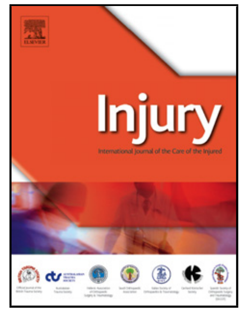

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PII: S0020-1383(15)00692-0
DOI: http://dx.doi.org/doi:10.1016/j.injury.2015.10.073
Reference: JINJ 6481

To appear in: *Injury, Int. J. Care Injured*

Received date: 25-3-2015
Revised date: 23-10-2015
Accepted date: 28-10-2015

Please cite this article as: Cantwell K, Burgess S, Morgans A, Smith K, Livingston M, Dietze P, TEMPORAL TRENDS IN FALLS CASES SEEN BY EMS IN MELBOURNE: The effect of residence on time of day and day of week patterns, *Injury* (2015), http://dx.doi.org/10.1016/j.injury.2015.10.073

TEMPORAL TRENDS IN FALLS CASES SEEN BY EMS IN MELBOURNE: The effect of residence on time of day and day of week patterns

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Keywords: Emergency Medical Service
Falls
Day of week
Time
Information Dissemination

ABSTRACT

Background

Injury due to falls is a major public health problem, especially for older people. We aimed to determine the accuracy of the ambulance call taker triage algorithm relative to paramedic assessment, and characterise variation in ambulance service demand for falls cases involving older adults over time and by residence type.

Method

We obtained all ambulance case records for January 2008 to December 2011 for adults aged 65 or over in Melbourne, Australia. Data elements comprised age, gender, date and time of emergency call, dispatch category, location of incident and the patient's clinical condition as ascertained by paramedics. We compared cases coded as falls by the call taker triage algorithm with those identified by paramedics. We also examined temporal variation (hour of day and day of week) in ambulance service demand for cases involving older adults, and compared community-dwelling cases and those from Residential Aged Care Facilities (RACFs). We used negative binomial regression to compare counts and trigonometric regression to compare temporal variation patterns.

Results

Over the four-year study period 77,891 falls cases involved older adults (6.5% of overall ambulance demand). Eighty-seven per cent of paramedic-assessed falls cases were correctly identified by the triage system. The RACF population was older (median age 87 years, IQR 82-91 vs 82 years, IQR 76-87), had higher hospital transport rates (89.5% vs 75.8%) and a higher incidence of falls at any age than the community-dwelling population. The temporal pattern for fall cases for all residence types peaked

between 6:00 and 12:00, but fall cases from RACFs showed an additional peak in the evening between 17:00 and 20:00.

Conclusion

Falls by older people are the second-biggest contributor to ambulance demand in Melbourne, consuming significant operational resources. Using call taker triage data instead of paramedic case records to calculate falls cases may underestimate the true incidence of falls by up to 13%. Temporal patterns can inform ambulance service policy and practice, falls referral and prevention programs to optimise service delivery which will lessen the number of future falls cases.

INTRODUCTION

Injury due to falls is a major public health problem, especially for older people. With over 170,000 cases per year, unintentional falls represent 39% of all injury-related hospital admissions, making them the leading cause of hospitalised injury in Australia[1]. Falls are also the second-biggest contributor to ambulance demand in Melbourne Australia, accounting for 10.3% of total demand, after cardiovascular cases[2]. The majority of falls (53%) occur in people aged 65 years and older (hereafter older adults)[1].An ageing population means falls in older adults are likely to consume an increasing proportion of ambulance resources over coming decades[3].

Previous research has shown residence type is an important factor when analysing ambulance and ED demand in older adults[4-6]. Overall ambulance demand has distinct time of day and day of week trends that vary by age group[4,7,8]. For older adults demand is highest in the morning and early afternoon [4,8], but patterns differ by residence type. Older adults living in residential aged care facilities (RACFs) do not have the distinct distribution differences between weekdays and weekends observed in older adults who do not live in RACFs (i.e., those in the wider community, hereafter termed community-dwelling)[4] . Residence type is especially important in falls research as management strategies differ for older adults in the community compared to those living in a RACF. Research shows that while strength and balance programs are effective falls prevention strategies for those who live in the community, these are not as effective in RACFs where prevention strategies instead focus on providing staff to assist with activities that are known falls risks such as toileting and to monitor those with cognitive impairment[9-11]. Whilst rates of hospitalised falls differ by residence type, with RACF residents having six times the rate of fall-related hospitalisations[1]; the impact on ambulance demand of falls in these two population groups and the associated temporal patterns are not known. Research examining falls incidence has used two main data sources: hospital-based data and ambulance dispatch data[1,12-15]. Hospital data includes people who have fallen and have injured themselves badly enough to warrant hospital attendance[1]. However, ambulance data can provide a different picture of falls incidence, as ambulances routinely attend falls cases where the patient has fallen but is not injured enough to require transport to hospital. Research has shown that if high-risk fallers (a category which includes people with a history of a fall) can be identified and provided with falls risk screening and targeted interventions, their risk of falling again can be significantly reduced[16]. Services such as hospitals and ambulances are mechanisms through which these people can be identified. The attendance but non-transport of patients captured in ambulance service data means that these data are especially useful for identifying the characteristics of high risk fallers for use in planning health programs and targeted interventions to prevent future falls. Indeed, these data combined with information on residence type and the temporal pattern of falls can inform ambulance and other health services as to peak times during which falls occur so that prevention and referral interventions are available at the times of greatest need

