

Farm injury hospitalisations in New South Wales (2010 to 2014)

Tony Lower,¹ Rebecca J. Mitchell²

There is a significant body of international literature highlighting the hazardous nature of agricultural production.¹ This is replicated in Australia, with agriculture having the highest rate of work-related fatalities.² While there have been several assessments of fatal incidents in farming environments over many years in Australia,³⁻⁵ there is a relative paucity of data relating to hospitalised morbidity. Although national figures provide data on compensable injuries to workers through Safe Work Australia, it is estimated that these data under-numerate the true injury burden within agriculture by about 45%.⁶ This is a function of several factors, including many owner-operator farmers not being eligible for workers' compensation and work often being undertaken on a voluntary basis by family members and others. Furthermore, the Safe Work Australia national statistics do not account for injuries that occur within recreation or leisure activities on farms.

The Australian Institute of Health and Welfare compiled reports describing the characteristics of individuals who were injured and hospitalised through to 2009–10 that incorporated a farm as a location of the injurious incident.^{7,8} Other studies have focused on describing injuries that have occurred due to specific equipment, such as agricultural machinery or quad bikes (quads), or to particular segments of the population, such as children and young people.⁹⁻¹¹ There is only one sentinel report that comprehensively described hospitalisations following farm-related injuries in New South Wales (NSW), assessing the 1990–2000

Abstract

Objective: To examine gender differences in the characteristics, treatment costs and health outcomes of farm injuries resulting in hospitalisation of New South Wales (NSW) residents.

Method: A population-based study of individuals injured on a farm and admitted to hospital using linked hospital admission and mortality records from 1 January 2010 to 30 June 2014 in NSW. Health outcomes, including injury severity, hospital length of stay (LOS), 28-day readmission and 30-day mortality were examined by gender.

Results: A total of 6,270 hospitalisations were identified, with males having a higher proportion of work-related injuries and injuries involving motorbikes compared to females. Females had a higher proportion of equestrian-related injuries. There were no differences in injury severity, with around 20% serious injuries, in mean LOS or 28-day hospital re-admission. Treatment costs totalled \$42.7 million, with males accounting for just under 80% of the total.

Conclusions: There are some gender differences in the characteristics of farm injury-related hospitalisations. Farm injury imposes modest, but nonetheless relatively considerable, financial costs on hospital services in NSW.

Implications for public health: Continued efforts to ameliorate these injuries in a farm environment, which are mainly preventable, will have personal and societal benefits.

Key words: injury, farm, occupational, hospital, agriculture

period.¹² On an annual basis, this previous study identified about 1,590 farm injury hospitalisations with a male:female injury ratio of 3:1. For males, injuries involving motorbikes (14.4%), falls (10.3%) and agricultural machinery (9.0%) were most frequent. In contrast, horses (21.9%) and falls (19.0%) were more frequent mechanisms of injury for females. Children represented 16.3% of all those injured, with males accounting for 14.0% and females 23.0% of those injured. The highest prevalence of hospital admission was in the 15–19-year age cohort. Previous study recommendations for farm injury prevention programs in NSW centred on motorbike safety, safe horse

riding/handling, fall injury prevention and child safety on farms.¹²

There have been substantial changes in agricultural practices and technology in several commodity sectors since this previous assessment and it is unclear if this has influenced the pattern of hospitalised morbidity by gender. Additionally, while some limited data is available on the costs associated with fatal agricultural injury in Australia,^{13,14} there is an absence of any such information for the financial impact of hospitalised farm injury in NSW.

To attain a broader picture of the farm injury burden to inform preventive approaches,

1. Australian Centre for Agricultural Health and Safety, School of Public Health, University of Sydney, New South Wales

2. Australian Institute of Health Innovation, Macquarie University, New South Wales

Correspondence to: Dr Rebecca Mitchell, Australian Institute of Health Innovation, Macquarie University, Level 6, 75 Talavera Road, Macquarie University, NSW 2109; e-mail: r.mitchell@mq.edu.au

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further information on the characteristics of injury hospitalisation, health outcomes and associated costs to individuals, communities and governments is required. This study examined gender differences in the characteristics, treatment costs and health outcomes of farm injuries resulting in hospitalisation of NSW residents.

