# The impact of ladder-related falls on the emergency department and recommendations for ladder safety

## Abstract

**Objectives:** To describe the characteristics of patients who presented to the emergency department (ED) from a ladder-related fall and their injuries, highlight the impact of ladder-related falls on the ED, identify contributing factors of ladder falls, and draw recommendations to improve ladder safety.

**Methods:** A prospective observational study was conducted in two EDs. Patients' demographics and ED services utilised were obtained from medical records. A 55-item questionnaire was used to gather information about the type of ladder used, ladder activity, circumstances of the fall, contributing factors, and future recommendations.

**Results:** One hundred and seventy seven patients were recruited for this study. The typical patient was male, over the age of 50, and using a domestic ladder. The ED length of stay was between 30 minutes and 16 hours, and was longer if patients were transferred to the Short Stay Unit. Services most utilised in the ED included diagnostic tests, procedures, and referrals to other health care teams. Most falls occurred because of ladder movement and slips or misstep. The major contributing factors identified were a combination of user features and flaws in ladder set-up.

**Conclusions:** Ladder-related falls carry a considerable burden to the ED. Recommendations include ladder safety interventions that target ladder users most at risk of falls; men, ≥50 years old, and performing domestic tasks. Safety interventions should emphasise task avoidance, education and training, utilisation of safety equipment, and appropriate ladder set-up.


**Keywords:** ladders, falls, injury, safety, injury prevention

## Introduction

The demand for emergency department (ED) services is increasing[1] and this establishes the crucial role of emergency medicine in injury surveillance and informing the public of injury prevention measures.[2,3] Recently, the Australian Institute of Health and Welfare ranked ladder falls as the top cause of do-it-yourself injuries.[4] Ladder-related falls is a public health issue that is increasing.[5-8] Notably, non-occupational ladder falls are most common[8,9] and the incidence of ladder falls in people aged 50 and over is growing.[6,7,10] This trend has been attributed to the popularity of do-it-yourself and home renovation shows,[6] older people's desire to be independent,[11,12] and the lack of ladder safety standards in the community.[8,13]

To date, research on ladder falls had focused on incidence,[5-10] patient outcomes, and inpatient services utilisation,[5,6,8-10,12-17] but less so on the impact of ladder-related falls on ED services and contributing factors for the purpose of developing prevention strategies. The objectives of this study were to: (1) describe the characteristics of patients who fell from a ladder or agent used as a substitute for a ladder, (2) highlight the impact of ladder-related falls on the ED, (3) identify contributing factors of ladder falls; and (4) make recommendations for ladder safety. It is anticipated that the findings of this study will direct fall prevention campaigns, renew awareness of ladder safety, and ultimately reduce the number of ladder-related falls and injuries in the community.

## Methods

### Ethics

The study was approved by Metro South Human Research Committee.

### Design

This was a prospective observational study conducted in two public hospital EDs in Queensland, Australia.

**Setting**

The Princess Alexandra Hospital is a level 1 metropolitan, adult tertiary referral ED in Brisbane that has over 61,000 presentations annually. At the time of the study, Nambour General Hospital was a level 2 ED with more than 55,000 presentations annually and was the major referral hospital for the Sunshine Coast.

**Participants**

Adult patients (≥18 years old) who presented to the EDs between October 2015 and October 2016 with ladder-related injuries were recruited. Of note, patients who presented with injuries sustained as a result of falls from other agents used as ladder substitutes (e.g. chairs, tables) were also included. For the purpose of this research, the term ladder-related falls or ladder falls also includes this cohort.

**Recruitment**

Research nurses were available from 0800 to 1700 on weekdays to recruit. Patients who met the study criteria were identified from the ED information system, coupled with a notification system whereby triage nurses or the nurse-in-charge contacted the research team whenever an eligible patient presented. Patients who were unable to consent in the ED due to the nature of their injuries or presented outside the staffed hours were enrolled in the ward or via telephone. Unsuccessful contact after three attempts was considered as missed recruitment.

