



An Australian Government Initiative



FARM MACHINERY INJURY

Injuries associated with posthole diggers

A report for the Rural Industries Research
and Development Corporation

by J Miller, L Fragar and R Franklin

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Foreword

Injury on farms and its prevention is a key issue for Australian agricultural and horticultural industries with the common causes of farm injury have been well documented in reports and papers.

This report is one of a series of in-depth investigations into preventable risk factors associated with operation of specific items of farm machinery.

Posthole diggers are found on many farms, although many are only operated on an infrequent basis as the need arises. This report establishes that most of these items of equipment have significant safety risks and a multifaceted approach to reducing risk of death and serious injury has been recommended.

The report has been considered by the Farmsafe Australia Farm Machinery Safety Reference Group and action is being based on the report findings and the responses from Australian suppliers and operators.

This project is funded by the RIRDC managed **Joint Venture in Farm Health and Safety** which is partnered by the Grains R&D Corporation, Meat and Livestock Australia, Australian Wool Innovation Corporation, Cotton R&D Corporation, Sugar R&D Corporation and the Rural Industries R&D Corporation.

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Executive Summary

Aim

The aim of the project was to collate and analyse all available injury data and case reports relating to accidents involving the operation of a posthole digger.

This information will be used to:

- Define the injury problem and identify contributing factors.
- Identify, define and recommend a range of measures to improve safety levels associated with this equipment, and to reduce the quantity and severity of injuries resulting from accidents while operating posthole diggers.
- Through the above measures to bring about a reduction in the human and financial cost of posthole digger accidents.

Background

Posthole diggers are a common implement on most Australian farms and are used for fencing and fence maintenance. Use is infrequent, thus the operator is often not familiar with associated hazards. The intermittent use factor raises the possibility that on a 'per hours of use' basis posthole diggers are among the more dangerous machines to be found on a farm. A national survey of 1 200 farmers carried out in 1993 by the Kondinin Group showed 86% reported having a posthole digger, and 29% a post driver (Kondinin Group, 1993).

The extent of the problem of injury related to operation of posthole diggers was not clear at the time the National Farm Machinery Safety Strategy was formulated, however there were indications of the possibility of three deaths per year average, with a proportional number of injuries.

Method

A search was carried out of all available sources of data relating to accidents involving post-hole diggers and post drivers, including internet resources, libraries and educational facility collections. The information collected was collated and analysed to identify key factors relating to the accidents.

Advertisements were placed in rural press publications seeking input from accident victims, respondents being asked a number of questions according to a pre-determined format in order to determine the factors involved in their accident.

The Monash University Accident Research Centre opportunistically included a question relating to injury associated with posthole diggers in a survey of farmers in Victoria in 2001.

Analysis of the data and case histories was carried out to determine the contributing factors, human, environmental and machine, which led to the accidents identified.

Methods for improving working practices, machine design, machinery standards and education were investigated, with a view to compiling recommendations that can be introduced to reduce the traumatic accident occurrence.

Results

The one fact that became obvious from the case studies of events involving posthole diggers was that, while such events are not numerically common, the resulting injuries are in almost every case extremely traumatic. It is this traumatic nature of injury, rather than the incident occurrence rate, that necessitates remedial action be taken to reduce the risk factors, and thereby reduce the injury events.

The risk factors identified from the available literature were reported in relation to operator risk factors, risk factors relating to the machine and environmental risk factors. Consideration of these, and of the nature of the injury and the body part affected allowed for options for risk reduction to be documented.

Recommendations

The following recommendations are made to the Farmsafe Australia Machinery Safety Reference Group for the reduction of risk associated with operation of posthole diggers in Australian agriculture and horticulture industries:

1. That information material be prepared outlining the hazards associated with the operation of posthole diggers and correct operating procedures to be followed to reduce those hazards, and that these materials be made readily available to rural workers. These materials should include information relating to modifications that may be possible to be carried out on existing machines.

Manufacturers should be consulted and asked to participate in the development of such material. The document should be developed as a nationally endorsed Guidance Note.

2. That educational materials be prepared and made available to rural education and training institutions.
3. That posthole digger manufacturers be encouraged to ensure that the machines achieve the highest possible safety standards, and that safe operation be actively promoted by sales personnel and via improved operators' manuals.

Manufacturers generally could advance the promotion of safety by the provision of much more comprehensive owners' manuals than are currently issued with most machines. Operators should be made aware of those risks that the manufacturer has not been able to eliminate, and to ensure they do not use the machine in a way that will create new risks.

4. That suppliers ensure that safety information is provided to buyers of posthole diggers. The design and fitting of safety features is of little use unless sales personnel are required to discuss safety issues with customers, and emphasise the importance of features such as force-down rams.
5. That farmers be encouraged to dispose of older posthole diggers, and to use fencing contractors for fencing requirements.
6. That an Australian Standard be prepared for the design of posthole diggers, establishing a level of safety that is economically achievable.

A specific Australian Standard should cover the design and operation of posthole diggers to encourage the broad use of the safety features that are available.

The Australian Standard AS1121-1983, *Guards for Agricultural Tractor PTO Drives*, requires revision to ensure that optimal safety requirements are met within practical limits. Improvements in materials and material testing since 1983 should be utilised in the Standard to promote the production of PTO guards with extended operating life, and the guard specification should be assessed to eliminate the chance of entanglement. The standard should be extended to cover alternative types of guard in addition to the conventional type.

7. That a method of recording rural accidents be introduced that will provide the data necessary for future accident research.
8. That future event data relating to posthole digger accidents be analysed in an ongoing manner to enable knowledge of the causal factors to be improved.

1. Aim

The aim of the project was to collate and analyse all available injury data and case reports relating to accidents involving the operation of a posthole digger.

This information would then be used to:

- Define the injury problem and identify contributing factors.
- Identify, define and recommend a range of measures to improve safety levels associated with this equipment, and to reduce the quantity and severity of injuries resulting from accidents while operating posthole diggers.
- Through the above measures to bring about a reduction in the human and financial cost of posthole digger accidents.