Method

A retrospective epidemiological examination was conducted of linked injury hospitalisation and mortality records between 1 January 2010 and 30 June 2014. Ethical approval was provided by the NSW Population and Health Services Research Ethics Committee (2015/08/599).

Linked hospitalisation and mortality data collections

The Admitted Patient Data Collection includes information on all inpatient admissions from all public and private hospitals in NSW. Diagnoses and external cause codes were classified using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM).¹⁵ Injury-related admissions involving NSW residents were identified using a principal diagnosis of injury (ICD-10-AM: S00-T78). Mortality data from 1 January 2010 to 31 March 2015 from the NSW Registry of Births, Deaths and Marriages was probabilistically linked to the APDC by the Centre for Health Record Linkage (CHeReL). Cases that were work-related were identified using the 'activity at time of incident' coding in the hospitalisation data.

Urban/rural and farm identification

The Australian Statistical Geographical Standard Remoteness Area (ASGS RA) was used to identify rural and urban residents. The ASGS RA assigns residents to one of five categories (i.e. major cities, inner regional, outer regional, remote and very remote) using defined index scores of distance to service centres of various sizes.¹⁶ The score is initially calculated on a one-kilometre grid, and then the mean value for each Census Collection District is aggregated to form the remoteness areas. The five categories were collapsed into two categories: urban (i.e. major cities) and rural (i.e. inner regional, outer regional, remote, and very remote NSW). Farm-related injury hospitalisations were identified using the place of occurrence classification of farm (i.e. ICD-10-AM: Y92.7).

Comorbidity identification

The Charlson Comorbidity Index¹⁷ was used to identify comorbidities using up to 50 diagnosis classifications in the hospital admission data and a 12-month look-back period to 1 January 2009. The Index was categorised as no reported comorbidity, mild-moderate comorbidity (i.e. 1 or 2) and severe comorbidity (i.e. ≥ 3).

Injury severity

Injury severity was estimated using the International Classification of Disease Injury Severity Score (ICISS) by applying existing survival risk ratios (SRR) to injury diagnoses classifications.¹⁸ The ICISS was derived for each individual by multiplying the probability of survival for each injury diagnosis using SRRs derived for each injury diagnosis.¹⁸ Three severity levels were used to define minor (≥ 0.99), moderate (0.941–0.99) and serious (≤ 0.941) injury.¹⁹

Hospital costs

The Australian Refined-Diagnosis Related Groups (AR-DRGs), episode of care length of stay (LOS) and episode of care type (e.g. acute, Sub-acute Non-Acute Patient (SNAP)) were used to estimate hospital costs. SNAP care was considered to involve psychogeriatric services, geriatric evaluation and management, maintenance services, and palliative care. In-hospital rehabilitation was separately identified using the AR-DRG classifications of Z60A, Z60B and Z60C.²⁰ Estimates of public hospital costs were obtained from national and NSW cost data collections.^{20,21} The average cost per AR-DRG included costs for medical and nursing clinical services, non-clinical salaries, pathology, imaging, allied health, pharmaceuticals, intensive and coronary care, operating rooms, emergency departments, supplies and ward overheads, specialist procedure suites, prostheses, staff on-costs (e.g. superannuation, termination, long-service leave, workers' compensation, recruitment costs), cleaning, linen and food services, and depreciation costs.²¹ For acute, rehabilitation and SNAP admissions within a period of care related to the index injury hospital admission, the average daily cost per AR-DRG was multiplied by the episode of care LOS up to 120 days. Where an episode of care exceeded 120 days, a flat rate of \$200 per day was applied thereafter, excluding long hospital stays for 19 select AR-DRGs used for

treatment involving tracheostomies, neonates and burns.²⁰ For patients who had existing chronic conditions that involved dialysis or chemotherapy treatment, the cost for these treatments were not included in the total hospital cost for injury. For patients treated for an injury-related period of care at a private hospital, the average daily public hospital AR-DRG costs were used as estimates of injury treatment cost. All costs are represented in 2009–10 Australian dollars.

