51 (79.7)
	80–89	2 (10.0)	18 (90.0)	1 (11.1)	8 (88.9)
	90+	0 (–)	1 (100.0)	0 (–)	1 (100.0)
<b>Ethnicity</b>	Māori	9 (7.4)	113 (92.6)	9 (4.5)	191 (95.5)
	Non-Māori	70 (7.7)	844 (92.3)	70 (6.6)	997 (93.4)
<b>DHB of injury</b>	Waikato	49 (8.0)	560 (92.0)	31 (6.2)	470 (93.8)
	Bay of Plenty	20 (14.1)	122 (85.9)	24 (8.6)	256 (91.4)
	Lakes	3 (2.3)	129 (97.7)	6 (3.7)	157 (96.3)
	Tairāwhiti*	4 (10.8)	33 (89.2)	4 (5.8)	65 (94.2)
	Taranaki	3 (2.6)	113 (97.4)	14 (5.5)	240 (94.5)
<b>Year of injury</b>	2012–13	12 (7.3)	152 (92.7)	8 (4.7)	163 (95.3)
	2013–14	13 (7.6)	157 (92.4)	12 (6.9)	162 (93.1)
	2014–15*	9 (5.4)	158 (94.6)	17 (6.5)	246 (93.5)
	2015–16	22 (10.0)	198 (90.0)	13 (5.7)	214 (94.3)
	2016–17	13 (9.0)	131 (91.0)	11 (5.1)	206 (94.9)
	2017–18	10 (5.8)	161 (94.2)	18 (8.4)	197 (91.6)
<b>Outcome (hospital)</b>	Died	3 (60.0)	2 (40.0)	0 (–)	0 (–)
	Survived	76 (7.4)	955 (92.6)	79 (6.2)	1188 (93.8)

\* Data from Tairāwhiti DHB included from 1 July 2014.  
DHB (District Health Board).

Ethics approval for this study was not required by the Health and Disability Ethics Committee because we used anonymised secondary data. The study was approved by the Waikato DHB (RD017028) and endorsed by the Te Puna Oranga Māori Consultation Research Review Committee. Statistical analyses were performed in Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA, USA).

## Results

A total of 2303 events met the inclusion criteria. There were 158 (6.9%) events classified as major injuries and 2145 (93.1%) as non-major (Table 1). Of the total number of events, 1036 (45.0%) occurred during farming activities.

Table 2. All on-farm injuries (occurring during both farming and non-farming-related activities), number of AIS diagnoses by body region and severity score

AIS Body Region	AIS Severity Score			Total
	1 n (%)	2 n (%)	3+ n (%)	
Lower extremity	385 (27.6)	829 (59.5)	180 (12.9)	1394
Upper extremity	701 (54.1)	540 (41.7)	56 (4.3)	1296
Thorax	100 (22.2)	180 (39.9)	171 (37.9)	451
Face	297 (78.0)	70 (18.4)	14 (3.7)	381
Head	145 (38.7)	141 (37.6)	89 (23.7)	375
Spine	38 (10.4)	232 (63.4)	96 (26.2)	366
Abdomen or pelvis	90 (52.3)	55 (32.0)	27 (15.7)	172
External, burns and other	143 (92.3)	11 (7.1)	1 (0.6)	155
Neck	46 (70.8)	12 (18.5)	7 (10.8)	65
<b>Total</b>	<b>1945 (41.8)</b>	<b>2070 (44.5)</b>	<b>641 (13.8)</b>	<b>4655</b>

AIS (abbreviated injury scale).

Fourteen percent of all events related to people of Māori ethnicity, with 59.3% being non-farming, non-major events. Of the farming-related events resulting in major injury, males contributed 84.8% and 70.9% of the major non-farming events. The highest numbers of injuries were for people aged 20–29 years. This group also had the most farming-related events. For injuries occurring outside of farming activities, youth aged 10–19 years had the highest number of events. Almost half (48.2%) of injuries occurred on farms in the Waikato DHB area. Five people died following hospital admission, all of whom had been carrying out farming-related activities at the time of injury. No statistically significant ( $P < 0.05$ ) associations were observed.