There are two types of ambulance data: dispatch data obtained at the point of emergency call taker triage and clinical case type data obtained from paramedic assessment. Dispatch data are a readily accessible and valuable form of ambulance data, but falls researchers have flagged some limitations[12,17] . One small study from the UK has shown that dispatch-coded data might lead to an underestimation of the actual number of falls cases and transport rates[17]. An understanding of the differences between dispatch data and clinical case type data can assist ambulance services without access to electronic patient records to estimate the impact of falls and quantify the impact of falls management and referral strategies on ambulance demand.

In this study we examined falls data for older people attended by ambulance in Melbourne, Victoria. These data allow for comparison between cases coded as falls by the call taker dispatch algorithm with those coded as falls cases after paramedic assessment. We also examined the temporal variation (time of day, day of week) in ambulance service demand for falls cases involving older adults, and by residence type, contrasting those attendances occurring in RACFs with those occurring in the wider community.

This study was approved by the Monash University Human Research Ethics Committee and the Research Governance Committee of Ambulance Victoria.

METHODS

SETTING

The study site was the greater Melbourne metropolitan area in Victoria, Australia, which has an area of approximately 10,000km^2 and a 2011 population (at the end of the study period) of 4.17 million people[18]. The population includes 540,400 older adults[18], of whom approximately 5.8% lived in an RACF[19]. Ambulance Victoria is the sole publicly funded state-wide emergency ambulance service that provides prehospital emergency care in Victoria.

POPULATION AND CASE DEFINITION

The methods we used were based on data and procedures that have been described previously[2,20]. Briefly, all cases of emergency ambulance attendance in metropolitan Melbourne were obtained from the Ambulance Victoria data warehouse for the period 1/1/2008 to 31/12/2011 for a retrospective descriptive analysis of routinely collected patient care data.

Data elements comprised age, gender, date and time of call to '000' (the local emergency service access telephone number), call taker dispatch category (Medical Priority Dispatch System, MPDS code), location of incident and the clinical condition of the patient identified after paramedic assessment using case nature (CN, the cause of the injury or illness) and the final primary assessment (FPA).

Caller information during the '000' call is used to determine the dispatch category given to the responding ambulance crew using the MPDS software. MPDS is a structured electronic triage processing system allowing operators (typically laypeople) to prioritise ambulance cases and is targeted at resource allocation and case prioritisation rather than clinical diagnosis[21]. MPDS sorts calls into 36 chief complaint categories based on responses to key questions. (Not all requests for ambulance attendance in Victoria are handled using MPDS; cases where there is a doctor or nurse with the patient are handled by a separate coding system.)

FPA and CN were coded according to the *International Classification of Disease, 10th Revision, Australian Modification (ICD-10-AM).* Each FPA was converted to an ICD-10-AM code using word matching or best fit and each CN was converted to an ICD-10-AM external cause of injury code using word matching or best fit[2]. If the CN was listed as a fall, the clinical case type was recorded as a falls case.

Over the four-year period 124,116 cases had a CN of fall, 10.3% of overall demand[2]. Of these, 122,968 cases were recorded as falls at ground height or from less than 3 metres and 1,148 cases from more than 3 metres. The patient's age, as calculated on the day of the case, was sorted according to the Australian Bureau of Statistics (ABS) age categories, with older adults categorised as 65 years and over[22]. Of the 124,116 falls cases attended over the four-year study period, 77,891 (62.8%) involved older adults (6.5% of overall demand) and these were extracted for the purposes of this study.

Patients' ages were grouped into three 10-year age strata; 65–74 years, 75–84 years and 85 years and older. We used greater metropolitan Melbourne population estimates for the 9th of August 2011 for calculation of the age-specific rates for 10-year age strata[19].