2. Background

Each year, on average, 36 deaths occur on Australian farms as a result of agricultural machinery accidents, and more than 500 people are admitted to hospital suffering severe injury related to farm machinery.

Farmsafe Australia established the National Farm Machinery Safety Reference Group with the purpose of developing and implementing strategies to reduce the number of deaths and injuries attributable to on-farm machinery accidents.

The National Farm Machinery Safety Strategy document, issued in June 1998 by Farmsafe Australia, identified farm machinery operators as the number one occupational group at risk of a work related fatality. This document further identified priority problem areas not currently being addressed as:

- Tractor run-overs;
- Grain auger injuries;
- Post-hole digger injuries;
- Other (PTO injuries)

With regard to posthole digger accidents, the strategy document identified the stakeholders as being:

- Operators of machinery
- Manufacturers/distributors
- Tractor/machinery group
- Surgeons and the rehabilitation sector
- Rescue organizations
- Ambulance
- Regulatory authorities
- Farm women
- Young person – potential farmer
- Agricultural college lecturers
- Engineers

The extent of the problem of injury related to operation of posthole diggers was not clear from the data available at the time the strategy was formulated, however there were indications of the possibility of three deaths per year average, with a proportional number of injuries.

Posthole diggers are a common implement, most Australian farms having such a machine available to use for undertaking fencing and fence maintenance. Use is infrequent, thus the operator is often not familiar with associated hazards. The intermittent use factor raises the possibility that on a 'per hours of use' basis posthole diggers are among the more dangerous machines to be found on a farm. A national survey of 1 200 farmers carried out in 1993 by the Kondinin Group showed 86% reported having a posthole digger, and 29% a post driver (Kondinin Group, 1993). The 1998-99 Agricultural Census conducted by the Australian Bureau of Statistics identified 145 226 establishments undertaking agricultural activity, of which 143 407 had agriculture as the primary activity. Accepting the Kondinin report as being representative of all farms, it is possible to estimate the number of machines in Australia as 123 000 posthole diggers and 41 500 post drivers.

Internationally, the problem of posthole digger accidents has been recognised for some time, although little remedial action has been taken. The United States Secretary of Labor defines some agricultural tasks "hazardous" to persons under the age of 16 years, and no person under that age may be employed at any time on that job. Such hazardous jobs include operating powered posthole diggers and post drivers. Violation of these laws may result in fines up to \$10 000 or up to 6 months jail. Similarly the Irish Republic has introduced a "Code of Practice on Preventing Accidents to Children and Young Persons in Agriculture" (2001). This document lists 'machines incorporating power-driven soil engaging parts' among those not to be driven, operated or maintained by minors.

For the purpose of this project any powered machine designed, or which may be utilised, to excavate a hole in the earth for the placement of a fence post was classified as a posthole digger. Because of the similarity in purpose, post drivers were also included in the project guidelines, bearing in mind that these machines are frequently fitted with an auger for the purpose of boring a pilot hole before driving the post.

3. Method

The report is the result of a research project carried out by the Australian Centre for Agricultural Health and Safety with a view to implementing the recommendations of the National Farm Machinery Safety Strategy. Research was carried out under the guidance of the National Farm Machinery Reference Group.

A search was carried out of all available sources of data relating to accidents involving post-hole diggers and post drivers, including internet resources, libraries and educational facility collections.

The search for data and case histories was hampered by the use of varied nomenclature for implements, especially in overseas countries. Posthole diggers were found under posthole auger, earth auger, earth drill, posthole borer, posthole drill, etc, and post drivers were listed as post pounders, pole drivers

The information collected was collated and analysed to identify key factors relating to the accidents.

Advertisements were placed in rural press publications seeking input from accident victims, respondents being asked a number of questions according to a pre-determined format in order to determine the factors involved in their accident.

The Monash University Accident Research Centre opportunistically included a question relating to injury associated with posthole diggers in a survey of farmers in Victoria in 2001. The survey was an evaluation of farm injury prevention in that state. The question asked was:

Have you ever had an injury or a frightening near miss while using a posthole digger?

If Yes, please describe how it happened and what injury you sustained.

The various designs of posthole digger currently in use were studied to determine hazards and safety features inherent in each design type.

Analysis of the data and case histories was carried out to determine the contributing factors, human, environmental and machine, which led to the accidents identified.

Methods for improving working practices, machine design, machinery standards and education were investigated, with a view to compiling recommendations that can be introduced to reduce the traumatic accident occurrence.

The limited data available for analysis did not allow definitive results to be obtained. Conclusions had to be reached based on the data that was available, by concentrating on the trends and patterns that could be observed.

The one fact that became obvious from the case studies of events involving posthole diggers was that, while such events are not numerically common, the resulting injuries are in almost every case extremely traumatic. It is this traumatic nature of injury, rather than the incident occurrence rate, that necessitates remedial action be taken to reduce the risk factors, and thereby reduce the injury events.

4. Research results

Reliable data relative to this project is not readily available. A search of internet resources and libraries, and contact with various overseas professional groups and individuals, has not resulted in any comprehensive overseas data, except from New Zealand (Anon, 1999). A number of cases have been identified from newspaper reports and court cases in the United States, however these are not in sufficient detail or number to provide a reliable database. Overseas accident reporting systems suffer the same deficiencies as the Australian system.

Australian data is not extensive, being limited in both availability and detail. The current method of classifying accidents does not specify posthole diggers as a cause, such cases generally being classed as 'other plant'. The main sources of Australian data are the first work-related fatalities study conducted by the National Occupational Health and Safety Commission, 1982 to 1984 and the second study conducted by NOHSC, 1989 to 1992 (Franklin et al, 2000). The Queensland "Survey of Farm Work Injury", (Ferguson, 1996) identified five injuries suffered during fencing operations, which may or may not have involved posthole diggers. One case identified in this report was a broken wrist caused by a digger.