Data management and analysis

All analyses were performed using SAS version 9.4.²² All episodes of care related to the one injury event were linked to form a period of care (i.e. all episodes of care related to the injury until discharge from the health system). Descriptive statistics and chi-square tests of independence were used to examine the characteristics and hospital costs of NSW residents who were hospitalised for an injury where the place of occurrence was a farm. Three-month mortality was calculated from the date of admission of the first injury-related hospital admission (i.e. the index admission). Twenty-eight day hospital readmission was considered as readmission within 28 days of hospital discharge for any cause. The calculation of hospital LOS included transfers between hospitals and both LOS and age-adjusted LOS were truncated to three standard deviations to exclude extreme outliers.²³ Linear regression was used to age-adjust for LOS and t-tests were used to compare differences between the sexes for unadjusted and age-adjusted LOS.²⁴

Results

Of the 709,464 injury hospitalisations of all NSW residents during the period, there were 6,270 identified as occurring on a farm (Table 1). Males dominated the cases (78.2%), with about 30% of male and female cases occurring in those aged 45–64 years. Children under 14 years of age accounted for 10.6% and 15.5% of male and female cases respectively, although the number of male cases was more than double that of females. Almost all the individuals injured on farm did not have any reported comorbidities (~95%). Working for income (34.7%) was the most commonly reported activity at the time of the incident. Males had a higher proportion of work-related injury admissions (38.7%

v 20.6%), with women incurring a higher proportion of sport and leisure-related injuries (21.2% v 12.1%), most notably involving equestrian activities (13.6% v 1.2%).

Transport incidents were responsible for just under half of all cases in both males and females (Table 2). Males had a higher proportion of incidents related to motorbikes (24.8% v 8.6%), with women having a higher proportion of other and unspecified land transport incidents (32.1% v 16.5%). The proportion of incidents involving quads and side-by-side vehicles (i.e. occupant of special all-terrain vehicles) were similar for both men and women (7.4% v 5.8%). Admitted injuries involving inanimate mechanical forces were more frequent for males (25.0% v 12.2%), while animate forces were responsible for a higher proportion of female injuries (21.7% v 13.0%), with incidents involving being bitten or struck by horses featuring (10.2%). In conjunction, the horse-related transport and animate force injuries accounted for 31.8% of all female injury admissions.

There were no statistically significant variations between genders for injury severity, with around 20% of injuries being classified as serious for both males and females. Similarly, there were no differences in 3-month mortality or readmission to hospital within 28 days. The mean age-adjusted LOS for males (4.2) and females (4.1) was also not significantly different.

Total hospital costs of injury-related hospital admissions and any subsequent rehabilitation or SNAP-related hospital treatment within the same period of care for farm injury were \$47.2 million (Table 4). Annually, this comprised: acute injury treatment (\$43 million); rehabilitation (\$3.1 million); and SNAP care (\$430,000). There was little difference in the mean or median costs by gender, with males accounting for just under 80% of the cases and total costs. Almost 30% of all costs were associated with persons aged 45–64 years and 56.8% for persons aged over 45 years. The highest mean and median costs were for those aged 65–84 years. Fractures represented the highest total hospital costs and accounted for 53.0% of all costs (Table 4). Injury to the nerves and spinal cord incurred the highest mean and median costs. The most serious injuries accounted for the highest costs and more than half the total costs.

Table 1: Demographic characteristics of individuals hospitalised with an injury that occurred on a farm by gender, linked hospitalisation and mortality data, NSW, 1 January 2010 to 30 June 2014.

	Male (n=4,904)		Female (n=1,366)		χ^2 (df)
	n	%	n	%	
Age group					
0-4	64	1.3	35	2.6	42.7 (11)**
5-9	148	3.0	59	4.3	
10-14	308	6.3	118	8.6	
15-19	446	9.1	137	10.0	
20-24	358	7.3	103	7.5	
25-34	593	12.1	149	10.9	
35-44	645	13.2	153	11.2	
45-54	728	14.9	222	16.3	
55-64	763	15.6	193	14.2	
65-74	518	10.6	106	7.8	
75-84	265	5.4	68	5.0	
85+	68	1.4	23	1.7	
Admission year^a					
2010	973	19.8	279	20.4	3.3 (3)
2011	1,073	21.9	288	21.1	
2012	1,080	22.0	325	23.8	
2013	1,206	24.6	312	22.8	
2014 ^b	572	11.7	162	11.9	
Number of comorbidities					
None	4,622	94.3	1,299	95.1	1.5 (2)
One or two	261	5.3	62	4.5	
Three or more	21	0.4	5	0.4	
Place of residence					
Urban	540	11.0	184	13.5	6.3 (1)**
Rural	4,364	89.0	1,182	86.5	
Activity at time of injury					
Sport or leisure activity	592	12.1	289	21.2	185.1 (5)*
Equestrian activities ^b	59	1.2	186	13.6	
Wheeled motor sports ^b	243	5.0	14	1.0	
Working for income	1,896	38.7	282	20.6	
Other types of work	369	7.5	121	8.9	
Resting, sleeping, eating or engaging in other vital activities	17	0.4	9	0.7	
Engaged in other specified activities	152	3.1	66	4.8	
Unspecified activity	1,878	38.3	599	43.9	

