ORIGINAL RESEARCH

Characteristics of accidental injuries from power tools treated at two emergency departments in Queensland

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Abstract

Objective: Injuries are a major burden on the Australian healthcare system. Power tool usage is a common cause of accidental injury. A better understanding of the trends of power tool injuries will inform prevention strategies and potentially mitigate costs.

Methods: The ED databases from two level 1 hospitals were reviewed for presentations between 2005 and 2015 resulting from accidental injury with power tools. A subgroup of patients presenting to one hospital between 2016 and 2017 were interviewed about the activities and circumstances that led to their injuries, and followed up 3 months later to assess outcomes.

Results: A total of 4057 cases of accidental injury from power tool use were identified. Power saws and grinders contributed to 54% of injuries. Most injuries were located on an upper limb (48%) or the head and neck (30%). Over half (54%) of all head injuries were associated with metal and wood fragments to the eye from grinders, drills and saws. Hospital admission rates were highest for patients aged >60 years. Injuries to females were <5% of all presentations, but 40% of those caused by lawnmowers. Among the 200 patients interviewed, lapses in concentration during use, and modification and inappropriate use of a power tool were the main contributors to injury. Recovery periods >3 months were common.

Conclusions: Accidental injuries from power tool use have a considerable impact on ED resources and can affect the long-term quality of life of those injured. Effective education about safe usage and protection may prevent many injuries.

Key words: accident prevention, accidents home, accidents occupational, emergency service hospital, wounds and injuries.

Introduction

Power tool usage has increased in recent years, attributed to the decreased costs of tools and the ‘do-it-yourself’ (DIY) revolution. In 2015, approximately 53% of Australian households owned at least one power tool. Many power tool users have poor knowledge of safe power tool use. Although power tools are the source of many accidental injuries, it is unknown what the main products are causing injuries, the predominant injury patterns and whether the rate of injuries from power tools has increased over recent years.

In Australia, between 2006 and 2014, 7% of hospitalised injury cases were attributed to power tools. The rate of hospital admission in 2013 to 2014 due to DIY power tool- and machinery-related injuries was six per 100 000 for persons aged ≥15 years. Males were 5.5 times more frequently admitted than females and increasing age was a risk factor.

There has been limited research describing power tool-related injuries in Australia. Studies have analysed US ED presentations for injuries from lawnmowers, power saws and nail guns (United States). Injuries from table saws, chain saws,
nail guns, power tools\textsuperscript{11,12} and penetrating injuries\textsuperscript{13} have also been studied. This research indicates that: (i) grinders, power saws, drills and welders are the most common power tools causing injury; (ii) males suffer more injuries than females; (iii) lacerations, muscular damage and amputations to the fingers and hands are the most common injuries; and (iv) older people have lower injury rates, but are more likely to be hospitalised. A large study of >23 000 construction work-related injuries at one ED in Denmark (1980–2010) found a slight decline in injuries from small power tools in younger (but not older) workers,\textsuperscript{14} possibly because of improvements in tool safety features.

There has been very limited Australian research describing ED presentations for power tool-related injuries. Most Australian data on power tool-related injuries is based on hospitalisations or compensation claims, though only a minority of cases require hospitalisation or are eligible to make a claim for compensation. There has been no Australian research comparing occupational and non-occupational injuries, and no interviews with patients to understand the context of injuries. Such information is essential to informing evidence-based preventive activities. Our aim, in this study, was to determine the circumstances, characteristics, outcomes and trends of accidental injuries from power tools in patients presenting to two major metropolitan EDs in Queensland, Australia.

Methods

This study involved a retrospective audit of the ED records, and prospective interviewing, of patients who presented to ED with a power tool injury. The retrospective audit involved data collected from the EDs at Royal Brisbane and Women’s Hospital (RBWH) and Princess Alexandra Hospital (PAH) from 5 May 2005 to 31 December 2015. The prospective survey was conducted at PAH from 5 December 2016 to 4 December 2017.