Advertising in rural papers asking for information from those who had been involved in accidents resulted in a very limited response, however the input from those who did respond was invaluable in assessing the problem, and to obtain the viewpoint of the user to posthole digger operation and hazards. In addition to a small number of farmers reporting accidents they had suffered, there was a response from several experienced fencing contractors with comments on general safety and operating issues concerning these machines. The information obtained from this source was treated as being possibly distorted by time and distance from the accident.

Annual accident figures cannot be estimated because of the difficulty in relating the sample of accidents identified to the total of posthole digger accidents.

While the sample of accidents identified may not include all types of posthole digger accidents that may occur, it would appear to be representative of common accident types.

4.1 Posthole Digger Designs

A number of machine types are in use to carry out the function of boring holes in the earth, whether for erection of posts or for other purposes. These generally consist of a vertical auger, rotated by some form of drive system, either mechanical or hydraulic. The designs encountered during the conduct of this project are described below, however it is not claimed that this is an exhaustive listing.

The concept of the posthole digger appears to have developed from a hand operated auger type machine invented in the United States in 1918. A US patent was issued in 1923 for a trailed type posthole digger, belt driven from the towing tractor. A US patent was issued in 1927 for a belt driven digger mounted on the front of a tractor. The first evidence of a PTO driven digger is a 1941 US patent for a unit mounted on the rear of a tractor.

A mechanical posthole digger was built from scrap parts by a Kansas, USA, farmer in 1943, and bears a striking resemblance to current linkage type machines. The first identifiable patent for a linkage type machine is in 1949, again in the United States. The portable engine driven, hand operated digger was patented in the United States in 1952.

A trailer mounted, manually operated, post driver was patented in the United States in 1866. Post drivers were generally available about 1950, with hydraulic post drivers fitted with pilot hole augers available about 1963.

During this project it was noted that several commercial linkage type posthole digger designs incorporate a lifting jig. The machines observed did not meet Australian legal specifications in that the maximum weight limit was not clearly displayed on the jib.

4.1.1. Tractor Mounted

This type of machine is bolted to the rear of the tractor. The auger is driven by PTO drive through a bevel and pinion to reduce speed and change the direction of drive, or by use of a hydraulic motor operating off the tractor hydraulic system. In some cases a chain drive is utilised to transmit power from the PTO to the pinion shaft. A steel frame bolted to the tractor has guides that allow the auger to be lowered as it rotates. Lowering may be by means of a wire cable and winch or by use of hydraulic rams. In some older machines the operator, while standing beside the machine, manually turns the winch handle. Regardless of whether the winch drive is manual or hydraulic, a positive downward force can be applied to the auger. Auger drive is usually achieved by utilising the tractor PTO drive shaft to power a chain drive that rotates the auger through a bevel and pinion. The auger shaft, either square or hexagonal, can slide through the pinion when the auger is being lowered.

Provided the manufacturers' guards are maintained in place the only danger area in modern versions of this design is the rotating auger.

There are some very old machines still in use that are mounted on the front of the tractor and driven by belt from the tractor pulley. These generally have a total lack of guarding over drive components, and are extremely dangerous.

Rear mounted machines are still available, but are not common.

4.1.2. Linkage Mounted

Linkage mounted machines are fixed to the tractor three point linkage arms, and driven by the PTO or a hydraulic motor. The three point linkage may be used to raise and lower the digger, or in some designs the linkage height is fixed, and a separate raising/lowering system is built into the digger.



Linkage mounted posthole digger

Photograph courtesy R Houghton

The most common design consists of a single beam mounted on the three point linkage, with the digger gearbox suspended from the outer end. Drive is via a shaft connected to the tractor PTO or a hydraulic motor. Some manufacturers use a twin beam frame as an alternative to the simpler single beam design.

The presence of two rotating potential entangling points, the PTO shaft and the auger, on these machines increases the risk of an accident.

Linkage machines have been popular for many years, being simple in design, relatively cheap, and easy to fit to and remove from the tractor. It is still the most common design on the market.

4.1.3. Trailer Mounted

As the name suggests, the digger unit is trailer mounted, and towed behind the tractor or other vehicle. Power is usually obtained from a dedicated engine, but may be from tractor PTO or hydraulics.

The trailer is usually designed as a carrier for posts and other fencing tools and materials in addition to the auger drive system.

Trailer designs are readily available, having greater market appeal with fencing contractors than individual farmers.

4.1.4. Other Mounting Systems

Manufacturers have also designed posthole diggers for fitting to equipment such as backhoe loaders, skidsteer loaders, etc. These are hydraulically driven from the machine hydraulic system and raising and lowering is by means of the machines loader arm mechanism. The digger mechanism is fixed to the loading bucket or suspended from the lift arm. The loader arms provide downward pressure on the digger.

This design is becoming more common with the increase in use of tractor loaders and skidsteer loaders on farms.

4.1.5. Hand Operated and Adaptations

Small, engine driven, augers are manufactured for manual operation, requiring one or two operators. The design consists of a chainsaw type engine mounted on the top of the auger shaft via a reduction gearbox, with handles for the operators.



Portable engine-driven posthole digger

The major hazard with these machines arises when the auger becomes jammed in the hole, and the handles rotate about the auger shaft.

Adaptations of these designs have been made to enable easier and safer use. These adaptations usually consist of fitting a mounting arm and wheels to operate as a manual trailer unit, or may be designed to mount on a vehicle tray or vehicle tow hitch.

These small designs are common, useful for small farms where only occasional use is required, and are commonly available from hire companies.

4.1.6. Post Drivers

Post drivers may be mounted directly on the rear of the tractor, on the side of the tractor, or attached to the three point linkage. Machines may also be fitted to skidsteer loaders, mounted on the tray of a truck or be trailer mounted. All types are available in Australia. Earlier machines were also mounted on the front of the tractor.



Trailer mounted post driver.

Operation is hydraulic, operating from the tractor remote hydraulic lines.

