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Tractor Rollover Fatalities Australia 2000 – 2010

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Accompanying documents to this report

*Tractor Rollover Fatalities, Australia
2000 – 2010 (Research summary)*

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Executive Summary

Tractors are associated with more fatalities than any other piece of machinery in agriculture, with tractor rollovers being a frequent mechanism. Tractor fatalities between 1985 and 2010 and the impact of the Rollover protection structures (ROPS) retrofitting legislation was investigated.

During this period 121 tractor fatalities occurred of which 55 were rollovers.

Statistical modelling indicated a significant decline in rollover fatalities during this period of approximately 7% per annum (Incidence rate ratio [IRR] = 0.93, 95% CI 0.90 - 0.97). There was no simple relationship between the introduction of the legislation and the fatality decrease, as the statistical modelling did not detect a significant change in the fatality rate in 1998.

It is proposed that the impact of previous voluntary retrofitting initiatives, may have hastened its effectiveness by encouraging farmers to install ROPS at an earlier point, diluting the effect over a number of years so that it could not be detected using the statistical techniques that have been applied.

Furthermore, the research indicated that there was an increase in run over fatalities over the same time period (IRR = 1.04, 95% CI 1.00-1.09) suggesting the need for research into interventions for this type of fatality, such as safe tractor access platforms.

Section A: Review of the scope of Tractor Rollovers in Victoria

Agriculture is one of the most hazardous industries in the U.S. (Sanderson et al., 2006) and Canada (Pickett 1999). In the U.S., tractor overturns produce the greatest number of agricultural machinery related fatalities (Sanderson et al 2006). Similarly, in Australia, tractors have been identified as being associated with more fatal injuries than any other piece of agricultural equipment. (Franklin et al, 1999).

A study of farm work related fatalities in Victoria, for the period of 1985-1996, showed that, in line with national trends, tractor incidents were the most common type of fatality (72%) in that state, and that tractor roll overs accounted for 61% of all fatal tractor incidents (Day, 1999) . Run-overs and entrapment in or between moving parts accounted for 12% and 11% of tractor fatalities respectively at that time.

Since that study, a number of measures have been employed in Victoria to reduce tractor roll over deaths specifically. In view of the demonstrated effectiveness of roll over protective structures (ROPS) in fatality prevention (Springfeldt, 1993), the state authorities sought to encourage the installation of ROPS by conducting a series of rebate programs (1987, 1990, 1994, 1997/98) to offset installation costs. These endeavours to address the tractor roll over problem were conducted within the context of other initiatives to address farm safety more generally. Legislation requiring ROPS to be installed on new tractors manufactured or imported from 1981 came into effect in November 1998 and was supported by information, awareness and education programs (Day and Rechnitzer, 1999).

The 1997/98 rebate program, which coincided with the implementation of legislation mandating the retro-fitting of ROPS to existing tractors, achieved high participation rates and was effective in reducing the number of unprotected tractors from approximately 24% to 7% (Day, Rechnitzer and Lough, 2004). However, it is not known whether this reduction in the number of unprotected tractors in Victoria, has translated into a sustained reduction in roll over related fatalities. Further, trends in other types of tractor related fatalities have not been examined for the post legislative implementation period.

Therefore, the main aims of this study were to (1) determine whether measures related to the increased use of roll over protective structures on tractors have resulted in a reduction in tractor roll over fatalities in Victoria, and (2) determine the patterns and trends of all fatal tractor related incidents in Victoria from 1985 to 2010.

Section B: Tractor Rollovers in Victoria, 2000-2010

Fatality data for agricultural workers (excluding forestry and fishing) aged 15 years and older for the period January 1985 to December 2010 was provided by WorkSafe, Victoria. Deaths determined to be strictly of natural causes, by suicide, or traffic accidents (unless due to work related causes) are not included in this definition.

Cases for this study were selected from the Worksafe database, with supplementary coding of each case undertaken by researchers. Tractor related fatalities were identified and coded according to type. A tractor incident was defined as one in which a tractor and/or attachment was the agent of fatal injury, or where the tractor and/or attachment was a major factor in the cause of a fatal injury event. Front-end loaders were assumed to be attached to a tractor and were therefore included in the analysis. Supplementary coding based on the textual descriptions of incidents was undertaken to classify tractor fatalities into rollover, run over by tractor or attachment, entrapment by tractor or attachment, and other causes. The textual descriptions for cases from 1995-2010 were also used to gain an understanding of the context of the fatality.