Retrospective audit

Search criteria were used to identify power tool presentations from the Emergency Department Information System (EDIS) at RBWH, and EDIS and FirstNet (Cerner Millenium) at PAH. Power tools were defined as tools powered by a motor; these included drills, saws, grinders and mowers, but excluded industrial tools such as presses. The search criteria consisted of 50 words about specific tools and 20 words and phrases about injury types. These were applied to the ‘presenting complaints’ and ‘diagnoses’ fields in EDIS and FirstNet to extract an initial dataset. This was then filtered by ICD-10 S and T injury codes to exclude cases not involving power tool injuries.\textsuperscript{15} The electronic medical records of the remaining cases were manually checked to confirm a power tool injury. The injured body part was recorded using information from the ICD-10 codes and free text. Cases were excluded if a power tool-related injury could not be confirmed, for injuries relating to assault or self-harm, and for repeat presentations. Australasian Triage Scale (ATS) categories were only available for PAH data and ATS was not provided for data from the RBWH.

Prospective survey

Patients were eligible for participation if they were ≥16 years of age and presented to the ED with a power tool-related injury. Patients were identified during daytime working hours (08.00–17.00 hours weekdays), by monitoring the FirstNet presentation screen or by notification from ED clinicians. Eligible patients who presented after-hours or on weekends were identified by reviewing FirstNet during the next available daytime work shift.

Eligible patients were seen by research staff, when appropriate, during their ED presentation or hospital admission. Eligible patients were discharged before being seen, or who presented after hours, were contacted by telephone. Three contact attempts were made before patients were classed as ‘missed’. Patients provided written or verbal consent.

An initial questionnaire was conducted in-person or by telephone. Three months after discharge, a follow-up questionnaire was administered by telephone. The initial questionnaire asked about the type of power tool and circumstances of its use, including: type, brand, age and condition of tool, activity involved, location, time of day, perceived risk, possible influencing factors, prevention measures, safety equipment used, participant’s occupation and previous experience with use of the tool. The follow-up questionnaire asked about recovery time, time to return to work or pre-accident activities, subsequent treatment, and significant impacts of the injury.

Statistical analysis

Data were analysed using IBM SPSS Statistics 24. Data were pooled across the two hospitals, and expressed as means, ± 95% confidence intervals (CI) or medians with interquartile range (IQR), as appropriate. \(\chi^2\) tests of proportions were used to determine the significance of differences in proportions. \(\chi^2\) tests of trends were used to determine changes in presentations over time.

Ethics approval for this study was granted by the Metro South Human Research Ethics Committee (EC00167), application number HREC/16/QPAH/591.

Results

There were 1 328 179 presentations to the two EDs during the 11 year study period. Of those, 4057 were due to accidental injuries from power tools. Figure 1 shows the annual rates of those power tool-related injury ED presentations for males, females and all patients combined. While the annual rates varied between 3.81 and 6.27 per 1000 ED presentations, there was no trend evident over the period. The average annual rates (mean [± 95% CI]) were 0.28 (0.06 95% CI) for males, 5.29 (0.55 95% CI) for females, and 0.55 (0.55 95% CI) for
males and 2.99 (0.29 95% CI) overall.

Presentations for males exceeded those for females (95.9% vs 4.1%, \( P < 0.001 \)) (Fig. 1, Table 1). In total, only 138 women presented with a power tool-related injury. Rates of presentations were 5.5 and 0.3 per 1000 presentations for males and females, respectively. Patients ranged in age from 16 to 89 years. The median age for males was 39.0 years (IQR 27.4–52.0) and females 41.7 years (IQR 29.3–53.3).

Presentations on weekends accounted for 25.6% of the total number of presentations (Table 1). For males aged \( \geq 30 \) years, the weekend presentation rate was over twice as high as during the week. The weekday presentation rate for males aged 30–59 years was similar to those <30 years on weekdays (Z-score 0.306, \( P = 0.756 \)) and there was an insignificant increase on weekends. For males aged \( \geq 60 \) years, the presentation rate was lower than other age groups (Z-score 13.887, \( P < 0.001 \)) and increased significantly at weekends.