Post drivers consist of a weight (usually 200 to 300 kilograms), which is raised and dropped on the top of the post to drive it into the ground. A small auger for drilling a pilot hole may be fitted.



Three-point-linkage mounted post driver.

The weight is lifted via a wire rope, by use of a hydraulic ram or mechanical winch.

An American company manufactures a post driver that operates by variable frequency vibration of the driving head, rather than dropping a weight. These are claimed by the manufacturer to be very effective, without the inherent dangers of having the weight impacting on the top of the post. This machine does not appear to be available in Australia.

4.2 Injury Data.

4.2.1. Case data

Case data from Australia and New Zealand was analysed in accordance with the identified key risk factor areas. A total of 66 cases of injury were examined, 18 fatal and 48 non-fatal. Forty four of the cases were identified in Australia, of which 16 were fatal and 28 non-fatal.

The Australian accidents identified occurred between 1982 and 2000, a period of 18 years.

Data from overseas countries other than New Zealand was insufficient for analysis.

4.2.1.1. Victoria Survey data

Data from the Monash University Accident Research Centre (MUARC) survey was tabulated by MUARC. There were 30 farms/respondents reporting *ever* having post-hole digger injuries or near-misses out of 1382 properties surveyed. A further 4 properties reported injuries/near-misses with post-hole drivers.

Of these 30 cases, 11 reported injury associated with the reported posthole digger incident, and 1 of the 4 reported an injury associated with drivers reported incident.

The main commodity produced by those reporting injury or near miss is displayed in Table 1.

Table 4.1: Main commodity produced by those reporting injury or near miss associated with use of posthole digger and driver

Main commodity	Posthole digger reports	Driver reports
Potatoes		1
Other vegetables	1	
Cereal grains	4	
Sheep	4	1
Cattle (Meat)	12	2
Cattle (Milk)	3	
Other	6	
Total	30	4

5. Risk Factors

5.1 Operator risk factors

5.1.1. Age

5.1.1.1. Case reports data

The limited data available, especially for non-fatal accidents, prevents rigorous analysis of the age range of victims.

Table 5.1 indicates the age distribution of cases examined as case reports.

Table 5.1: Age range of victims of posthole digger injury.

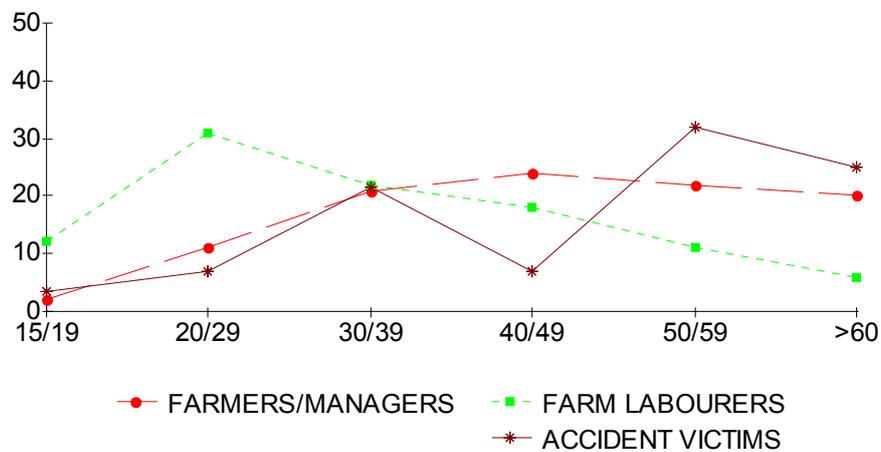
Age group	Australia fatal	Australia non-fatal	Australia total	New Zealand fatal	New Zealand non- fatal	New Zealand total	ANZ total
0-14	0	1	1	0	0	0	1
15-19	1	0	1	0	0	0	1
20-29	2	0	2	0	1	1	3
30-39	0	6	6	0	8	8	14
40-49	2	0	2	1	1	2	4
50-59	5	4	9	1	8	9	18
60-69	2	2	4	0	0	0	4
>70	2	1	3	0	2	2	5
Unknown	2	14	16	0	0	0	16
TOTAL	16	28	44	2	20	22	66

The age distribution of male farm owners/managers, and of farm labourers in Australia in 1991 may be obtained from charts published by Fragar and Franklin, “The Health and Safety of Australia’s Farming Community”. Table 5.2 shows the age distribution (percent of total) of posthole digger injury cases compared to age distribution of Australian farm workers. This is visually represented in Figure 5.1.

Table 5.2: Age range of victims of posthole digger accidents compared to age range of farm workers (Australian accident data, % of total).

Age Group	Farmers/Managers	Farm Labourers	Accident Victims
15-19	2	12	3.5
20-29	11	31	7
30-39	21	22	21.5
40-49	24	18	7
50-59	22	11	32
>60	20	6	25
Unknown	0	0	4
Total	100	100	100

Figure 5.1: Age of posthole digger accident victim compared to age of farm workers



From these cases it would appear that the risk of having an injury may increase for older workers. A study of Table 5.1 in conjunction with Table 5.2 suggests a higher risk that an accident will be fatal for victims over the age of 50 years. If this were the case, possible causes could be postulated:

- Physical factors such as
 - Impaired vision and hearing
 - Reduced agility preventing escape from the potential accident
 - Older workers may be more prone to fatigue.
- Familiarity leading to reduced sensitivity to risk.

- Older workers may not readily adapt to change to safer work systems.
- Older workers may be more likely to be operating older, less safe, machinery.

5.1.1.2. Victoria Survey data

The age of farmers reporting ever having an injury or near miss associated with posthole diggers and drivers is displayed in Table 5.3. It should be noted that age at time of injury was not reported.

Table 5.3: Age of farmers reporting ever having posthole digger and driver injury or near miss.