* $p < 0.0001$, ** $p < 0.01$.

a: Data were only available for 1 January 2010 to 30 June 2014.

b: Not included in χ^2 .

Discussion

This study identified a total of 6,270 farm-related hospitalised injuries, with these injuries involving a higher proportion of males (78.2%) than females (21.8%). A higher proportion of males were injured during work activities compared to females. Transport injuries accounted for just under half of male and female cases. Motorbikes and inanimate objects (machinery) for males and horses for women dominated these patterns. There were no differences in injury severity, with around 20% being serious, in mean LOS or 28-day hospital re-admission. Treatment costs totalled \$47.2 million, with males accounting for just under 80% of the total costs.

Treatment costs associated with the 20% of serious cases, accounted for 58% of the total expenditure for injury hospitalisation.

The ratio of male:female farm injury in these data was 3.6:1. These figures are comparable to a previous NSW study (1990–2000) and a more recent national Australian study (2009–10).^{8,12} They are also similar to a Canadian study that identified a ratio of 3:1 for non-machinery-related incidents, while the ratio for incidents involving machinery was 9:1.²⁵ While males account for 70% of the employed persons working in agriculture in Australia,²⁶ a comparative disproportionate gender impact of machinery on male injury was also evident in the current study, with a

Table 2: Injury mechanism of individuals hospitalised with an injury that occurred on a farm by gender, linked hospitalisation and mortality data, NSW, 1 January 2010 to 30 June 2014.

Injury mechanism	Male (n=4,904)		Female (n=1,366)		Total n
	n	%	n	%	
Transport incidents (ICD-10-AM: V00-V89)	2,205	44.9	613	44.8	2,818
Pedestrian	26	0.5	10	0.7	36
Motorbiker	1,218	24.8	117	8.6	1,335
Motor or heavy vehicle occupant	152	3.1	47	3.4	199
Other and unspecified land transport	809	16.5	439	32.1	1,248
Rider of horse	194	4.0	295	21.6	489
Occupant of special all-terrain or other motor vehicle designed for primarily off-road use	365	7.4	79	5.8	444
Water, air and other and unspecified transport (ICD-10-AM: V90-V99)	#		#		16
Falls (ICD-10-AM: W00-W19)	411	8.4	191	14.0	602
Fall on same level	127	2.6	90	6.6	217
Fall on and from ladder or scaffolding	20	0.4	7	0.5	27
Fall from, out of or through building or structure	36	0.7	14	1.0	50
Other fall from one level to another	104	2.1	21	1.5	125
Other fall on same level	47	1.0	25	1.8	72
Other and unspecified fall	77	1.6	34	2.5	111
Inanimate mechanical forces (ICD-10-AM: W20-W49)	1,227	25.0	167	12.2	1,394
Struck by thrown, projected or falling object	158	3.2	28	2.0	186
Striking against or struck by other objects	104	2.1	18	1.3	122
Caught, crushed, jammed or pinched in or between objects	166	3.4	49	3.6	215
Contact with lifting and transmission devices, not elsewhere classified	#	0.9	#	0.7	37
Contact with knife, sword or dagger	#	6.1	#	1.3	73
Contact with non-powered hand tool	46	2.2	9	0.7	55
Contact with other powered hand tools and household machinery	#	36.8	#	21.5	69
Contact with agricultural machinery	301		18		319
Contact with other and unspecified machinery	108		9		117
Other	452		36		488
Animate mechanical forces (ICD-10-AM: W50-W64)	639	13.0	297	21.7	936
Bitten or struck by dog	15	0.3	10	0.7	25
Bitten or struck by horse	95	1.9	140	10.2	235
Bitten or struck by cattle	316	6.4	76	5.6	392
Bitten or struck by sheep	69	1.4	23	1.7	92
Smoke, fire and flames (ICD-10-AM: X00-X09)	57	1.2	12	0.9	69
Venomous animals and plants (ICD-10-AM: X20-X29)	92	1.9	15	1.1	107
Poisoning (ICD-10-AM: X40-X49)	52	1.1	8	0.6	60
Intentional self-harm (ICD-10-AM: X60-X84)	#		#		11
Assault (ICD-10-AM: X85-Y09)	#		#		11
Other and unspecified injury mechanism (remaining ICD-10-AM codes)	186	3.8	54	3.9	240