RACF cases were defined as those in which the fall occurred at a RACF. Community-dwelling cases were those not listed as occurring in a RACF but at a location consistent with community living such as patient's private home (84% of cases), patient's workplace or driver of a car. These location types were assigned by the treating paramedics. Only emergency transport use (not routine or booked ambulance transport) was examined.

STATISTICAL ANALYSIS

Descriptive analyses involved generating tabulated raw counts and percentages of case demand in the older adult population for each residence type. Negative binomial regression was used to calculate differences in raw counts for each day of the week. Demand distribution patterns across different days of the week were broken down across different times of the day and compared using trigonometric regression. This method of analysis has been described previously[20]. Briefly, trigonometric regression is a family of models appropriate for modelling data characterised by fluctuating yet cyclical peaks and troughs[23]. Although the negative binomial model can be used to analyse hourly timescale data it requires the generation of many dummy variables. It was felt that the trigonometric model was more parsimonious and provided clearer results to inform clinical practice. Regression diagnostics for the trigonometric regression were appropriate, meaning that the use of trigonometric regression for these count data did not lead to any breaches of key model assumptions.

We tested five different trigonometric models using the overall dataset. Starting with the simplest model consisting of one sine and cosine terms first, we then added a pair of double sine and cosine terms. We added up to five terms with the last pair being quintuplet terms. Across our models, the R^2 values increased sharply up to 3 terms and then plateaued, with only minor improvements in fit with more complex terms. We chose the most parsimonious model which still maintained low variation of residuals with high values of R^2; the model with 3 pairs of terms. Table S1 in the supplemental material shows the R^2 terms for the first 4 pairs of terms. The residuals from this model were checked and were found to be normally distributed. The actual and predicted model curves are shown in Figure S1 in the supplemental material.

We tested two models, one with and one without the day of week variable. We performed a likelihood ratio test to see if stratification by day of week was statistically significant. We then generated seven different models with three pairs of terms, one for each day of the week to determine if demand trajectories patterns on particular days were statistically significantly different to other days. Differences between time of day patterns were examined using the coefficients obtained from the trigonometric regression analysis for each day of week, compared to Mondays. A likelihood ratio test was used to determine if the day of week differences were statistically significant. We also used this method to examine possible confounding by age by analysing hour and day of week patterns across residence in 10-year age strata. All statistical comparisons were two-tailed and for all analyses $p<0.05$ was considered significant. All analyses were undertaken using Stata version 11.2 (StataCorp, College Station, Texas).

RESULTS

BASIC DEMOGRAPHICS OF AMBULANCE-ATTENDED FALLS IN OLDER ADULTS

Over the four-year study period there were 77,891 cases where the treating paramedic recorded the patient's clinical case type as a fall. Of these cases, 51,580 involved community-dwelling people (65.9%), with 17,771 involving RACF residents (22.8%). Residential status could not be determined in 8,540 cases and these cases were excluded from further analysis. Table 1 shows the number of falls cases, median age, number of falls per 10-year age range, transport to hospital rate for each age range, and gender distribution. Figure 1 shows the age-specific rates (per 100,000 of the population) for falls by residence type and age range.

MPDS TRIAGE DISPATCH CODING VERSUS CLINICAL CASE TYPE FOR FALLS CASES

There were 69,312 cases involving older adults in which the attending paramedic coded the case type as a fall, 25.6% originated from a RACF. These cases had a transport rate of 79.3%. Of all the 59,162 cases in which the MPDS dispatch algorithm was used (85% of total; the remainder was not coded using MPDS as a nurse or doctor was with the patient) and the treating paramedics listed the case type as a fall, 17% were from an RACF and the overall transport rate was 76.7%. Eighty-seven percent of cases coded via MPDS were dispatched as falls cases (category 17) with a 76.1% transport rate, while 6.1% were dispatched as unconscious/faint (category 31) with a 82.6% transport rate and 1.2% were dispatched as a traumatic injury (category 30) (82.6% transport rate).

AMBULANCE-ATTENDED FALLS CASES IN OLDER ADULTS BY TIME OF DAY

Figure 2 shows falls attendances for older adults in RACFs compared to community-dwelling older adults, stratified by age to account for the difference in median age between patients in the two residence types. Visual examination and trigonometric regression (Table S1 in the supplemental material) shows that attendances in the two residential types have markedly different time of day distribution patterns. Attendances involving falls by community-dwelling older adults were most likely to occur in the late morning, whereas attendances involving patients living in RACFs showed a bimodal distribution, in which falls most often occurred in the late morning and in the early evening.