**Data collection**

*Medical records*

The following were collected from the ED electronic medical records: patients' age, sex, existing comorbidities, length of stay, mode of arrival, diagnostic tests, procedures, consultations, and discharge destination.

*Questionnaire*

The questionnaire administered to patients consisted of 53 items (Appendix I) that captured ladder activity, location and time of the fall, mechanism of fall, safety equipment used, fall height, ladder condition and set-up, contributing factors, reflections on lessons learnt, and other factors (e.g. training, perceived risk). The questionnaire was developed collaboratively through consultation with product safety experts, injury prevention researchers and emergency physicians to ensure broad capture of critical aspects for consideration. It has not been previously validated.

**Data analysis**

Data were entered into Excel (Microsoft Pty. Limited, North Ryde, New South Wales) shortly after interviews. Patient falls were grouped according to occupational and non-occupational settings. Descriptive statistics were used to describe patient characteristics, ladder details, and utilisation of ED services. Patient characteristics included age, sex, and comorbidities. Ladder details included ladder type, day and time of fall, fall category, and ladder activity. Emergency department utilisation involved length of stay, disposition, diagnostic tests, consultations, and procedures.

*Contributing factors and safety recommendations*

Haddon's Matrix was utilised to categorise and cluster risk factors. Haddon's Matrix is a conceptual framework used to identify risk factors, develop injury prevention strategies, and mitigate the severity of outcomes. The matrix has nine cells composed of three columns that elucidate factors that contributed to the fall (host, agent, and environment), and three rows of time intervals (pre-event, event, and post-event).[18] The host refers to the person operating

the ladder; the agent refers to the objects involved in the injury; and the environment is the setting where the fall occurs.[19] The free-text information from the questionnaires were categorised and clustered according to the nine Haddon's Matrix risk factors. Subsequently, specific prevention measures were proposed based on the contributing factors identified in the matrix.

## Results

There were 255 patient presentations during the study period: 185 from Princess Alexandra Hospital and 70 from Nambour General Hospital. Out of 255, 13 were excluded because they were under 18 years old (n=2), unable to recall events (n=7), died in ED (n=2), and unable to have access to an interpreter (n=2). Of the eligible presentations (N=242), 177 were recruited (73%), 47 were missed, and 18 declined to participate.

### Population characteristics

Patient characteristics and ladder information are presented in Table 1. Overall, patients' median age was 58 (range 18 to 87 years). When stratified to 10-year age groups, almost two-thirds (66%) of the patients belonged to the over 50's category. The participants were predominantly men, comprising 82% of the study population. As for comorbidities, functional comorbidity (i.e. osteoarthritis, visual deficit) was present in 26% of the population, cardiopulmonary (i.e. hypertension, chronic obstructive pulmonary disease) in 33%, 7% had neurological comorbidities (i.e. epilepsy), and 43.4% had other comorbidities (i.e. dyslipidaemia, gastro-oesophageal reflux disease). A small proportion lived alone (17%).

The median fall height was 2 metres (range 0.15 - 13 metres) and 142 participants (80%) fell from a height greater than a metre. Step ladders, extension ladders and A-frame ladders were commonly used. Many of the ladder falls occurred between 10:00 and 18:00 hours, and mostly on weekends.

The vast majority were non-occupational falls (70%). Non-occupational ladder use included home maintenance (50%), cutting tree branches (24%), cleaning out-of-reach areas (23%), retrieving materials from an out-of-reach area (7%), and other activities (5%). In occupational ladder falls, a large proportion occurred while working in building and construction (42%), the remainder occurred while doing maintenance-related work (13%), painting and decorating services (11%), and mechanical trade (7%), sales (6%), electrical (6%), and other activities (15%).