Age Group	Posthole Digger	Post Driver
15-19	0	0
20-29	0	0
30-39	4	0
40-49	6	1
50-59	9	2
>60	10	1
Unknown	1	0
Total	30	4

5.1.2. Gender

Table 5.4 indicates the gender of operators in the injury cases reviewed.

Table 5.4: Gender of victims of posthole digger accident injury.

Gender	Australia Fatal	Australia Non- Fatal	Australia Total	New Zealand Fatal	New Zealand Non- Fatal	New Zealand Total	ANZ Total
Male	15	24	39	2	19	21	60
Female	1	4	5	0	1	1	6

All farmers/owners reporting injury or near miss in the Victoria survey were male.

The lower number of females involved in accidents would most likely reflect the lower number working in the agricultural industries. Within the Australian cases three of the female victims, including the fatality, were identified as self-employed farmers, while the other two were not specified. Census data is not available specifying the number of females working in rural industries; therefore it is not possible to determine whether incidents are more or less frequent for females than males

5.1.3. Clothing

Examination of Table 5.5 indicates further operator related risk factors – clothing and work practice

Table 5.5. Mechanism of posthole digger injury in Australia.

Mechanism	Fatal	Non-Fatal	Total	Comment
CLOTHING CAUGHT	13	4	17	The most common cause of accidents is from clothing becoming entangled, either in the PTO shaft or in the auger. This frequently results from the victim wearing loose fitting clothing, or loose drawstrings hanging from coats etc.
HAIR CAUGHT	0	2	2	Both victims were females with long hair. One victim had her hair tucked up, but still became entangled.
FENCE WIRE CAUGHT	0	2	2	One event involved fence wire laid along the line. The wire became caught in the auger and pulled around the victim's leg. The other case involved hinge-joint type mesh laid along the fence, but clear of the hole digging operation. The auger jumped from the hole and caught the mesh. The victim was standing on the mesh and was pulled towards the auger, but avoided entanglement.
UNKNOWN	2	21	23	The available data on non-fatal accidents does not provide sufficient detail.

Loose clothing worn by the victim is a feature in 38% of the cases studied. However it cannot be considered that this alone is the cause of accidents. Some other factor or factors, such as guards removed, ineffective guards or poor work practices can be identified in each case.

The Victoria survey tabulation of “What happened?” responses (Table 5.6) also provide some further information. Clothing is a feature of 1 injury event and 4 near misses in this dataset.

Table 5.6: Summary of descriptions of posthole digger and driver injuries and near misses

What Happened:	Injury	Near Miss	Missing	Total
Caught clothing on digger/driver	1	4	1	6
Digger/driver fell/dropped/broke	1	4	2	7
Digger/driver hit or jammed fingers	2	0	0	2
Digger/driver hit a rock or tree root or other hard object	1	0	2	3
Cleaning digger (cut/grazed)	1	0	1	2
Adding/putting weight on digger/driver to push it further down and slipped	2	2	0	4
No information provided	1	2	7	10
Total	9	12	13	34

5.1.4. Work practice

Actions that have a high risk factor are sitting or standing on the digger to increase downward pressure, removing dirt or objects from the hole while the auger is turning, and shovelling soil from the auger during operation

The digger falling was a feature in 5 of the 30 Victoria survey reports, and adding weight to push it further down was reported in 4 responses.

5.1.5. Training

Significantly, no professional fencing contractors or their employees are identified in any of the data. This may suggest that posthole diggers can be operated safely by persons who have experience and/or extensive training.

5.2 Risk factors relating to the machine

Unfortunately the lack of data does not allow identification of the mechanism of all accidents, however study of the data on nature of injury received and body part affected indicates that entanglement in the PTO shaft or the auger is probable in many cases.

Table 5.7 indicates the possible machine related factors associated with the cases reviewed.

Table 5.7: Machine related risk factors involved in posthole digger injury accidents in Australia.

Mechanism	Fatal	Non-Fatal	Total	Comments
PTO SHAFT	3	4	7	<p>The number of incidents identified involving power take off shafts indicates that many more cases may have occurred, being identified on the accident report as being a PTO accident, without the posthole digger being specified as the machine involved. Standing or sitting on the posthole digger frame to provide additional weight for penetration in hard ground is commonly associated with cases involving PTO entanglement.</p> <p>Accidents generally occur when loose clothing or hair becomes entangled in the rotating shaft. Problems arise from bolts projecting from the shaft, protruding balance weights, nicks, or mud or rust adhering to the shaft.</p> <p>Hair or loose drawstrings may be attracted to the shaft by static electricity or a vacuum caused by wind flow around the shaft. Under these circumstances the hair or clothing may be drawn into the shaft through openings in conventional approved guards.</p>
AUGER	11	3	14	<p>These events usually involve the victims clothing becoming entangled in the rotating auger. Two instances were the result of the victim being struck by the auger as it hit an object and jumped from the hole. Two of the events were caused by wire becoming entangled in the auger. Auger entanglement is frequently the result of the victim being too close to the auger while shovelling soil away from the top of the hole. One event was a result of the victim reaching into the hole to retrieve fallen spectacles while the auger was rotating above the hole.</p>
POST DRIVER WEIGHT	1	0	1	<p>While only one accident involving a post driver was identified in Australia, it is probable that many more accidents have occurred, but are not identifiable using current data methods. Overseas reports relate to crush injuries from the area of impact at the top of the post, and face or eye injuries from splinters ejected from the top of the post.</p>
UNKNOWN	1	21	22	<p>There are a large proportion of unknown machine factors in the available data on non-fatal accidents owing to the deficiencies inherent in current accident reporting.</p>

The results indicate that the auger is involved in more injury events than other parts of the machine, however as stated previously, the limited data available may not be indicative of the true situation. Anecdotal evidence indicates that guards on posthole diggers, especially PTO guards, are frequently removed from the machine as the available guards are not resilient, and also are a nuisance when fitting and removing the shaft from the tractor. Ferguson (2000) found that many PTO shafts were without guards for at least 25 % of the time.