In the absence of an figure for hours worked on tractors, total working hours estimates prepared by the ABS (2006b) were used as the best available measure of exposure to risk for the agricultural worker population involved in the study. As this figure was not constant (average weekly working hours ranged from 45.1 \pm 2.2 hours per week in 1986 to a minimum of an average of 38.8 \pm 1% hours per week in 2004, before a slight increase to 41.7 \pm 1.2% hours in 2009), the annual estimate of working

hours was incorporated in the statistical modelling as an estimate to control for the amount of exposure that farmers had to tractors.

Fatality frequencies were converted to rates per 1,000,000 working hours of adult persons employed in agricultural industries in Victoria using, as the denominator, labour force estimates prepared by the Australian Bureau of Statistics (2006b).

These estimates include persons 15 years and over, who are employed in agriculture as an employer, employee, self-employed or contributing family member, as well as estimates of the hours worked. The annual employed population was calculated as the average of the four quarterly estimates, and working hours were based on summing the quarterly part-time and full-time working hour estimates.

Three-year moving average fatality rates were generated by dividing the average frequency for each three year interval by the employed work force average of each interval. Three-year moving average rates were used for the descriptive analysis, since considerable year-to-year variation was present in the annual frequencies.

The analysis tested to see what sort of trends in annual agricultural fatalities existed (all farm fatalities, all tractor fatalities, tractor roll over fatalities, tractor non roll over fatalities, and non tractor fatalities) were analysed. The process explored if there was a linear change in fatality rate, or if it changed significantly in 1998, or if there were multiple changes over the years (in 5 year blocks).

RESULTS

Tractor fatality trends

There was a total of 131 tractor related fatalities in Victoria between 1985 and 2010, of which 55 were due to tractor roll over (Table 1). Three-year moving average rates for all farm fatalities and tractor related fatalities (roll over and all non roll over) for the period between 1986 and 2010 and are shown in Figure 1. A downward trend for deaths due to tractor roll over can be seen particularly between 1985 and 1997.

Table 1. Frequency of tractor and all farm fatalities, 1985-2010

Year	Roll over	All farm	All tractor	Run over	Other tractor fatality type
1985	2	5	3	0	1
1986	5	10	10	1	4
1987	7	8	7	0	0
1988	5	7	7	1	1
1989	2	4	4	2	0
1990	4	8	7	1	2
1991	2	5	3	1	0
1992	5	9	6	0	1
1993	3	7	6	0	3
1994	5	14	9	1	3
1995	2	12	6	4	0
1996	1	9	3	0	3
1997	1	11	4	1	2
1998	0	9	4	3	1
1999	1	14	5	3	1
2000	1	11	6	3	2
2001	3	12	7	3	0
2002	0	9	1	0	1
2003	0	7	5	3	2
2004	2	13	8	2	4
2005	0	1	0	0	0
2006	1	7	3	1	1
2007	1	8	6	2	3
2008	0	8	3	1	2
2009	1	13	5	3	1
2010	1	11	3	2	0

Inspection of Figure 1 reveals that there is no consistent trend associated with the rebate programs, with decreases notable for only two of these (1987 and 1991). Most of the reduction had occurred prior to mandatory requirement for ROPS retro-fit and the final round of rebates in 1997/98, by which time the fatality rate had fallen to an average of 3.54 roll over fatalities per 1,000,000 person working hours. Inspection suggests that, although there was a temporary increase in fatality rate in the early 2000s related to 3 fatalities that occurred in 2001, there was no further reduction following introduction of the ROPS retro-fit legislation.

The statistical analysis confirmed these observations and found that a linear change was the best explanation for the trend observed, rather than a change in the rate in 1998, or multiple changes in rates in 5 year blocks. The model estimated that the annual incidence rate decrease was 7% (Incidence rate ratio [IRR] = 0.93, 95% Confidence Interval 0.90 - 0.97)¹. When reading IRR results, a figure greater than one is an increase, and less than one is a decrease, where 0.01 equals a one percent change.

All farm fatality rates, non-tractor fatality rates, all tractor fatality rates, run over tractor fatalities and other tractor fatalities (all tractor fatalities that were not roll over or run over) were analysed using the same techniques. Over the 26 years, the all cause farm fatality rate increased by an estimated 2%, however within that figure,

¹ The 95% confidence interval represents the range that the statistical procedure estimates the actual change to be contained within 95 times if the study were repeated 100 times.

the rate of tractor fatalities remained constant. Of tractor fatalities, run over fatalities increased (IRR = 1.04), while other tractor related fatality types remained constant (IRR = 1.00) (Table 2).