**Insert Table 1 here**

## Care Provided in the ED

Table 2 describes the care provided in the ED. The majority (68.9%) of patients arrived by ambulance. The ED length of stay ranged from 30 minutes to 16:01 hours with a median of 3:35 hours. A total of 403 diagnostic tests were ordered (more than 2 tests per patient on average). Of which, 37.5% were x-rays, 27% were computed tomography scans, 21.6% were blood tests, and 13.9% were electrocardiography, ultrasound, or magnetic resonance imaging. There were 72 procedures performed, backslab (23.6%), wound closure (22.2%), and fracture reduction (20.8%) were the most common. Aside from ED doctors and nurses, patients were reviewed by the Orthopaedic team (42.4%), Allied Health professionals e.g. Physiotherapist, Occupational Therapist, Community Nurse (28.3%), Surgical team (13.1%), and other Specialties (16.2%). Approximately, one in three were admitted to the inpatient unit (35%). The remaining 65% (n=115) were either sent home after treatment completion (28.2%) or were transferred to the ED short stay unit (36.7%) where patients stayed a median of 4:11 hours (range 26:00 minutes to 23:39 hours) in addition to the ED length of stay.

**Insert Table 2 here**

## Mechanism of fall

Almost half (47.5%) of the falls occurred while working from the ladder, the remainder occurred while descending (27.1%) or ascending (15.3%). Ladder movement (i.e. slipping, tilting sideways) was associated with ladder falls when ascending and while working from the ladder. Meanwhile, slips or missteps were common when descending (Table 3). A proportion of patients fell from chairs or stools due to slipping, losing balance, agent movement or breakage.

**Insert Table 3 here**

## Contributing factors

Table 4 presents Haddon's Matrix factors associated with ladder-related falls and patients' recommendations for preventing ladder falls.

*Pre-event*

There were five pre-event factors associated with the host that contributed to ladder falls. The most commonly reported were lack of ladder safety training (53.7%) and inappropriate choice of footwear, i.e. sandals or slippers (27.1%). There was a proportion (21.5%) of patients who took medications (i.e. anti-hypertensives, opioids) that may have influenced their awareness while operating the ladder. Insufficient ladder height was the most commonly identified agent issue (24.2%) and ladder placement on a sloped or slippery ground (26%) was the most common pre-event environmental factor.

*Event*

At the time of the fall, many patients reported that they were carrying equipment (58.2%) and/or overreaching (36.7%). In 7.3% of patients, ladder malfunction was associated with the fall.

*Post-event (Risk avoidance)*

Approximately 1 in 10 (11.9%) patients identified factors that could have prevented their ladder fall when asked to reflect on lessons learnt as a result of the ladder fall. These included hiring a professional, avoiding the task, performing a risk assessment, and utilising safety equipment. As for the agent, one in five patients believed that having another person supporting the ladder may have prevented the fall. Other common recommendations include, applying more caution (16.4%), choosing the right ladder for the job, i.e. right height (15.8%), and ensuring that the ladder is secure (13.6%) and close to the task (7.3%).

**Insert Table 4 here**

## Discussion

This study explored the characteristics of patients who presented to ED for ladder-related injuries, ED services utilisation, and contributing factors of ladder-related falls. It was anticipated that the study findings will contribute to ladder injury prevention campaigns and direct efforts to those who are at risk.

Step ladders, extension ladders, and A-frame ladders were the most common ladder types used. Overall, ladder falls usually occurred between 1000 and 1800 hours, and on the weekends. Patients were predominantly male and over the age of 50. Non-occupational ladder falls were more frequent than work-related ladder falls. Non-occupational ladder falls mainly occurred at home while doing home maintenance. These findings are similar with previous studies,[6-10] which support renewed efforts to target populations at-risk of ladder falls.

The burden of ladder-related injuries to the ED was emphasised. Resources utilised included time (including extended ED stay in the ED Short Stay Unit) diagnostic tests, procedures, and consultations by other medical specialists. The findings can be considered “stating the obvious” but they highlight the burden and potential cost implications to the ED, as demonstrated by the requirement for primary assessment, diagnosis, and treatment for patients following ladder trauma. In the context of increasing demand for emergency services[1] and the role of emergency medicine in injury prevention,[2,3] these findings help establish the importance of preventing ladder-related falls.