AMBULANCE ATTENDED FALLS CASES IN OLDER ADULTS BY DAY OF WEEK

Community-dwelling population

Table 1 shows the number of falls cases attended by ambulance for each day of the week. Community-dwelling cases were attended more often on Thursdays and Fridays than Mondays. Likelihood ratio testing showed that the inclusion of day of week to the trigonometric regression model improved the fit of the model (X^2 (1)=9.03, p<0.00). Figure 3 shows the demand distribution by time of day for each day of week. Visual examination reveals a small difference in demand between weekdays and weekends, with a slight decrease in case numbers between 10:00 and 16:00 on weekends. Trigonometric regression analysis showed a statistically significant difference in the daily patterns between Saturday and Sunday and Monday (the reference day) (see Table S2 in the supplemental material), but visual examination showed that this was only for cases between 09:00 and 17:00; this represents a difference of only 165 cases per year. Weekend demand accounted for 27% of total falls cases. Of the 73% of falls cases that occurred on weekdays, only 40% occurred during business hours (09:00–17:00).

RACF population

There were no statistically significant differences in the daily numbers of falls cases when compared to Mondays (Table 1), and visual examination of the demand distribution in Figure 3 showed that there was no clear difference in demand patterns across days of the week. Likelihood ratio testing showed that the inclusion of day of week to the trigonometric regression model did not improved the fit of the model (X^2 (1)=0.06, p=0.81). Analysis of the demand patterns using trigonometric regression (Table S2 in the supplemental material) showed that Friday and Sunday had statistically different patterns from

Monday, however this did not represent an operationally significant difference to ambulance demand. Weekend demand accounted for 29% of total falls cases. Of the 71% that occurred on weekdays, only 28% occurred during business hours (09:00-17:00).

DISCUSSION

Our study provides new information on patient characteristics and temporal patterns associated with ambulance demand related to older adult falls cases and the differences when analysed by residence type. Cases from RACFs were older, with a higher incidence of falls at any age and higher associated transportation rates than for the community-dwelling population. Falls cases for both residence types peaked between 6:00 and 12:00, but falls cases from RACFs showed an additional peak in the evening between 17:00 and 20:00. There were statistically significant difference in both populations by day of week, but the operational significance to ambulance services of these small differences is likely to be negligible. This information can be used by ambulance services to inform policy and practice around referral of people who fall in the community to falls programs to prevent future falls and alert RACF staff to times when falls are most likely to occur so that opportunities for falls prevention can be maximised.

While ours is the first study to focus on temporal patterns in ambulance demand, it is not the first study to use ambulance demand data involving falls. In contrast to previous studies that have used dispatch data alone to identify falls cases attended by ambulance[12,13,24], our study used both MPDS dispatch data and data obtained after paramedic assessment, allowing for a comparison of these data types. Results were relatively consistent: compared to paramedic assessment of a falls case, the MPDS dispatch system allocated 87% of falls cases to the dispatch category of falls (category 17). The remaining 13% of paramedic-assessed falls cases were allocated to other dispatch categories – a finding similar to that of a UK study, which suggests that this is consistent across ambulance jurisdictions[17]. However, the 13% of cases not categorized as a fall by MPDS attracted a higher transportation rate. This confirmation of the validity of the MPDS system allows other ambulance services who rely on MPDS data for planning to have reasonable confidence in their estimates of falls incidence.

The lower transport rates for community-dwelling cases and the high fall rates for RACF cases have important implications for ambulance services and RACFs. The temporal demand patterns associated with these rates can assist with demand planning for both residence types. Using ambulance instead of hospital data quantifies the number of patients who are not transported to hospital (where referral to falls programs often occurs) but are left at home. This represents a missed opportunity to minimise the chance of future falls. The consequences of falls resulting in minor or no injury are often neglected[11]. Factors such as fear of falling again and reduced activity level can profoundly affect function and quality of life[11], and increase the risk of seriously harmful falls[14,16]. Given that we have shown that a large number of patients fall in the community but do not attend an emergency department, reliable and timely referrals by paramedics to a falls screening and support service would be valuable[25]. The temporal patterns shown in this study highlight the large number of cases that paramedics attend on weekends and after business hours. Any onward referral system needs to be able to accommodate referrals made after hours.

Our data highlight that increasing age is strongly associated with falls incidence. However, compared to their community-dwelling peers, older people who live in RACFs have a greatly increased falls incidence and higher rates of transport to hospital, irrespective of age. People living in RACFs usually have advanced cognitive and functional impairment and medical co-morbidities[5], making them frailer and more vulnerable to injury following a fall than their community-dwelling peers. Falls prevention programs in RACFs include improving surveillance of high risk fallers (notably those with agitated wandering behaviour who can readily self-mobilize, so-called ‘sundown syndrome’), and staff assistance with toileting routines [9,26] .The temporal patterns of falls in RACFs should be used to inform operational practices and staff rostering profiles to ensure there are enough staff for these important falls prevention strategies. As many RACFs have fewer and less clinically qualified staff on site after hours and on weekends, it may be that a different staffing profile (including a lower staff-client ratio) would assist mobilisation of RACF clients during known peak fall times, and that these staffing levels should be made uniformly available daily, including on weekends, to accommodate the pattern of RACF falls identified in this paper.