ATS categories were only available for the PAH data. The majority (53.4%) of cases were assigned to ATS category 3 requiring treatment within 30 min, followed by ATS category 4 requiring treatment within 60 min (30%), ATS category 2 requiring treatment within 10 min

![Figure 1. Rates of ED presentations because of power tool injury by sex and year. (■), Females; (▲), males; (●), total. [Colour figure can be viewed at wileyonlinelibrary.com]]

### Table 1. Summary of time of presentation and destination after ED treatment for patients with power tool injury

| Age (years) | Sex | Monday–Friday | Weekend | Z-score |
|-------------|-----|---------------|---------|---------|
|             |     | n  | Rate | n  | Rate  |         |         |
| <30         | F   | 30 | 0.239 | 12 | 0.224 | 0.190, \( P = 0.849 \) |
|             | M   | 946 | 7.567 | 215 | 3.290 | 12.128, \( P < 0.001 \) |
| 30–59       | F   | 61 | 0.389 | 41 | 0.683 | −3.118, \( P < 0.002 \) |
|             | M   | 1566 | 7.480 | 627 | 8.053 | 1.622, \( P = 0.105 \) |
| 60+         | F   | 11 | 0.168 | 3  | 0.137 | 0.339, \( P = 0.727 \) |
|             | M   | 381 | 3.821 | 162 | 4.691 | −2.391, \( P = 0.016 \) |
| All         | F   | 102 | 0.286 | 56 | 0.394 | −2.258, \( P = 0.023 \) |
|             | M   | 2893 | 6.632 | 1004 | 5.670 | 3.736, \( P < 0.001 \) |
| Total       |     | 2995 | 3.697 | 1060 | 3.302 | 2.619, \( P = 0.008 \) |

| Disposition | Total | Mode of arrival |
|-------------|-------|-----------------|
|             | n   | %   | n   | %   | n  | %   |
| Admitted to hospital | 1419 | 34.9 | 853 | 63.7 | 566 | 20.9 |
| Discharged from ED | 2504 | 61.9 | 416 | 31.1 | 2088 | 76.9 |
| Did not wait | 21 | 0.6 | 4 | 0.4 | 17 | 0.7 |
| Transferred to another hospital | 103 | 2.6 | 62 | 4.1 | 41 | 1.5 |
| Total | 4057 | 100 | 1335 | 100 | 2712 | 100 |

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During the year-long prospective study at PAH, there were 411 power tool-related presentations. Of these, 366 were eligible for interview and 186 (45.8%) were recruited; 106 (56.9%) of those were retained for the 3 month follow up. A total of 87 (46.8%) patients stated their injury occurred while in paid employment. The median age was 30 years (range: 17–76) for those with occupational injuries and 51 years (range: 18–87) for non-occupational injuries. Patients were predominantly male (n = 180, 96.8%). All but two of the occupational group presented during the week. In contrast, 40 (44.4%) of the non-occupational group presented at the weekend.

Angle grinders and various types of power saw (excluding chainsaw) were the most common power tools causing injury (53.7%) (Table 3). Among those interviewed these tools were distributed across the occupational and non-occupational groups. In the interviewed patients where details of the tool were obtained, nail guns were the primary cause in the occupational group and garden tools in the non-occupational group.

For men, lacerations and eye complaints were the most common injuries, with grinders being the most frequently-involved tool. Amputations (n = 6) and lacerations (n = 5) were the most frequent causes of injury for female patients, with lawn mowers causing most injuries.

In terms of injury treatment, total of 381 diagnostic tests were ordered and 260 procedures performed in the ED. Complex wound care (e.g. fracture reduction), removal of a foreign body and stapling or suturing were the most frequent procedures performed. A large percentage (70.3%) of presentations were referred for further specialty consultation.