Several recommendations can be drawn from this study. The results indicate that ladder-related falls are consequences of the interplay between the ladder user, the ladder, and the environment. Individuals who are over the age of 50, taking medications that can affect mental awareness and stability, and those who suffer from conditions that impair physical capacity or are intoxicated are at the greatest risk of a ladder-related injury and should be the target of injury prevention initiatives. For that group, tasks that require the use of a

ladder might be best delegated to a professional. Non-occupational users, performing home maintenance and cleaning tasks are also a high-risk group and ladder safety education and training is lacking for this cohort.[8] The high proportion of ladder users from the present study who were: a) not wearing safety footwear or b) slipped from a ladder or rung, suggests that increasing the use of non-slip footwear is necessary to minimising the frequency of ladder falls. The user's feet primarily support their load while on the ladder,[20] therefore non-slip footwear can provide stability that minimise the risk of slipping. Finally, while working on the ladder, users must take precautions when carrying items and ensure they don't overreach as this can cause the ladder to tip.[21]

Adequate ladder set-up is also paramount to safety. The choice of ladder must be appropriate for the task and ladder placement needs to be within arm's reach to the task to negate overreaching.[22] Prior to use, the user must ensure that ladder condition is satisfactory to prevent ladder malfunction. Placement of ladder on a sloped or slippery ground is strongly discouraged because this increases the risk of the ladder base slipping.[23] Movement of the ladder user is inevitable, thus ladders must be fastened or stabilised to prevent the ladder from tipping or slipping away. It is interesting to note that not one of the non-occupational patients identified they had used any form of accessory such as tie down straps or stabilising arms. Lastly, it is recommended that a second person hold the ladder for support and pass equipment to the ladder user.

In the Australian setting, the government launched a ladder safety campaign in 2006 with the aim to promote safe ladder use[22] and renewed their efforts 10 years later.[24] As the trend of ladder falls has been increasing over the years,[6-10] perhaps the campaign has not achieved its purpose. Oxley and colleagues affirm that, "very little has been done to establish preventative strategies to support safe ladder usage outside the workplace, with limited information provided for home and personal use of ladders".[8,p.15] Education is a start and this may be provided through ladder safety brochures or posters, which are available

online.[22,24,25] However, ladder users are unlikely to access them[17] therefore these resources should be distributed at the point of ladder purchase and displayed in hardware stores. This initiative could be coupled with mass (i.e. radio shows, television advertisements, news) or social media campaigns to disseminate ladder safety to the public particularly to the at-risk population. Bedi and Goldbloom asserted that although the effectiveness of such educational strategies is debated, it can promote ladder safety awareness.[5] Utilisation of faulty or dated ladders could be mitigated by using a buy-back scheme.[8] Ladder movement is a recurrent issue[8,21,26] so there is a strong case for the sale of ladder accessories either to be made compulsory or combined in the purchase price. These accessories (ladder trays, limbs for holding equipment, ladder hooks and base stabilisers), although readily available, are all optional extras at the current time.

*Limitations*

The findings must be interpreted with the following limitations. Those who did not present to the study EDs, i.e. those who chose to be treated in a private hospital or general practitioners were not captured. As well, recall bias may be possible in patients who were recruited in the ward or via telephone.

## Conclusion

Patients who presented to ED from ladder-related falls were predominantly male, domestic ladder users, and were 50 years or older. Ladder presentations have a significant impact on ED services. Ladder falls were a product of an interaction between the ladder user, ladder, and the environment. In light of these findings, recommendations have been made to enhance ladder safety and boost ladder injury prevention strategies. These recommendations include task avoidance, education and training, utilisation of safety equipment, and appropriate ladder set-up.

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