There are limitations to this study. Firstly, our study is a secondary analysis of EMS data, meaning there was no opportunity to influence data collection. However, these data are collected for clinical purposes rather than administrative purposes alone, so the data fields used were compulsory for completing the case record, meaning that there were no incomplete records. In addition, there was no ability to confirm the accuracy of the recorded paramedic assessments.

Secondly, cases were classified according to the paramedic's determination of the location of the incident, not according to the patient's formal address, so misclassification bias is possible where RACF patients fall outside of their RACF or community-dwelling patients fall inside an RACF (e.g. when visiting). Formal addresses are obtainable from billing addresses but it is common for RACF residents to have a billing address which is not the RACF and so incident location is a more accurate reflection of the patient's residence. The extent to which falls occur outside of place of usual residence as categorised is unknown, but we suspect that the likelihood of RACF residents falling outside of their RACF would be higher than community-dwelling patients falling inside an RACF. Further research is required but it is likely that the magnitude of this effect on a large dataset such as that which we used is likely to be small.

Finally, we analysed data from one large metropolitan region and one EMS service; we excluded rural and regional data and other EMS services and metropolitan regions. The focus on one region might affect the generalisability of the results.

CONCLUSION

Falls by older people are the second-biggest contributor to ambulance demand in Melbourne Australia, consuming significant operational resources so it is important to have the best evidence to inform planning. Clinical case type data obtained after paramedic assessment provides information not available using other ambulance or hospital datasets. Ambulance dispatch data may underestimate the true incidence of falls by up to 13% and hospital data can miss up to 24% of elderly people who fall and are left at home.

The temporal demand patterns for falls cases in older adults can be used to inform policy and practice around ambulance service delivery as well as primary fall prevention strategies and secondary referral to programs to minimise the chance of future falls. Community-dwelling cases varied across time of day and had higher non-transport rates, highlighting not only the need for referral into falls prevention services outside of those available in hospitals but the operating hours needed for these services and referral possibilities. Falls are more common in the RACF population and involve higher rates of hospital transport and a different time of day demand pattern compared to community-dwelling cases. The demand distribution pattern seen in RACF cases can be used by ambulance services for demand planning and to inform RACF policy and practice so that preventative measures can occur at times when residents are more likely to fall.

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Conflict of Interest Statement

Two authors were employees of Ambulance Victoria at the time of manuscript preparation and submission. However, Ambulance Victoria had no direct input into the design, analysis and conduct of the project.

Funding Source

The authors gratefully acknowledge the contribution to this work of the Victorian Operational Infrastructure Support Program. Paul Dietze is the recipient of an NHMRC Research Fellowship (1004140). Michael Livingston is a recipient of an NHMRC Early Career Research Fellowship. Kate Cantwell is the recipient of an NHMRC Post Graduate Scholarship (1074335).

TABLES

Table 1. Ambulance Demand for falls cases with demographics in metropolitan Melbourne 2008-2011.

	Community Dwelling	RACF
Number of cases and percentage transport (%)	51,580 (75.8%)	17,771 (89.5%)
Female (%)	31,773 (61.6%)	12,760 (71.8%)
Median age (IQR)	82 (76-87)	87 (82-91)
Number of cases per age bracket (n) and percentage transport rate (%)		
65-74	11,303 (76.8%)	1,183 (83.1%)
75-84	21,451 (75.7%)	5,197 (88.8%)
85+	18,826 (75.8%)	11,391 (90.4%)
Rate per year per 100,000 population	2,594	10,276
Day of Week	N (%) IRR (95% CI)	N (%) IRR 95% CI
Monday	7,274 (14.1%) Reference	2,592 (14.6%) Reference
Tuesday	7,438 (14.4%) 1.02 (0.74-1.41)	2,483 (14.0%) 0.96 (0.81-1.14)
Wednesday	7,459 (14.5%) 1.03 (0.74-1.42)	2,473 (13.9%) 0.95 (0.80-1.13)
Thursday	7,618 (14.8%) 1.05 (0.76-1.45)	2,509 (14.1%) 0.97 (0.82-1.15)
Friday	7,738 (15.0%) 1.06 (0.77-1.47)	2,561 (14.4%) 0.99 (0.83-1.17)
Saturday	7,229 (14.0%) 0.99 (0.72-1.37)	2,595 (14.6%) 1.00 (0.84-1.97)
Sunday	6,824 (13.2%) 0.94 (0.68-1.30)	2,558 (14.4%) 0.99 0.83-1.17)

Figure 2. Time of day distributions of older adults falls cases stratified by residence type and age range, Metropolitan Melbourne, 2008-2011.