Cell sizes <5 or to disguise cell sizes <5

Table 3: Health outcomes of individuals hospitalised with an injury that occurred on a farm by gender, linked hospitalisation and mortality data, NSW, 1 January 2010 to 30 June 2014.

Injury severity	Male (n=4,904)		Female (n=1,366)		χ^2 (df)
	n	%	n	%	
Minor (ICISS \leq 0.99)	1,805	36.8	533	39.0	2.5 (2)
Moderate (ICISS between 0.942-0.99)	2,055	41.9	560	41.0	
Serious (ICISS <0.942)	1,044	21.3	273	20.0	
3-month mortality	23	0.5	5	0.4	0.3 (1)
28-day readmission	474	9.9	129	9.6	0.09 (1)
Hospital length of stay	Mean	(SD)	Mean	(SD)	t-test (df)
Hospital length of stay (days)	4.1	9.1	4.5	9.4	-1.5 (2099.5)
Age-adjusted hospital length of stay (days)	4.2	2.5	4.1	2.5	1.9 (2.26.7)

ratio of 15:1. Although measures of exposure are not available, it is likely that this accounts for a substantial component of this gender variation.

The case distribution by age for both genders was slightly skewed to the older age groups, specifically those in the 45–74 year age range and may reflect the average age of Australian farmers (53 years).²⁷ Children under 15 years are also evident in the data, though their relative contribution to the overall burden has reduced somewhat for both genders from the prior 1990–2000 study.¹² Notwithstanding, children continue to be involved in around 10–15% of hospitalised injury, a finding which is in parallel with their representation in fatal injury.²⁸ In conjunction, these data reflect the mix of work and play that occurs on farms and reinforces the need to focus on child safety within the agricultural sector.

In the 1990s, almost 15% of all male admissions involved motorbikes;¹² however, this has now risen to one-quarter of all male admissions. At the same time, there has been a slight decrease in horse-related injury hospitalisations for males from 7% (1990–2000) to 4%.¹² Meanwhile, incidents involving other and unspecified vehicles including quads, have risen from 7% (1990–2000) to 24% in the current study.¹² Despite the lack of exposure data, some authors have speculated that quads have largely replaced motorbikes and horses within the agricultural sector.²⁹ However, the relative increase in motorbike incidents and slight reduction in horse incidents for males, runs counter to this suggestion. For women, horses have historically been the leading cause of admissions for farm injury and this remains the case, with virtually no change in the relative proportion of cases from 1990–2000 to this study.¹²

In examining mechanisms by age, transport incidents were proportionally more likely in the younger cohort, a pattern that is consistent and may indicate higher risk-taking in this group.³⁰ Meanwhile, the older cohorts were more likely to be involved in falls and animate mechanical injury. These later injuries frequently involved contact with cattle and horses in both genders, although the involvement of horses was elevated for females. Older age is a well acknowledged risk factor for fall injury in all areas of society.³¹ There is also existing data highlighting physiological changes (reflexes, balance, sight, hearing) that have been postulated as affecting safety within agriculture.³²

Persons in the 20–64 years categories had proportionally more inanimate injuries (inclusive of agricultural machinery). This finding is somewhat at odds with Canadian data suggesting older farmers actually increase their relative use of farm machinery as they age, preferring to use equipment rather than undertake alternate farm tasks.³³ However, whether the same scenario is true within Australian agriculture has not been determined.