Table 2. Time based characteristics of fatality rates for farm fatalities, Victoria, 1986-2010.

	IRR	95% CI
All farm fatalities	1.02*	1.01-1.04
Tractor fatalities (all types)	0.99	0.97-1.01
Roll over fatalities	0.93*	0.90 - 0.97
All non-roll tractor fatalities	1.03*	1.00 - 1.07
Run over fatalities	1.04*	1.00 - 1.09
Other fatalities	1.00	0.96 - 1.05

*Change is statistically significant

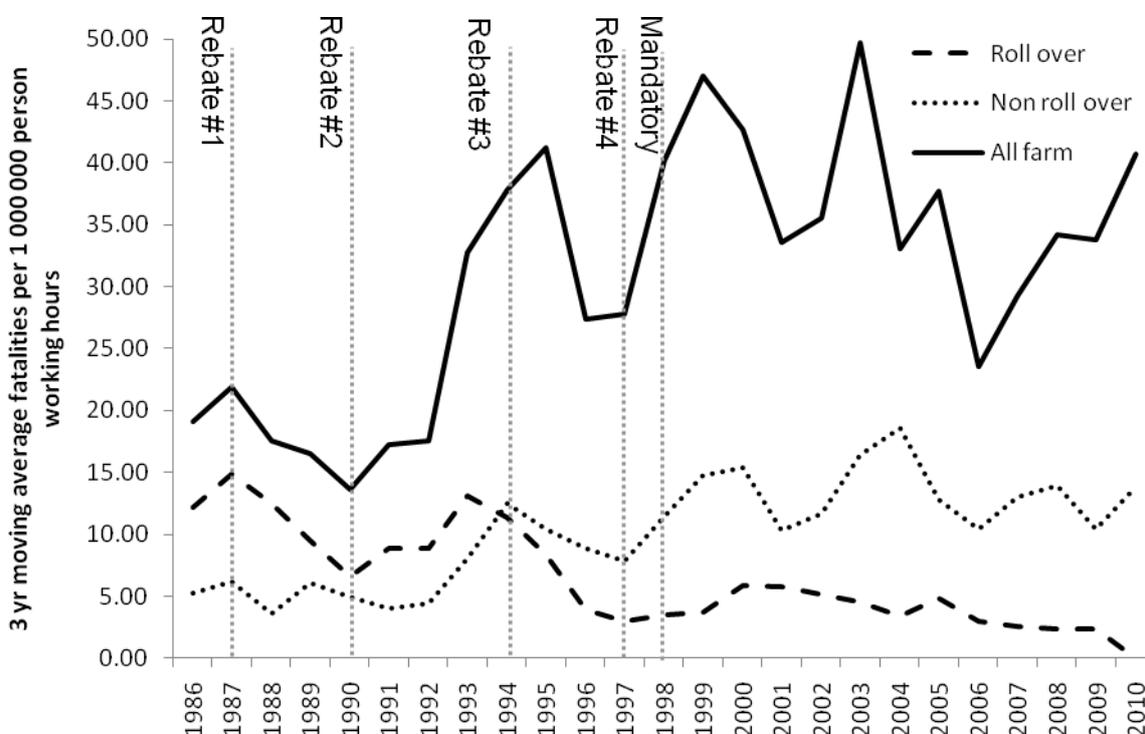


Figure 1: Three-year moving average per 1 000000 person working hours for All farm, Roll over and Non roll over tractor fatalities, Victoria, 1986 – 2010. *Note: Rebate 1 (1987) N = 389, Rebate 2 (1990) N = 1990, Rebate 3 (1994) N = 1116, Rebate 4 (1997) N = 12,129*

3.2 Type of incident

Three main types of incident associated with the tractor fatalities were identified: tractor rolled over (or flipped), run over by a tractor or its attached implements, or entrapment where the person was caught in or between tractor parts (or tractor and object). The three year moving average for each is reported in Figure 2.

