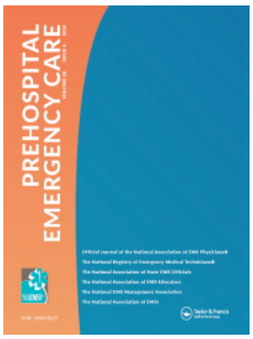

Prehospital Emergency Care

ISSN: (Print) (Online) Journal homepage: informahealthcare.com/journals/ipec20

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To cite this article: Paige M. Watkins, Peter Buzzacott, Hideo Tohira, David Majewski, Anne-Marie Hill, Deon Brink, Rudi Brits & Judith Finn (15 Apr 2024): Emergency Medical Service Attendances for Adults with Repeat Falls in Western Australia: A State-Wide Retrospective Cohort Study, Prehospital Emergency Care, DOI: 10.1080/10903127.2024.2338915

To link to this article: https://doi.org/10.1080/10903127.2024.2338915

PREHOSPITAL EMERGENCY CARE
https://doi.org/10.1080/10903127.2024.2338915

Emergency Medical Service Attendances for Adults with Repeat Falls in Western Australia: A State-Wide Retrospective Cohort Study

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ABSTRACT

Objectives: The risk of falls increases with age and often requires an emergency medical service (EMS) response. We compared the characteristics of patients attended by EMS in response to repeat falls within 30 days and 12 months of their first EMS-attended fall; and explored the number of days between the index fall and the subsequent fall(s).

Methods: This retrospective cohort study included all adults (>=18 years of age) who experienced their first EMS-attended fall between 1 January 2016 and 31 December 2020, followed up until 31 December 2021. Patients who experienced >=1 subsequent fall, following their first recorded fall, were defined as experiencing repeat falls. Multivariable logistic regression was used to identify the factors associated with repeat falls; and Kaplan-Meier analysis was used to estimate the time (in days) between consecutive EMS-attended falls.

Results: A total of 128,588 EMS-attended fall-related incidents occurred involving 77,087 individual patients. Most patients, 54,554 (71%) were attended only once for a fall-related incident (30,280 females; median age 73 years, inter-quartile range (IQR): 55–84). A total of 22,533 (29%) patients experienced repeat EMS-attended falls (13,248 females; median age 83 years, IQR: 74–89, at first call). These 22,533 patients accounted for 58% (74,034 attendances) of all EMS-attendances to fall-related incidents. Time between EMS-attended falls decreased significantly the more falls a patient sustained. Among the 22,533 patients who experienced repeat falls, 13,363 (59%) of repeat falls occurred within 12 months: 3,103 (14%) of patients sustained their second fall within 30 days of their index fall, and 10,260 (46%) between 31 days to 12 months. Patients who were transported to the hospital, *via* any urgency, at their first EMS-attended fall, had a reduced odds of sustaining a second EMS-attended fall within both 30 days and 31 days to 12 months, compared to non-transported patients.

Conclusion: Nearly 30% of all patients attended by EMS for a fall, sustained repeat falls, which collectively accounted for nearly 60% of all EMS-attendances to fall-related incidents. Further exploration of the role EMS clinicians play in identifying and referring patients who sustain repeat falls into alternative pathways is needed.

ARTICLE HISTORY
Received 13 September 2023
Revised 18 March 2024
Accepted 20 March 2024

Introduction

Emergency Medical Services (EMS) are responding to an increasing number of people who have fallen (1–4). Increasing age is a risk factor associated with falling (5, 6). As the proportion of older adults in the population increases globally, an increase in the incidence of falls is growing concurrently (7). Falls at any age have the potential to result in injuries ranging from minor to life threatening or even death (8), and often require prehospital emergency care and transport to the hospital. Moreover, there is a risk of a subsequent fall following an initial fall (2, 9, 10).

Patients categorized as experiencing 'repeat falls' are described as sustaining one or more subsequent falls, following their initially recorded fall (2, 9, 10). The risk of repeat falls increases with age and immobility (5, 9, 11–13). Repeat falls are shown to be associated with reduced independence (14), reduced quality of life (14), and with repeat transports to hospital in older adults (5, 9, 11–13). Multiple EMS systems globally have reported an increase in responses for repeat falls (1–4, 11). A study in the USA, showed that among older adults attended by EMS for a fall, nearly 20% experienced one repeat transport within 30 days, and 40% within 6 months (11).