Figure 3. Older adult falls cases by day of week and residence type in metropolitan Melbourne 2008-2011. A) Community Dwelling B) RACF.

Figure 1

Figure 1.

Age specific rates (per 100,000 in each residence type) for ambulance attended falls cases in older adults by residence type in metropolitan Melbourne 2008-2011.

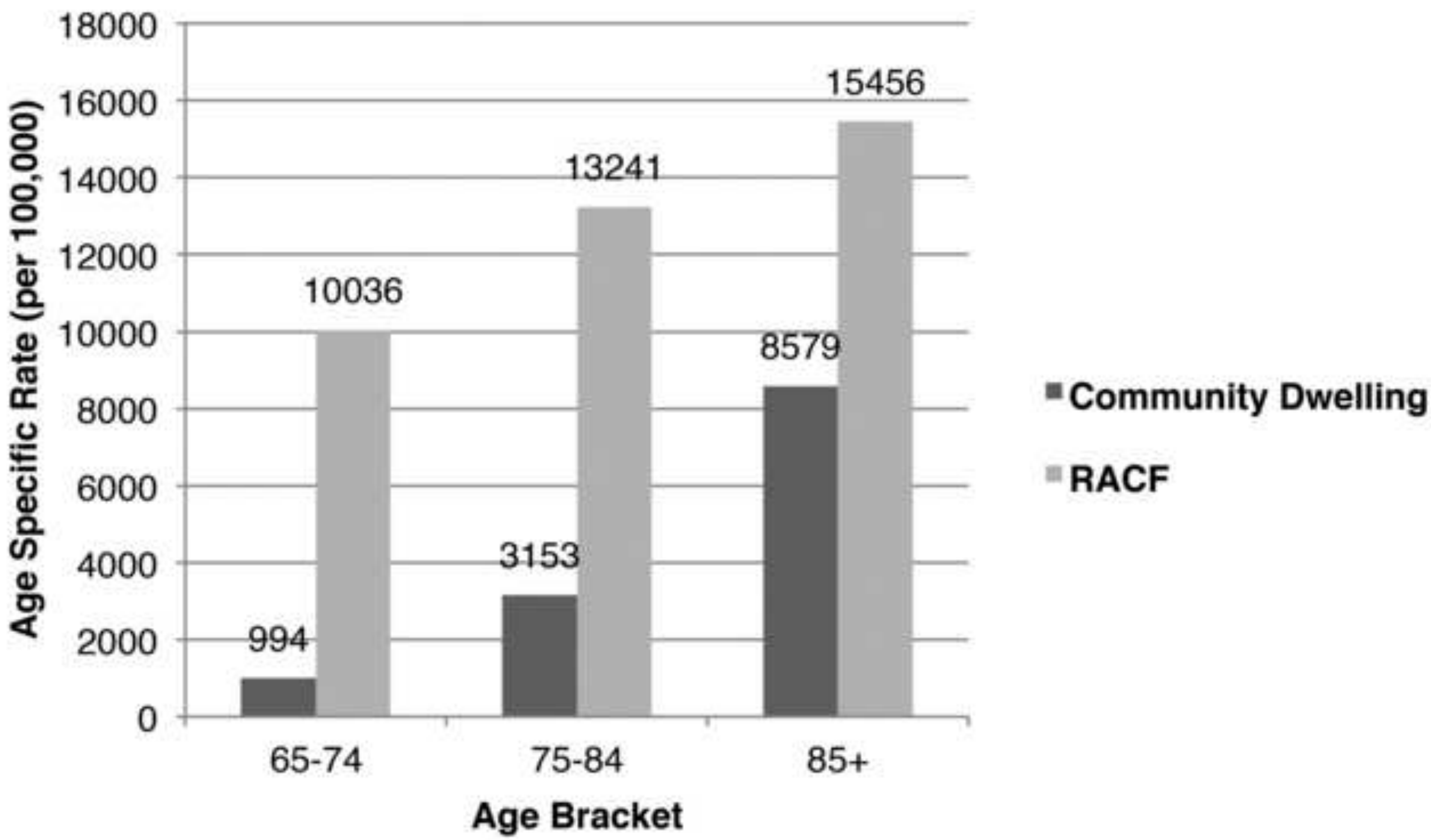

Figure 2.

Time of day distributions of older adults falls cases stratified by residence type and age range, Metropolitan Melbourne, 2008-2011.

A) Community Dwelling

B) RACF.