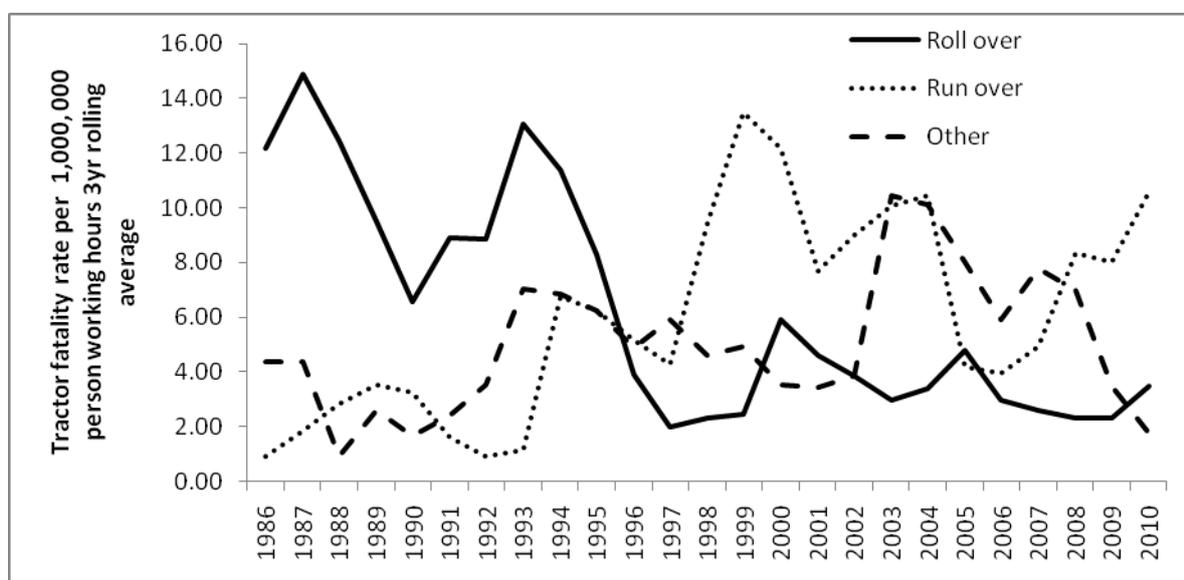


Figure 2: Three-year moving average tractor fatality rate per 1,000,000 person working hours by tractor fatality type, Victoria, 1985 – 2010

Circumstances associated with tractor fatalities

Roll over (N=55)

Of the 10 roll over fatalities since 2001 for which data is available, five are known to have involved tractors that had no ROPS fitted, three were known to have ROPS fitted, and for the remaining two, ROPS status is unknown. Most cases involved driving the tractor on steep embankments, and two involved the tractor flipping

backwards (towing a heavy load up an incline; attempting to pull out a tree stump). In one case where a ROPS was attached, being thrown out of the tractor caused the death.

Run Over (N=38)

Common circumstances associated with tractor run over deaths were parking on sloping ground, with brakes not fully engaged, or alighting from the tractor to perform another activity such as to close a gate, cut hay bale string or feed out hay. While in some cases the slope was steep, in others it was only slight but sufficient to give rise to movement. Other run over fatalities occurred while attempting to start or adjust the tractor, after falling from or being thrown from the tractor, or attempting to mount a tractor while in motion.

Other (N=25)

Fatality circumstances included becoming entangled in unguarded power take off shaft/ auger, or being caught by a moving wheel or an attachment such as a trailer or wire.

Section C: Discussion of results and Future Directions

During 1985-2010 fatalities due to tractor rollover fell from a 3 year rolling average rate of almost 12 per 1 million person working hours at the start of the study period to approximately 2.3 at its conclusion. These findings are similar to findings in Sweden between the 1950s and 1980s that showed a significant decrease in tractor roll over fatalities associated with ROPS installation in that country.

The statistical tests confirmed a significant decline in roll over fatalities over the study period, however the modelling did not indicate a significant change in the rate of the decline at 1998 (the year of the mandatory installation requirement). This indicates that imposition of the mandatory installation requirement did not of itself significantly change roll over fatality frequency. On the surface, this is somewhat surprising, given the proven effectiveness of ROPS (Reynolds and Groves, 2000). However, the known impending status of legislation may have hastened its effectiveness by encouraging farmers to install ROPS at an earlier point, diluting the effect over a number of years so that it could not be detected using the statistical techniques that have been applied. Furthermore, in the years following the mandatory installation requirement, the fatality frequency has remained at zero or one per year (except in 2001 and 2004 where there were three and two fatalities respectively).