This study aimed to examine EMS-attended adults who sustained repeat falls in Western Australia (WA). The study objectives were to 1) compare the characteristics of patients

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who sustained one fall compared to those who sustained repeat falls; 2) describe the characteristics of patients attended in response to repeat falls within 30 days and 31 days to 12 months of their first EMS-attended fall; 3) explore the number of days between the index fall and the subsequent fall(s); and 4) compare the mortality in patients who sustained one fall compared to those who sustained repeat falls.

Methods

Study Design and Setting

This retrospective cohort study included all adult patients (≥18 years of age) attended by St. John Western Australia (SJWA) EMS in response to a fall between 1 January 2015 and 31 December 2021. As the sole provider of ground-based EMS in the state of WA, SJWA covers the largest geographical area (2.5 million square kilometers) of any single EMS agency in the world; responding to more than 280,000 calls for EMS assistance each year (15). The SJWA EMS is staffed by paramedics in the metropolitan area, with a mix of paramedic and emergency medical technicians (EMTs) in rural areas (known as volunteer ambulance officer crews in WA) (15). Following an EMS attendance, a patient can be transported to hospital *via* transport urgency 1 (most urgent) to 5 (least urgent). During the study period no alternative referral pathways to other healthcare providers were available to EMS personnel in WA when managing patients who fell.

Data Collection/Data Source

Data were obtained from SJWA EMS electronic patient care records (ePCR), where paramedics and EMTs (hereafter collectively referred to as EMS clinicians) described each patient's presentation and clinical management, together with EMS dispatch data. Falls were identified by researchers using data from the Medical Priority Dispatch System (16), and by searching free-text fields within the ePCR fields, using manual screening, machine learning and natural language processing (17). The machine learning model used to identify the cohort presented in this study has been previously described (17). All identified falls from these sources were included after removal of duplicate cases. Falls identified as: suicide, patient not located on scene, motor vehicle incidents, assaults or kicked by an animal were excluded.

Using probabilistic linkage techniques, we linked records in the WA Death Registry (18) with those in the ePCR by surname, given name, date of birth, and residential address. Date of death was extracted for all patients with a death registration. We also linked records in the ePCR associated with the same individual using the same techniques, to identify people who had multiple emergency EMS attendances. For this linkage we used "Fine-grained record linkage software" (Fril, version 2.1.5, Emory University and Center for Diseases Control and Prevention, Atlanta, Georgia, U.S.), supplemented by Python Record Linkage Toolkit (version 0.14.0). Fril has elsewhere been reported to perform well for identifying the same individual, with 99% precision (positive predictive value) and 95% recall (sensitivity) (19). This screening could include false positive links, so it was refined by using machine learning techniques (17). Missing examination texts were exceedingly rare because this field on the ePCR is where the primary EMS clinicians record details of the case.

We defined a patient's index fall as their first recorded fall in the data set. Therefore, patients who only sustained one single fall during the study period, only sustained their index fall. We defined patients who experienced >=1 subsequent fall, following their index fall, as experiencing repeat falls. For the purpose of this study, and to identify patients who experienced repeat falls, a one-year phase-in period and one-year follow-up period were applied to this data set.

The data extracted were from 1st of January 2015 to the 31st of December 2021. Patients who sustained any EMS-attended fall in 2015 (one-year phase-in period) were excluded, as were any patients who experienced their index fall in 2021 (the one-year follow-up period). This allowed follow-up on all patients who sustained their index fall in 2016 to 2020, as this study focused on subsequent falls that occurred within 30 days and 12 months of a patient's index fall (2). A 5-year cohort of all EMS-attended adults who sustained their index fall between 1 January 2016 and 31 December 2020 formed the study cohort.