### AIS injury scores and length of hospital stay

There were 4655 AIS scores for individual injuries recorded for the 2303 patients (Table 2). Examination of injuries by body region showed that over half (54.1%) of all upper extremity injuries scored 1 (minor), with almost 60% of lower extremity injuries being moderate (AIS 2). The most severely injured body region was the thorax, with close to 40% of thoracic injuries being categorised as AIS 3+ (combining serious, severe and critical). Injuries to the spine also tended to be more serious, with 63.4% being moderate and one-quarter serious, severe and

critical (AIS3+). In contrast, injuries to the face, neck and external areas tended to be minor (AIS 1).

The median length of stay in hospital was higher for farming-related activity major injuries than major non-farming activities at 7.5 days (s.d. = 17.1) compared with 6.0 days (s.d. = 8.0). The length of hospital stay for non-major injury was a maximum of 75 days for farming activity injuries and 43 days for non-farming activity-related events.

### Injury activity or mechanism

Horse riding was the mechanism with the highest number of total events, most (91.6%) occurring during non-farming activities (Table 3). Motorcycles, livestock-related injuries, falls (both on the same and different levels) and quad bike injuries were the most common injury mechanism categories. The eight major injury falls during farm work were falls at stock yards and falls when spraying weeds or scrub cutting on steep terrain. Of the 125 non-major falls, many involved injury while herding stock, slipping on surfaces, falling when carrying things, falling off vehicles, jumping obstacles (drains, fences) and tripping in unseen holes. There were a variety of reasons in the descriptions of the 256 falls events. Several noted uneven ground and injuries occurring when jumping off hay bales or vehicles (eg ute trays, tractor steps).

Table 3. Mechanism of injury on the farm by activity when injured, and injury severity

Mechanism of injury	Farming-related activity		Non-farming related	
	Major n (%)	Non-major n (%)	Major n (%)	Non-major n (%)
Horse riding	2 (5.7)	33 (94.3)	26 (7.0)	345 (93.0)
Motorcycle – off road	12 (9.2)	119 (90.8)	18 (7.6)	219 (92.4)
Bitten or struck by livestock	9 (5.3)	162 (94.7)	9 (5.4)	157 (94.6)
Falls	8 (6.0)	125 (94.0)	2 (1.6)	121 (98.4)
Quad bike	21 (13.3)	137 (86.7)	9 (10.6)	76 (89.4)
Struck, caught, crushed by objects	6 (4.6)	125 (95.4)	3 (3.2)	92 (96.8)
Machinery or hand tools	5 (3.5)	137 (96.5)	2 (3.3)	58 (96.7)
Vehicle, non-traffic	13 (26.0)	37 (74.0)	4 (9.3)	39 (90.7)
Knife related	–	31 (100.0)	–	15 (100.0)
Fire, ignition of flammable material	–	8 (100.0)	–	12 (100.0)
Foreign body	–	11 (100.0)	–	8 (100.0)
Other	1 (11.1)	8 (88.9)	–	9 (100.0)
Lifting and transmission devices	2 (18.2)	9 (81.8)	–	4 (100.0)
Firearms	–	3 (100.0)	1 (11.1)	8 (88.9)
Hot fluids or steam	–	4 (100.0)	–	4 (100.0)
Assault	–	–	–	6 (100.0)
Go-kart	–	–	1 (16.7)	5 (83.3)
Aircraft	–	–	3 (60.0)	2 (40.0)
Pedestrian	–	–	1 (20.0)	4 (80.0)
Accidental poisoning	–	4 (100.0)	–	1 (100.0)
Contact with glass	–	2 (100.0)	–	1 (100.0)
Exposure to electrical current	–	–	–	2 (100.0)
Explosion	–	2 (100.0)	–	–
<b>Total</b>	<b>79 (7.6)</b>	<b>957 (92.4)</b>	<b>79 (6.2)</b>	<b>1188 (93.8)</b>

There were 20 incidents of ‘fire or ignition of flammable material’ resulting in hospitalisation with 14 events related to burning rubbish and using petrol or diesel to assist the process. Twenty-one of the 46 injuries categorised as ‘knife, sword, dagger’ were due to butchering or skinning an animal and another five were due to cleaning or trimming animal hooves.

### Children injured on farms

Over 93% of injuries to children (aged <18 years) were non-major and occurred during non-farming-related activities (Table 4). Farms, as homes, often have risks associated with the terrain, type of

activities available to children and presence of farming equipment. There were 124 children hospitalised following riding an off-road motorcycle, another 94 due to horse riding and 29 hospitalisations related to quad bikes. Twenty-four children were hospitalised with non-major injuries from farming activities, the mechanisms including off-road motorcycles, being bitten or struck by livestock, falls, quad bikes, contact with machinery or hand tools and contact with hot fluids or steam. For injuries outside of farm work, 13 children had major injuries, with the capture of non-major injury information for the other 345 children showing the value of the MTS trauma registry in collecting both major and non-major injury information.