Typical posthole digger auger

The most serious areas of risk with posthole diggers are the PTO shaft and the auger, providing other parts of the machine have the manufacturers guards fitted. Problems with the PTO drive shaft and auger arise from hair or loose clothing becoming caught on the shaft, and pulled in by the rotation. It only requires a small piece of mud or rust adhering to the shaft, or a nick in the shaft, to catch and pull hair or clothing.

Post driver risk is in the impact area of the weight and the top of the post

The speed at which a tragedy can occur may be understood when it is realised that the PTO shaft, approximately 30 centimetres circumference, rotates at 540 revolutions per minute. Thus in one second hair or clothing that becomes entangled will be pulled 2.7 metres. To put it another way, a person caught in the PTO shaft could be whipped around the shaft nine times in one second.

5.3 Environmental risk factors

Reference to Tables 5.5 and 5.6 indicates some risk factors associated with the work environment.

Wire lying along the fence-line can become caught in the auger and drag the operator into the rotating machine or cause a traumatic amputation.

Rocks, tree roots and old steel posts below the ground can cause the auger to jump from the hole and catch the operator, bystanders or wire in the vicinity. Three point linkage digger designs restrain the auger from swinging sideways, but place no restriction on rear swing.



The worker standing behind the digger is in danger of being struck and/or entangled if the auger hits an object and jumps from the hole. Wire, steel posts and tools lying near the posthole increase the hazard.

Photograph courtesy R Houghton

5.4 Injury outcomes

Tables 9 and 10 indicate the nature of injuries incurred and body part injured for the reviewed cases.

Table 9: Nature of injury resulting from posthole digger accidents.

Injury	Australia Fatal	Australia Non-Fatal	Australia Total	New Zealand Fatal	New Zealand Non-Fatal	New Zealand Total	ANZ Total
Traumatic Amputation	2	6	8	0	5	5	13
Asphyxia	2	0	2	2	0	2	4
Crush Injury	1	5	6	0	1	1	7
Fracture	0	6	6	0	14	14	20
Scalped	0	1	1	0	0	0	1
Open Wound	0	7	7	0	6	6	13
Sprain Strain	0	4	4	0	1	1	5
Superficial	0	4	4	0	1	1	5
Unknown	8	0	8	0	1	1	9

The nature of the injuries demonstrates the traumatic effects associated with accidents involving posthole diggers, with a high proportion involving traumatic amputation or asphyxiation. The effect of the traumatic nature of the injuries is to increase the cost to the community of each accident, both in financial and human terms.

Table 10: Body Area Affected By Posthole Digger Accidents.

Body Area	Australia Fatal	Australia Non- Fatal	Australia Total	New Zealand Fatal	New Zealand Non- Fatal	New Zealand Total	ANZ Total
Back	0	0	0	0	1	1	1
Head	1	4	5	0	2	2	7
Face	0	1	1	0	0	0	1
Neck	1	0	1	0	2	2	3
Chest	1	6	7	0	0	0	7
Groin	0	1	1	0	0	0	1
Arm/Hand	2	19	21	0	17	17	38
Leg/Foot	0	4	4	0	7	7	11
Unknown	8	1	9	0	1	1	10

Note: The total of injuries may not equal the total of victims owing to multiple injuries reported in some instances

6. Options for Risk Reduction

Consideration of methods of reducing the risk of accidents follows the generally accepted “hierarchy of control” framework, viz:

- Elimination - removing the hazard or hazardous work practice from the workplace.
- Substitution – substitute or replace the hazard or hazardous work practice with a less hazardous one.
- Engineering/design controls, including isolation of the hazard from workers. – if the hazard cannot be eliminated or substituted engineering or improved design control is the next preferred measure.
- Administrative controls – ensuring safe work practice, labour organisation and operator skills.
- Personal protective equipment – considered when other control measures are not practical, and where it is possible to protect body parts from injury.

The higher order controls are considered to be more effective as their effectiveness is not dependent on human behaviour. Effective risk control in the workplace generally involves a combination of several control methods.

The issue of reduction in accidents involving posthole diggers, as with other safety issues, is extremely complex, and must be approached from several angles. Formulating a reduction program needs to be in the context that average rural businesses use posthole diggers only infrequently, and therefore the equipment will be retained for many years before replacement. Ferguson (2000) found that the average age of tractors on farms in Queensland was 18.1 years. It could be reasonably assumed that the average age of posthole diggers would be greater. Thus improved safety aspects of more modern digger designs take several years to become generally available within the rural workforce. The relatively low capital cost of the existing machine results in a reluctance on the part of the rural operator to either replace the machine with a more expensive, but safer, new model, or to spend money on what are seen as unnecessary modifications to existing plant.

6.1. Elimination options

Elimination of the hazard associated with posthole diggers would rarely be an option for most farms where fencing jobs need to be undertaken. However, the safety of the machinery should be a factor in determining the design of the fence to be constructed. Different fencing options vary in their requirements for fence posts to be put in place.

6.2. Substitution options

Newer, safer equipment is available for erecting fence posts. These involve down-force rams and hydraulic powered systems.

Farmers who do not see purchasing such equipment should consider using fencing contractors with safer equipment.

6.3. Engineering/ design options

6.3.1. Machine Design

The basic design principle of posthole diggers has not substantially changed since the introduction of the concept in the 1940s, although several advancements have been made in the safety area. These advancements largely consist of such things as PTO covers and drive chain covers, which are now a legislative requirement, however other safety features such as down-force rams and improved auger designs have become available, and are actively promoted by some manufacturers.

Scope for advanced design improvements exists in machine guarding aspects and penetration capability, and these should be priorities for designers.

It has been suggested that emergency stop controls be fitted adjacent to the areas of likely entanglement, i.e. the PTO shaft and the auger. The speed with which the victim may be pulled into the shaft would not allow sufficient reaction time to activate the control. Another suggestion is to fit sensors to shut off the machine should a person enter the danger area, however it is probable that such a device would be disabled by the operator.