Surgery was required for half (51.16%) of the total presentations. In the occupational group, 36.5% had surgery in the public hospital and 43.5% went privately (covered by their employment insurance). In the non-occupational group, 88% went public and 12% private.

Haddon’s Matrix (Table 4) was used to categorise the aetiology (i.e. the host [person injured], agent [tool causing the injury] and environment [where the injury took place]) and the temporal factors (pre-event, event, post-event) of an injury. Table 4 also lists items identified by patients as risk factors and preventative strategies to power tool injury.

There were three pre-event factors identified as contributors to injury: lack of formal training, inappropriate safety and prior consumption of alcohol. Factors associated with the tool itself included using a tool on an unsecured project and poor tool condition. Environmental factors included inadequate tool placement and wet or slippery conditions. Incorrect hand placement was identified as the most common host factor contributing to injury. Host factors for injury prevention included avoiding the task, using safety equipment, correcting hand placement and training. Only 90 (48.5%) of respondents had completed formal power tool training.

At the 3 month follow up, half the patients reported a ≥2 week recovery before returning to work or resuming normal activities (Table 5). The occupational group was more likely to require a longer recovery (62.2% vs 47.5% in the non-occupational group).

**Discussion**

Our findings show that power tool injuries are common causes of ED presentation. The total number of presentations rose over the study period; however, annual rates of power tool-related injury presentations per 1000 ED presentations demonstrated no discernable pattern. Our retrospective data did not permit identification of occupational versus non-occupational injuries, and we could not confirm if DIY injuries are increasing, as reported by researchers who reviewed research by Australian surveillance units and trade bodies. Safe Work Australia note that for the category that includes power tools, claims for serious injury dropped by nearly 30% between 2000 and 2016. Nevertheless, our findings show that power tool injuries still place a
| Location of injury | Saw | Welder | Grinder | Drill | Lawnmower | Nail gun | Hedge trimmer | Chain saw | Other | Unspecified | Total |
|-------------------|-----|--------|---------|-------|-----------|---------|--------------|-----------|-------|-------------|-------|
| Laceration        | 482 | 66.6   | 9 2.5   | 758   | 53.2      | 185     | 49.6         | 145       | 41.8  | 85 23.6     | 32    |
| Head              | 812 | 20.1   |         |       |           |         |              |           |       |             |       |
| Foreign body      | 8  | 1.1    | 73 20.5 | 438   | 30.8      | 36 9.7  | 13 3.6        | 44 12.2   | 2     | 5.13        | 34    |
| Eye               | 306 | 7.5    |         |       |           |         |              |           |       |             |       |
| Fracture          | 79  | 10.9   | 0 0.0   | 46    | 3.2       | 10.7    | 66 19.0       | 30 8.3    | 1     | 2.56        | 65    |
| Face and mouth    | 30  | 0.7    |         |       |           |         |              |           |       |             |       |
| Flash burn        | 1  | 0.2    | 65.8    | 8 0.6 | 1 0.3     | 0 0.0   | 0 0.0         | 0 0.0     | 0.00  | 1 0.9       | 0.00  |
| Neck              | 23  | 0.6    |         |       |           |         |              |           |       |             |       |
| Penetrating injury| 1  | 0.1    | 5 1.4   | 15 1.1 | 30 8.0    | 0 0.1   | 0.3 158       | 43.8 1    | 0.36  | 4 3.5       | 5 3.9  |
| Upper limb        | 271 | 6.7    |         |       |           |         |              |           |       |             |       |