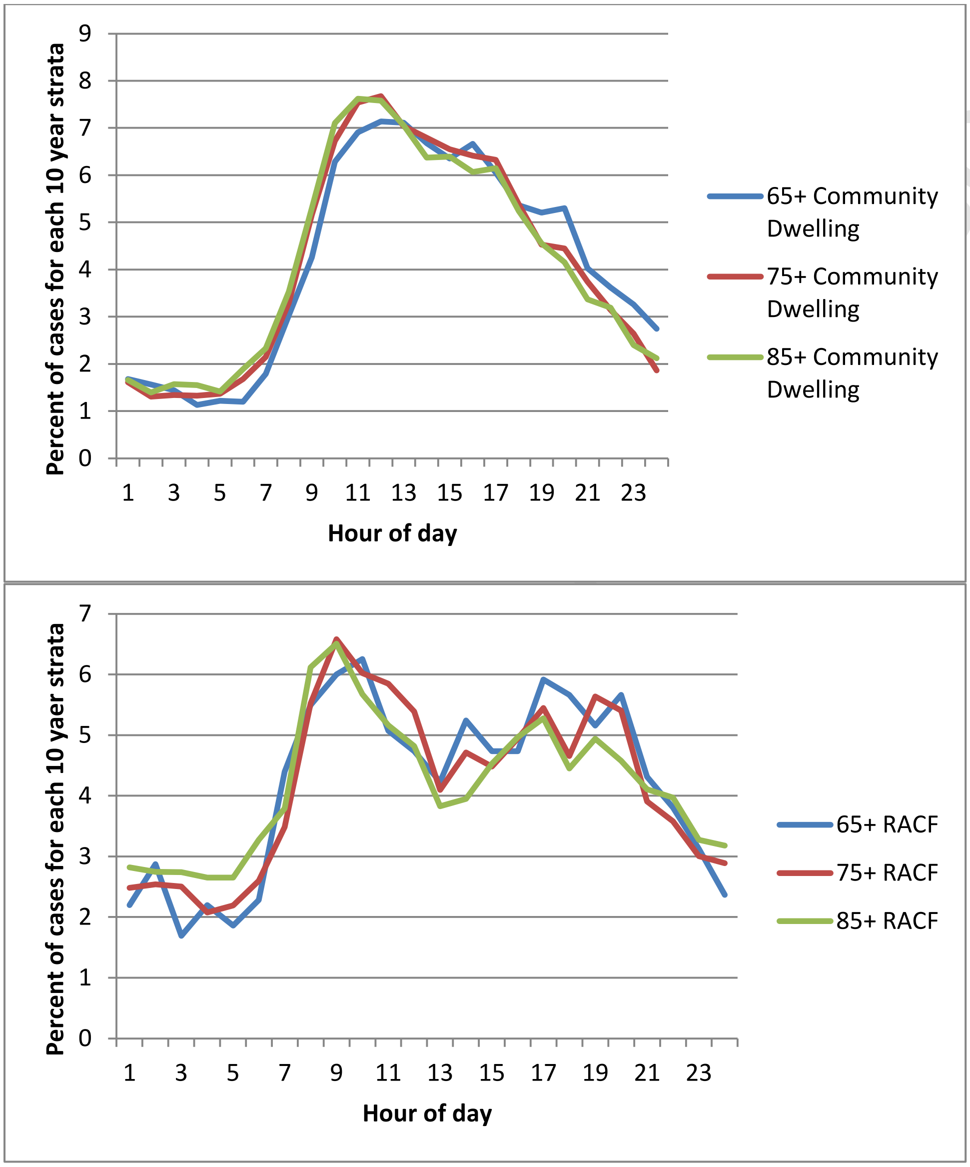

Figure showing actual case counts is available in supplemental material S1.

Figure 3.

Older adult falls cases by day of week and residence type in metropolitan Melbourne 2008-2011.

A) Community Dwelling

B) RACF.