Slip clutches as fitted to the drive train by some manufacturers are designed to allow the auger drive to slip in the event of an overload. These should be so designed as to prevent operators from over-adjusting to the point where slip can no longer occur.

Accidents have occurred from the auger contacting an object, forcing the auger to jump from the hole and swing backwards. A stop should be fitted to the digger frame to limit the arc of swing.

6.3.2. Guarding

The Australian Standard AS1121-1983, Guards for Agricultural Tractor PTO Drives, provides a guide for the provision of guarding for the power take-off drive, however the specification does not fully protect from entanglement, as hair or a cord may still enter at the end of the drive line, between the tractor or implement shaft guard and the PTO shaft guard. The specification also allows an inverted “U” design for the tractor and implement guards, open at the bottom. There is a possibility of hair or clothing being drawn up under the guard and becoming entangled. It appears that the Standard does not make allowance for wind factors or static electricity that could draw hair etc into the rotating shaft. There remains a risk that operators may become complacent, thinking that an approved PTO guard removes any risk of entanglement.



Power-take-off shaft universal joint exposed when digger is starting to dig.

Photograph courtesy R Houghton



**A different model posthole digger.
The same problem of exposed universal joint is evident.**

While modern machines must comply with design standards relating to guarding of machine parts, it appears from the evidence that these standards do not remove the risk factor. This may be due to failure on the part of the operator to refit guards after maintenance or repair, or to failure to replace guards that lose effect owing to damage or normal wear and tear. Operators have commented that PTO guards have a short life span under normal working conditions. Australian Standard AS1121-1983, Guards for Agricultural Tractor PTO Drives, Paragraph 1.5, note, “Where guards are constructed from plastics material, the plastics should be a type that is known to be resistant to deterioration due to the effects of exposure to sunlight or to high ambient temperatures.” The vague nature of this note provides no assistance to designers or manufacturers, and operator comments suggest that materials in common use certainly are not resistant to deterioration.

Two suggested areas for development of improved safety aspects of machine guarding are to utilise more resilient materials for manufacture of the guards, and to simplify the fitting and removal procedures to lower the chance of operators not refitting them following service and repairs.

It is considered that for some machine design types it would be possible to fully enclose the PTO shaft through the machine frame. PTO covers currently in use do not fully cover the rotating parts in the area of the universal joints, allowing hair or clothing to become entangled. The PTO shaft should also be guarded in such a way as to prevent it from flailing in the event that a universal joint should fail. Research into improved materials for PTO guards should include testing of static electricity levels generated.



The PTO shaft cover, while apparently complying with the standard, exposes the shaft when the posthole digger is raised.

Photograph courtesy R Houghton

Some manufacturers have experimented with various methods of guarding the auger, however no system has been found which provides adequate guarding without causing interference with the hole digging operation.

6.3.3. Auger Design

The auger is generally fixed to the auger shaft by means of a shear pin, a metal pin or bolt designed to break, or shear off, in the event of the auger becoming jammed. Shear pins are usually a special bolt, with protruding bolt head and nut. The operator frequently replaces the shear pin with an ordinary bolt, or other metal rod, which may protrude sufficiently to become a catch point for loose clothing etc. The area surrounding the shear pin should be guarded, or the design be such that a non-standard shear pin cannot be used. Original equipment shear pins should be so designed that the ends are flush with the auger tube, with no protruding heads, nuts or fixing pins that could provide a catch point.



Picture showing shear pins replaced with steel rods. The protruding ends make this very dangerous.



Not as obvious as the previous picture, however these protruding bolts are sufficient to catch clothing.

Augers and drive shafts should not have any weld slag, notches, balance weights, etc, in a position which could catch clothing or hair. There appears to be a common hazard of weld protrusion or a gap in the joint between sections of the auger flight, which should be addressed during the manufacturing process.

In the area of soil penetration, advances have been made in the design of cutting blades to improve digging capabilities, however not all augers are fitted with these improved designs of blades as standard equipment.

Several machines are marketed which have the ability to dig through very hard ground, or even soft rock. Unfortunately, the inevitable cost of such a machine discourages purchase by the small operator who only wishes to dig an occasional posthole.

6.3.4. Controls.

Posthole diggers and drivers should be fitted with a “dead man” type control, which would stop the machine in the event that the operator lets go of the control for any reason. This would serve the dual purpose of discouraging the operator from approaching the hazard areas of the machine, and would stop the machine in the event that the operator should get pulled into the operating mechanism for any reason. One soil-sampling auger sold in the United States of America has an emergency shut-off trip cable, which instantly stops the auger rotation.

The provision of a reversing mechanism in auger drives to allow clearing from holes when they become caught should be considered.

6.3.5. Machine Modification

Current model machines, and some older models, may be modified to improve safety by fitting more efficient guarding, ensuring there are no catch points on shafts or augers, and fitting hydraulic push-down rams.

Modifications to a posthole digger, as with any other machine, should be carried out using accepted engineering principles, and farmers should be encouraged to seek professional guidance. The production of a brochure outlining general guidelines would be of assistance to farmers in assessing and upgrading the safety aspects of their posthole digger.

Farmers should be encouraged to scrap older equipment that cannot be modified to a safe condition, and purchase a new machine or engage contractors to carry out posthole digging operations.

6.4. Administrative controls

6.4.1. Safe work practice

Three work practice factors are significant in the data:

1. Standing or sitting on the machine to apply additional weight for improved penetration in hard ground,
2. Shovelling soil from the auger while digging, and
3. Boring the posthole while fence wires are adjacent to the machine.

Operation of a correctly selected and maintained posthole digger should not require additional weight to be added to the machine.

Difficulty in achieving satisfactory penetration with a modern posthole digger is an indication of one of the following:

- The cutting blades require replacement. Commonly operators will continue to use the machine after the blades have worn because they see the changing of cutting blades to be wasted downtime, or because of the cost of blades. Part time farmers may be ignorant of the need to keep blades in good condition.