| Other             | 14  | 1.9    | 1 0.3   | 51    | 3.9       | 36 9.7  | 43 12.4       | 11 3.1    | 0     | 0.00        | 9 61   |
| Wrist and hand    | 1445| 35.6   |         |       |           |         |              |           |       |             |       |
| Amputation        | 112 | 15.5   | 0 0.0   | 0 0.0 | 0 0.0     | 0 0.0   | 0 0.0         | 0 0.0     | 0.00  | 1 0.9       | 0 0.0  |
| Fingers           | 509 | 12.5   |         |       |           |         |              |           |       |             |       |
| Abrasion          | 6  | 0.8    | 21 5    | 85 6.0 | 16 4.3    | 13 3.8  | 0 1.1         | 6 0.8     | 0.00  | 9 7.6       | 1 0.8  |
| Thorax            | 31  | 0.8    |         |       |           |         |              |           |       |             |       |
| Open wound        | 10  | 1.4    | 0 0.0   | 0 0.0 | 9 2.4     | 2 0.6   | 0 20 5.5      | 0 0.0     | 0.00  | 0 0.0       | 8 6.1  |
| Abdomen, back, spine | 47  | 1.2    |         |       |           |         |              |           |       |             |       |
| Crush injury      | 9   | 1.2    | 0 0.0   | 2 0.1 | 8 2.1     | 10 2.9  | 1 0.3         | 0 0.0     | 0.00  | 5 4.2       | 1 0.8  |
| Lower limb        | 366 | 9.0    |         |       |           |         |              |           |       |             |       |
| Electric shock    | 1  | 0.1    | 6 1.7   | 5 0.4 | 3 0.8     | 1 0.3   | 0 0.0         | 0 0.0     | 0.00  | 2 1.7       | 0 0.0  |
| Ankle and hoot    | 182 | 4.5    |         |       |           |         |              |           |       |             |       |
| Burn              | 1  | 0.1    | 7 2.0   | 1 1.0 | 0 0.0     | 10 2.9  | 2 0.6         | 0 0.0     | 0.00  | 2 1.7       | 0 0.0  |
| Multiple body parts | 14  | 0.3    |         |       |           |         |              |           |       |             |       |
| Contusion         | 1  | 0.1    | 0 0.0   | 3 0.2 | 3 0.8     | 10 2.9  | 4 1.1         | 1 0.1     | 2.56  | 1 0.9       | 0 0.0  |
| Unspecified       | 21  | 0.5    |         |       |           |         |              |           |       |             |       |
| Total             | 724 | 100    | 357 100 | 1424 100 | 373 100  | 100 347 100 | 361 100 | 39 100 | 118 100 | 130 100 | 184 100 | 4057 100 | 4057 100 |
burden on Australian healthcare services particularly EDs, with two-thirds triaged as a 3 or higher (requiring treatment within 30 min) and a third of patients admitted to hospital. This was further evidenced in the prospective data for the sample of 186 patients that calculated 381 tests and 260 procedures being performed in the ED on these patients, 70% requiring specialist consultation and over half of the patients ultimately requiring surgery. This demonstrates a significant morbidity associated with power tool-related injuries and a considerable burden on ED services.

In this study, presentation in males predominated; females accounted for only one-in-20 presentations. In the United States, 92.3% of the 124 000 annual power tool-related injuries occur in males, and power tools are one of the products with the greatest degree of gender bias towards males in injury causation. In our study, this gender bias shifted considerably towards females for lawnmower injuries. This is consistent with previous overseas work\(^5,11,18\) and with data from the Queensland Injury Surveillance Unit (QISU).

The prospective data showed that almost all weekday presentations were occupational, and almost all weekend presentations were non-occupational (DIY). This is consistent with other Australian data.\(^5\) Increased weekend presentations in the 30–59 years, compared with the <30 years, age group is suggestive of more weekend DIY participation in the older group.