On a national basis it is estimated that injury is responsible for 7% of the main long-term health conditions experienced by the estimated 4.2 million Australians living with a disability.³⁴ Within this study there were approximately 1,390 farm injury hospitalisations per annum, with 290 of these being classified as serious. While there were no gender variations in relation to injury severity, 30-day mortality, 28-day hospital readmission or LOS, the highly conservative annualised cost of these farm incidents is around \$10.5 million per annum in NSW. While this is a relatively modest sum in comparison to state expenditure on hospital care, they are nonetheless significant, particularly as there is a high potential for prevention of these incidents.³⁵ It is also noteworthy that the financial impacts only include hospitalised injury treatment costs, so no account is taken of a range of other factors including personal (e.g. lost earnings), business (e.g. replacement labour, equipment damage, workers compensation) and societal costs (e.g. psychological trauma, lost opportunity). Further, other treatment provided by general practitioners and/or allied health professionals is not included in the cost estimates. Consequently, while quantitative data regarding returns on investment in preventive approaches cannot be precisely determined, there is likely to be significant scope for such benefits.

The current study has a number of limitations. The identification of farm-related hospitalised injury in the current study is likely to be under-enumerated due to no incident location being specified in around one-third of the cases. Furthermore, the self-report classification of 'farm' is open to subjectivity and will likely include a range of properties from smaller lifestyle 'hobby' farms to commercial agricultural enterprises. Consequently, it cannot be ascertained to what extent the results reflect commercially orientated farm businesses. As already outlined, there is no exposure

Table 4: Total hospital costs by demographic, injury severity and nature of principal injury characteristics of individuals hospitalised with an injury that occurred on a farm, linked hospitalisation and mortality data, NSW, 1 January 2010 to 30 June 2014.

	n ^a	Mean (\$)	Median (\$)	Total (\$)	Annual Mean (\$)
Gender					
Male	4,904	7,585	2,536	37,195,566	2,565,211
Female	1,366	7,354	2,523	10,046,207	692,842
Age group					
0-14	732	4,109	2,103	3,007,582	207,419
15-24	1,044	5,952	2,227	6,214,351	428,576
25-44	1,540	7,034	2,523	10,832,903	747,097
45-64	1,906	7,757	2,999	14,785,616	1,019,698
65-84	957	10,971	3,797	10,498,767	724,053
85+	91	20,907	9,530	1,902,554	131,211
Nature of principal injury					
Fracture	2,620	9,570	4,050	25,074,518	1,729,277
Open wound	1,059	4,008	2,211	4,244,337	292,713
Poisoning by medicinal substances	12	5,207	3,811	62,473	4,308
Superficial injuries	336	2,321	1,175	779,905	53,787
Dislocations, sprains and strains	248	5,077	2,227	1,258,888	86,820
Injury to muscle, fascia and tendons	246	4,757	2,999	1,170,201	80,704
Injury to internal organs	552	9,507	1,939	5,247,643	361,906
Burns	121	13,948	2,449	1,687,675	116,391
Injury to nerves and spinal cord	64	44,024	5,977	2,817,558	194,314
Toxic effects of non-medicinal substances	107	2,266	1,262	242,494	16,724
Traumatic amputation	163	6,335	3,548	1,032,621	71,215
Injury to blood vessels	23	12,803	5,046	294,466	20,308
Injury of eye and orbit	41	6,721	2,206	275,544	19,003
Crushing injury	63	4,259	2,199	268,286	18,502
Other and unspecified injuries	615	4,529	1,106	2,785,165	192,080
Injury severity					
Minor	2,338	3,719	2,523	8,694,757	599,638
Moderate	2,615	5,269	2,211	13,779,592	950,317
Serious	1,317	18,806	6,250	24,767,424	1,708,098

a: Where valid AR-DRG was present.

data underpinning the range of injurious mechanisms and hence inferences from these data need to consider in this context issue. Additionally, data validity was not able to be assessed and it is possible there could be some misclassification in hospital records. There is also likely to be some degree of error in the data linkage process; however, the CHeReL estimates the false positive rate for this linkage to be 0.5%.

Conclusion

There are some gender differences in the characteristics of hospitalised farm injury. The overall pattern of injury remains similar to earlier hospitalised morbidity data (1990–2000), with transport incidents being key issues for both genders. While there is some variation in causal mechanisms, targets for prevention should include motorbikes (males), horses (females) and quads (both genders). Injury issues related

to agricultural machinery (males), falls (both genders) and children also persist. There is also a relatively high injury burden incurred by older persons. While the overall hospitalisation costs associated these farm injuries is relatively minor in comparison to the total state budget for these services, they remain considerable. There are personal and societal benefits that can accrue from reducing these predominantly preventable injuries by addressing the identified targets for preventive activity.

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