Given that a continuous decline in the fatality rate was noted, one explanation could be the cumulative effect of previous effective voluntary installation efforts and associated education and awareness raising initiatives (Day and Rechnitzer, 1999). A similar course of events can be seen with other public safety initiatives, such as

the introduction of mandatory bicycle helmets wearing laws (“helmet laws”) which occurred in 1990 in Victoria. Helmet wearing rates were reported to have increased prior to the introduction of the helmet laws especially in children (Finch, Heiman and Neiger, 1993). An assessment of their effectiveness in their first 4 years of operation showed a decrease in head injuries to cyclists of approximately 40%, compared with pre-legislation rates (Carr, Skalova and Cameron, 1995). Similar effects (25-29% reduction) have been noted in New South Wales (Walter, et al.,2011). As with the ROPS legislation, when the helmet laws took effect on 1 July 1990, they had been preceded by at least 10 years of promotion, including public education, consultation with cycling groups and financial incentives (Carr, Skalova and Cameron, 1995).

The pattern of reduction in fatalities over time is consistent with observations in the literature from the Nordic countries that ROPS prevalence rates need to reach 75-80% before rollover fatalities approach zero (Meyers and Hendricks, 2010). The estimated penetration rate in Victoria was 93% by the time ROPS was mandated (Day, 1999).

Roll-over fatalities still occur, and the available evidence indicates that this is due to some tractors remaining without ROPS fitted (or have been removed after fitting), or other mechanisms of death have occurred that ROPS could not prevent (for example being thrown out of a tractor due to a failure to wear a seatbelt, noted with two-post ROPS fatalities (Day and Rechnitzer, 1999). The narrative accompanying one fatality report indicated that a ROPS fitted tractor rolled, but the fatality was attributed to an object incursion into the cabin, and in another, the deceased was ejected from the

cabin. In the latter circumstance fitment and use of seatbelts is a known effective intervention (Myers, Cole and Westneat, 2006).

Overall, the statistical tests indicate an increase in the all farm fatality rate over the period, however it appears that this is not due to an increase in tractor related fatalities, as this rate did not significantly change over time. Nevertheless, although the overall tractor fatality rate has remained constant, this is due to the combined effects of a decrease in roll over fatalities being offset by an increase in non roll over fatalities, with no change in the rate of tractor fatalities for other reasons. This observation of an increase in run over fatalities continues the trend noted by Day (1999).

Similar mechanisms to those underlying tractor run over fatalities (e.g. parking on an incline coupled with the inappropriate functioning of brakes) have also been noted in non-crash heavy vehicle fatalities (Jones, Ibrahim and Ozanne-Smith, 2011) which may also suggest that prevention strategies targeting brakes and braking practices may be effective for both populations. Further research is required on fatalities due to all types of rolling vehicles and in particular, enhancements to ensure 'failsafe' braking mechanisms for inclines would appear to be warranted.

In addition, fitment of safe tractor access platforms for mounting tractors, to lessen the risk of run-overs is one strategy that may be effective and could be implemented, as retrofit design solutions at reasonable prices have been developed and tested (Day, 2004). Likewise, ensuring that new tractors have suitable access platforms

(e.g. by use of assessment tools such as the Safe Tractor Assessment Rating System (Scott, Williams Day, Rechnitzer, Walso and Boyle, 2002) would likely prevent fatalities.

As newer tractors have more advanced safety features than older tractors, it might be expected that as the tractor fleet is renewed over time, tractor related fatalities will decrease. Certainly a 4% increase in the odds of farm machinery injury has been observed for each year increase in machine age (Baker and Day, 2008). Future research into the age of the tractor fleet may provide insight into whether retrofitting in other areas to address other fatality modalities (eg safe tractor access platforms and steps to prevent run over) would have sufficient benefit to warrant large scale intervention.

Clearly, while less-safe tractor designs remain in the fleet, behaviour change with respect to safe use of tractors is also needed, yet this has been notoriously difficult to achieve, although recent attempts utilizing social behaviour techniques may provide a way forward (Sorensen et al 2008).

Study Strengths and Limitations

This study was based on historical data extending over a 25 year study period, including 12 years following a primary intervention that required the mandatory installation of ROPS. However the nature of the design does not allow elimination of other potential factors, and hence causation cannot be concluded. Nevertheless,

the potential confounding exposure factors of population and working hours have been incorporated in the analyses.

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