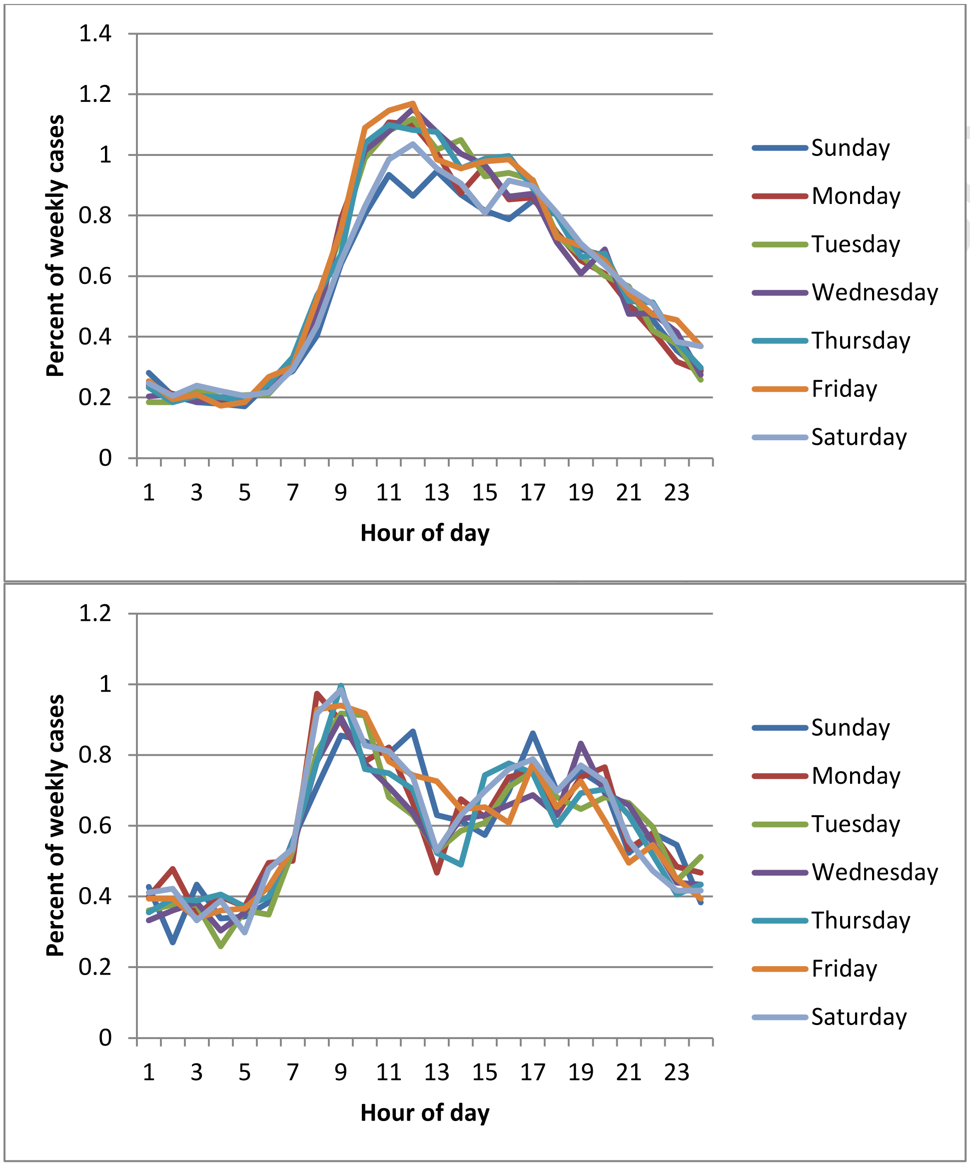

Figure showing actual case counts is available in supplemental material S2.

TABLES

Table 1. Ambulance Demand for falls cases with demographics in metropolitan Melbourne 2008-2011.

	Community Dwelling	RACF
Number of cases and percentage transport (%)	51,580 (75.8%)	17,771 (89.5%)
Female (%)	31,773 (61.6%)	12,760 (71.8%)
Median age (IQR)	82 (76-87)	87 (82-91)
Number of cases per age bracket (n) and percentage transport rate (%)		
65-74	11,303 (76.8%)	1,183 (83.1%)
75-84	21,451 (75.7%)	5,197 (88.8%)
85+	18,826 (75.8%)	11,391 (90.4%)
Rate per year per 100,000 population	2,594	10,276
Day of Week	N (%) IRR (95% CI)	N (%) IRR 95% CI
Monday	7,274 (14.1%) Reference	2,592 (14.6%) Reference
Tuesday	7,438 (14.4%) 1.02 (0.74-1.41)	2,483 (14.0%) 0.96 (0.81-1.14)
Wednesday	7,459 (14.5%) 1.03 (0.74-1.42)	2,473 (13.9%) 0.95 (0.80-1.13)
Thursday	7,618 (14.8%) 1.05 (0.76-1.45)	2,509 (14.1%) 0.97 (0.82-1.15)
Friday	7,738 (15.0%) 1.06 (0.77-1.47)	2,561 (14.4%) 0.99 (0.83-1.17)
Saturday	7,229 (14.0%) 0.99 (0.72-1.37)	2,595 (14.6%) 1.00 (0.84-1.97)
Sunday	6,824 (13.2%) 0.94 (0.68-1.30)	2,558 (14.4%) 0.99 0.83-1.17)