Table 4. Mechanism causing child (&lt;18 years) injury occurring on a farm, by severity

Mechanism of injury	Farming-related activity		Non-farming related	
	Major n (%)	Non-major n (%)	Major n (%)	Non-major n (%)
Motorcycle – offroad	–	10 (100.0)	4 (3.5)	110 (96.5)
Horse riding	–	–	3 (3.2)	91 (96.8)
Quad bike	–	2 (100.0)	2 (7.4)	25 (92.6)
Falls	–	2 (100.0)	–	27 (100.0)
Bitten or struck by livestock	–	3 (100.0)	2 (9.1)	20 (90.9)
Struck, caught or crushed by objects	–	1 (100.0)	–	21 (100.0)
Vehicle, non-traffic	–	1 (100.0)	–	16 (100.0)
Machinery or hand tools	–	2 (100.0)	–	9 (100.0)
Pedestrian	–	–	1 (20.0)	4 (80.0)
Go-kart	–	–	1 (20.0)	4 (80.0)
Foreign body	–	–	–	4 (100.0)
Fire, ignition of flammable material	–	1 (100.0)	–	3 (100.0)
Hot fluids or steam	–	1 (100.0)	–	2 (100.0)
Knife, sword, dagger	–	1 (100.0)	–	1 (100.0)
Lifting or transmission devices	–	–	–	2 (100.0)
Other	–	–	–	2 (100.0)
Firearms	–	–	–	2 (100.0)
Exposure to electrical current	–	–	–	1 (100.0)
Accidental poisoning	–	–	–	1 (100.0)
<b>Total</b>	–	<b>24 (100.0)</b>	<b>13 (3.6)</b>	<b>345 (96.4)</b>

### Injury rates: farmers engaged in farming activities

Farming-related injuries were categorised into the District in which they occurred, with the aim of locating where injury rates might be higher. For this measure, only patients domiciled in the Midland region were included. The district of Waitomo had the highest age/sex standardised rate per 100,000 farmers (4370), followed by Rotorua District (4217), Waipa District (4045) and Taupō District (4013) (Table 5). Six of the 10 Districts with high hospitalisation rates are located in the Waikato DHB, two in the Lakes DHB and two in the Bay of Plenty DHB (all districts in Tairāwhiti and Taranaki DHBs were outside the top 10). In all Districts, rate ratios showed males being more likely to be hospitalised due to an injury occurring during a farming activity.

### Discussion

Farms have many risk factors for injury, including presence of livestock, farm machinery, power tools and activities that may combine these factors in varied terrain and environmental conditions. Our findings around farming-related injuries confirm those from international studies, in terms of the most common mechanisms for injury being agricultural machinery (including vehicles), interaction with livestock and falls.<sup>3,7,8,17–22</sup> Our study has identified some high-risk mechanisms for injury, regardless of whether individuals were undertaking a farming activity or not. In summary, some of the key risks in the Midland region are for:

- Females – injuries related to horses, both falls from horses and being bitten or struck by horses. This finding aligns with previous work at the MTS

Table 5. Farming activity-related injury rate requiring hospitalisation, 15+years employed in the agricultural industry (ANZSIC06), top 10 Districts

District	Rate per 100,000 female farmers	Rate per 100,000 male farmers	Rate ratio (M/F)	Age/sex standardised rate per 100,000 (95% CI)
Waitomo	1815	5426	2.9	4370 (3119–5620)
Rotorua	1900	5212	2.7	4217 (3323–5112)
Waipa	2872	4551	1.6	4045 (3343–4747)
Taupō	2409	4477	1.9	4013 (2915–5110)
Thames-Coromandel	1709	4219	2.5	3504 (2334–4674)
South Waikato	2443	3861	1.6	3385 (2431–4339)
Matamata-Piako	1877	3939	2.1	3205 (2600–3810)
Opotiki	–	3589	–	2703 (1519–3886)
Whakatane	670	3333	5.0	2601 (1829–3374)
Ōtorohanga	980	3264	3.3	2564 (1706–3422)
Total (all 20 Districts)	1285	3296	2.6	2604 (2448–2761)

M (male); F (female); CI (confidence interval).

on equine injury, which found a higher risk profile for females.<sup>23</sup>

- Males <17 years – injuries from riding off-road motorbikes.
- Adult males – Motorbikes and quad bikes, injuries involving other vehicles or being struck, caught or crushed by objects.
- All males and females – injuries related to using quad bikes and two-wheeled bikes and falls in a wide variety of circumstances.