| Tool type          | Total presentations \(n = 411\) | Total recruited to interview \(n = 186\) |
|--------------------|-------------------------------|------------------------------------------|
|                    | Occupational \(n = 87\) | Non-occupational \(n = 99\) | Total recruited \(n = 186\) |
| Grinder            | 147                           | 35.7                                | 18 | 20.7 | 30 | 30.3 | 48 | 25.8 |
| Saw                | 74                            | 18.0                               | 20 | 23.0 | 29 | 29.3 | 49 | 26.3 |
| Garden tools       | 66                            | 16.0                               | 5  | 5.7  | 23 | 23.2 | 28 | 15.1 |
| Drill              | 47                            | 11.4                               | 13 | 14.9 | 6  | 6.1  | 19 | 10.2 |
| Nail gun           | 29                            | 7.0                                | 21 | 24.1 | 3  | 3.0  | 24 | 12.9 |
| Other              | 48                            | 11.4                               | 10 | 11.5 | 8  | 8.1  | 18 | 9.7  |

| Host               | n  | %   | Agent                                      | n  | %   | Environment                    | n  | %   |
|--------------------|----|-----|-------------------------------------------|----|-----|---------------------------------|----|-----|
| Pre-event          |    |     | Lack of formal training                    | 95 | 51.1| Poor tool condition or maintenance | 6  | 3.2 |
|                    |    |     | Inappropriate safety                      | 55 | 29.6| Unsecured project (wood/metal)   | 14 | 7.5 |
|                    |    |     | Alcohol intake                            | 8  | 4.3 | Inadequate tool placement       | 5  | 2.9 |
| Event              |    |     | Incorrect hand placement                  | 16 | 8.6 | Tool malfunction                | 13 | 7.0 |
|                    |    |     | Distraction or frame of mind               | 9  | 4.8 | Disc, blade or drill bit shattered | 13 | 7.0 |
|                    |    |     | Modification of tool                      | 9  | 4.8 | Inadequate tool placement       | 1  | 0.6 |
| Post-event         |    |     | Avoid the task                            | 10 | 5.4 | Apply more caution             | 23 | 12.4|
| recommendation      |    |     | Safety equipment application              | 35 | 18.8| Choosing alternative tool       | 15 | 8.1 |
|                    |    |     | More training                             | 4  | 2.2 | Use vice or clamp instead of hands | 14 | 7.5 |
|                    |    |     | Hand placement                            | 16 | 8.6 |                                |     |     |

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In agreement with the literature, powered saws were the most frequent cause of injury requiring admission. In the United States in 2006, this prompted legislation requiring power saws to include safety devices, reducing injury rates substantially.\(^6\) When all presentations are considered, the greatest number of injuries, one-third, were caused by grinders. Older QISU data supports this finding.\(^19\) The large number of grinder injuries in the non-occupational group was surprising as grinders are specialised tools; however, they are also low cost.

The part of the body most frequently reported as being injured were the fingers, hands, arms and the face or head; this is consistent with the literature.\(^8,12,20–22\) For lawn-mowers, lower leg injuries predominated. Again, this is supported by other studies.\(^5,23\)

The participants identified multiple potential causes of, and options to prevent, power tool injuries. Causative factors such as hand, equipment and project placement may benefit from training in correct power tool use, although half of the interviewed patients in our study reported receiving no training. We note the research suggesting two-thirds of people read instructions about safe power tool usage, but fewer than half understand what they read.\(^1\)

### Limitations

The number of power tool-related injuries identified in this study is likely an underestimate, due to variations in the quality and completeness of retrospective ED documentation. Also, not all power tool-related eye injuries necessarily present to ED, as both RBWH and PAH operate outpatient eye casualty clinics to which patients may be directly referred, bypassing ED. Finally, the exact nature of injury is an approximation for patients discharged home directly from ED, and whose injury was not coded for hospital admission.

### Conclusion

Power tool injuries continue to present a burden to the healthcare system particularly EDs. A significant number of these injuries are preventable and opportunities to capitalise on teachable moments during ED presentations and provide injury prevention materials to patients should be considered. The findings of our study are currently being communicated through State and Federal product safety committees to help inform ongoing development of educational materials and safety initiatives through these channels and can contribute more broadly to informing evidence-based preventive activities, including public information and training.

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### Competing interests

None declared.

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