- The machine is not suitable for the conditions. Operators will attempt to use the machine they own, when a more suitable design (eg a rock drill type) should be hired for the current job.
- The operator is expecting unrealistic production. Operator expectations of posthole digger output, as with other plant items, are often beyond the capabilities of the machine.

To ensure safe operation of a posthole digger the following procedures should be adhered to:

- Train all operators prior to use of the machine.
- Ensure that the operator has read the operating manual.
- Limit work hours to minimise fatigue.
- Operators must have long hair secured by a cap or other means.
- Operators must not wear loose clothing, or clothing having a drawstring.
- No person, worker or bystander, should be allowed to approach the machine while it is in operation.
- The practice of standing or sitting on the frame of the posthole digger to increase penetration must not be allowed.
- The operator, or his/her assistant, should not shovel, or otherwise remove, soil from the auger area while it is in operation.
- Remove all fence wire, wire netting, etc, a minimum of five metres from the vicinity of the posthole.
- The correct cutter points to suit digging conditions must be used and maintained in good condition.
- Manufacturers' safety guards must be fitted to the machine.
- The posthole digger must be serviced and repaired to maintain optimum operating ability.
- Two people should be on the worksite while operating the posthole digger.
- When purchasing a posthole digger, operating conditions must be considered, eg hard soil, rocks etc.
- When operating a post driver no part of the body should be in a position that could result in contact with the weight.



A number of hazards are apparent in this photograph:

- **The workman is pushing on the digger.**
- **The workman is too close to the auger.**
- **The PTO shaft is exposed.**
- **Fence wire is lying adjacent to the hole.**
- **Steel posts are lying adjacent to the hole.**

Photograph courtesy R Houghton

6.4.2. Training of operators

Training to ensure the safety of operators is probably the most important immediate requirement.

There are two levels of training that are required:

1. Farmer/ manager training that manages the risks associated with the operation of posthole diggers by identifying hazards associated with the equipment and the system of work, provides a safe machine and ensures that operators are trained in safe operation.
2. Operators need specific training and skill to ensure that the operation is undertaken in a safe manner.

6.4.3. Personal protective Equipment

Personal protective equipment that would be required for posthole digger operation includes hearing protection and steel capped boots.

7. Discussion

This report is based on analysis of very limited data obtained in Australia and overseas, complemented by a survey of Victorian farmers. The search was severely restricted by the lack of available data. The large proportion of self-employed people in rural industries limits the relevance of traditional sources of data such as the National Data Set (NDS) of workers' compensation statistics.

Anecdotal evidence indicates that the problem of accidents involving posthole diggers is extensive. A large proportion of long-term rural residents relate incidents where people they know have had an accident of some kind while operating a posthole digger, but in many cases the accident has never been reported as injuries were minor.

The information that is available on the cases analysed in this project usually does not include details of the make, age or condition of the posthole digger involved. The efforts of manufacturers to improve safety features of their machines are slow in having an overall effect on accident rates, as the posthole digger is not an implement that is frequently replaced, thus it is possible that many accidents are a result of use of older, less safe, diggers.

The number and severity of those incidents that have been identified justifies continued efforts to reduce the risk factor. Although it is not possible to obtain precise data, it would appear that posthole diggers are among the most dangerous machines operated on the farm, on a per-hours-of-use basis.

There have been anecdotal reports of persons being injured when hit by posthole diggers not attached to the tractor (i.e. during storage) falling. These reports have not been verified by first-person evidence.

Post drivers were included in the scope of this investigation because in the similarity of purpose, and the fact that many modern drivers are fitted with an auger for digging a pilot hole, and fitment of such an auger immediately imposes the same safety risks as are experienced by users of posthole diggers. In fact the investigation found only two accidents related to use of a post driver in Australia, although overseas reports are more common.

8. Recommendations

The following recommendations are made to the Farmsafe Australia Machinery Safety Reference Group for the reduction of risk associated with operation of posthole diggers in Australian agriculture and horticulture industries.

1. That information material be prepared outlining the hazards associated with the operation of posthole diggers and correct operating procedures to be followed to reduce those hazards, and that these materials be made readily available to rural workers. These materials should include information relating to modifications that may be possible to be carried out on existing machines.
2. Manufacturers should be consulted and asked to participate in the development of such material. The document should be developed as a nationally endorsed Guidance Note.
3. That educational materials be prepared and made available to rural education and training institutions.
4. That posthole digger manufacturers be encouraged to ensure that the machines achieve the highest possible safety standards, and that safe operation be actively promoted by sales personnel and via improved operators' manuals.
5. Manufacturers generally could advance the promotion of safety by the provision of much more comprehensive owners' manuals than are currently issued with most machines. Operators should be made aware of those risks that the manufacturer has not been able to eliminate, and to ensure they do not use the machine in a way that will create new risks.
6. That suppliers ensure that safety information is provided to buyers of posthole diggers. The design and fitting of safety features is of little use unless sales personnel are required to discuss safety issues with customers, and emphasise the importance of features such as force-down rams.
7. That farmers be encouraged to dispose of older posthole diggers, and to use fencing contractors for fencing requirements.
8. That an Australian Standard be prepared for the design of posthole diggers, establishing a level of safety that is economically achievable.
9. A specific Australian Standard should cover the design and operation of posthole diggers to encourage the broad use of the safety features that are available.
10. The Australian Standard AS1121-1983, Guards for Agricultural Tractor PTO Drives, requires revision to ensure that optimal safety requirements are met within practical limits. Improvements in materials and material testing since 1983 should be utilised in the Standard to promote the production of PTO guards with extended operating life, and the guard specification should be assessed to eliminate the chance of entanglement. The standard should be extended to cover alternative types of guard in addition to the conventional type.
11. That a method of recording rural accidents be introduced that will provide the data necessary for future accident research.
12. That future event data relating to posthole digger accidents be analysed in an ongoing manner to enable knowledge of the causal factors to be improved.

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