The recorded injury descriptions showed some categories of activities with smaller numbers of injuries resulting in hospital admission that could be prevented. An example of this would be not using accelerants to assist when burning rubbish on the farm (14 patients) and not allowing passengers on quad bikes or children (<17 years) to operate them. This aligns with research undertaken in the Midland region related to the use of quad bikes, which showed an increasing trend in related hospital admissions.<sup>24</sup> Appropriate training and close attention to safe knife use when skinning or butchering animals (21 patients) or trimming hooves (five patients) may prevent some of these injuries, although being in close quarters with livestock while trimming hooves is clearly a job with risk.

Falls may also be hard to prevent. Many falls occurred while chasing stock, slipping on wet surfaces, when carrying things, falling off vehicles or ladders, jumping obstacles, tripping in unseen holes and general slips, particularly on wet surfaces. Bentley *et al.* investigated slips, trips and falls in the dairy farming sector, looking for contributory risk factors through a systems analysis approach.<sup>25</sup> Due to task distractions and time pressures, farmers often did not identify underfoot hazards appropriately or used footwear not best suited to the task.<sup>25</sup> However, the reality is complicated by the fact that many are working on constantly wet surfaces such as concrete in cowsheds. There is also a wide variety of other surfaces to navigate in any farm environment, including steel surfaces, grass, mud, wood and gravel.<sup>25,26</sup>

Including all injury severities and using age and sex standardised hospitalisation rates in the farming sector (while undertaking farming activities), the highest rates were in Waitomo, Rotorua, Waipa and Taupō Districts – all with rates above 4000 per 100,000 population. These injury rates deserve further consideration in terms of the underlying mechanisms to raise awareness. In a 2015 Kellogg Rural Leadership Report, Brown<sup>27</sup> noted that from a farmer's perspective, health and safety issues are sometimes seen as the result of 'widespread



systemic failure in controls, process, management and culture', with no clear solution<sup>27</sup> with the farming industry needing to have their perceptions of themselves challenged. Brown identified some key issues in respect of this, including on-going high level of risk tolerance among farmers; inadequate and insufficient understanding of risks, hazards and responsibilities; lack of incentives (positive and negative) to foster behaviour and drive improvement; and poor data and measurement due to under-reporting of some incidents and near-misses.<sup>27</sup>

Alongside these issues, the conditions under which farmers often work include stresses from economic factors, working extended hours in certain seasons and not using the correct personal protective equipment.<sup>20,28</sup> In this context, farmers can be injured by animals, the machinery they operate (sometimes not sufficiently maintained) and the wider environment in which they work.<sup>26</sup> These factors may contribute to the high level of risk tolerance identified by Brown,<sup>27</sup> and collectively contribute to a complex setting for awareness raising and injury prevention. It is in this context that the MTS, as the regional trauma service provider, is in a unique position being able to review both major and non-major injuries severe enough to require hospitalisation. The inclusion of non-major injuries that can have significant impacts on injured people and their whānau, allows a clearer picture of the extent of the trauma burden. Making MTS trauma findings available for public discussion is ultimately aimed at injury prevention through awareness raising, and working collaboratively with others to improve health and safety.

### Study limitations

Limitations of this study include that people injured on a farm who attended an emergency department but were not admitted to a hospital, or who died at the scene, are not captured in the MTS trauma registry. Our study does not include injuries treated in primary care alone or injured people who sought no treatment from formal health services.

### Conclusion

Farms are both workplaces where agricultural workers are vulnerable to high injury and fatality

rates and also homes where farmers and their families (and visitors) undertake a wide variety of non-farming activities that can result in injury. The complex nature of farms and the farming environment means that people of all ages are exposed to a different set of risk factors than people in urban areas, whether engaging in farming-related activities or not. Children continue to be injured on quad bikes (as passengers and riders) as public debate continues around the wider safety aspects of these vehicles. This study found a wide variety of injury mechanisms and, while the trend in the number of farming-related injuries was variable over time, the number of injuries occurring outside of farm work increased over the 6-year period.

### Conflict of interest

The authors declare no conflicts of interest.

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