Data Extraction

Patients' demographic details (age, sex); EMS dispatch priority to the patient [from 1 (highest) to 3 (lowest)]; clinical information (Glasgow coma scale (GCS) score, pain score (0–10), medications administered (time, route of administration)) stratified by sex; other interventions (type, effect) stratified by sex, were extracted from the ePCR and computer aided dispatch system (CAD). Free texts were searched in the event of missing demographic or dispatch priority data. Injury location was extracted and allocated into the following categories: head and neck; hip to foot; trunk, back and pelvis; and shoulder to hand, as described in the ePCR (20). Any reported injury was included in the analysis of results as described in the ePCR, e.g., abrasion, bleeding, dislocation.

Patient disposition (non-transport/transported from the scene to hospital) was extracted. For transported patients, transport urgency level, was determined by the EMS clinicians at the scene. Transport destination level was coded according to the WA trauma service role delineation and trauma service organizational chart (21). A triage revised trauma scores (tRTS) was computed as a surrogate measure for patients' physiological condition severity level (22). The first measured values of systolic blood pressure (SBP), Glasgow coma scale (GCS), and respiratory rate (RR) recorded on the ePCR were used to calculate the tRTS, from '0′ to '12′, for each patient. Lower tRTS scores indicated a high injury severity (22).

Measures/Outcomes

We compared the characteristics and outcomes for patients with repeat falls versus a single fall, and explored factors associated with repeat falls. The independent variables explored

included: demographic information (age, sex), dispatch priority, observations [SBP, pain, injury status and location (head or neck; hip to foot; shoulder to hand; and trunk, back or pelvis), respiration rate, oxygen, GCS], and patient disposition (transport urgency, non-transport, and transport destination).

Statistical Analysis

Descriptive statistics were used to summarize the characteristics of all study participants. Kaplan-Meier plots estimating the time (in days) between consecutive EMS-attended falls were generated for the first five patient falls. Patients who only sustained n EMS-attended falls (where $n < 5$) in the study period, or who were reported to have died after their n-th fall, were censored for their $n+1$ fall. The censor date was either the 31 December 2021 or the patient's date of death, if earlier. Differences in time between consecutive falls were assessed using log-rank tests. Odds ratios (OR) were produced in the multivariable logistic regression allowing for the identification of factors (from the patient's index fall) that are associated with the likelihood of a repeat fall. The patient data analyzed in the model reflects all patient data collected at their first EMS-attended fall. A Wald test was conducted on all categorical variables to assess their significance as predictors of the dependent variable. Data analysis was performed using STATA statistical software Version 17.0 (College Station, TX, USA).

We could not derive a cox proportional hazards model (proportional hazards assumption) and non-proportional hazards models (Weibull survival distribution: generalized gamma distribution) to determine the association between survival time (time to second EMS-attended fall) of patients because our data violated the model's assumptions, even after data stratification. Multivariable logistic regression was used to investigate the association between independent variables recorded at a patient's index fall and the likelihood of experiencing a repeat fall within two-time frames: i) within 30 days, and ii) between 31 and 365 days of the index fall. To ensure all patients were alive and therefore at risk of experiencing a second fall, patients who died within 30 days of their index fall were excluded from the regression model exploring repeat falls within 30 days. Similarly, patients who died within 365 days of their index fall were excluded from the regression model exploring repeat falls between 31 and 365 days of their index fall. All patients who were therefore alive and could potentially have experienced the outcome of interest, namely a second fall, were included in the model.

Ethical Approval

Curtin University Human Research Ethics Committee approval [HR128/2013-85, 09 March 2022] and SJWA Research Governance Committee approval [11 March 2022] was obtained.

Results

Study Cohort

Between 1 January 2016 and 31 December 2020, 77,087 patients sustained their index fall. Following-up until 31 December 2021 (12 month follow up), we included 128,588 EMS-attendances to falls. A total of 54,554 (71%) individual patients only had one EMS-attended fall-related incident. A total of 22,533 (29%) individual patients had more than one EMS-attended fall. These 22,533 patients accounted for 58% (74,034 attendances) of all EMS-attendances to fall-related incidents. Figure 1 graphically presents all EMS-attendances to falls by fall frequency. A total of 177 falls identified as: suicide, patient not located on scene, motor vehicle incidents, assaults or kicked by an animal were excluded.

The 22,533 (29%) patients who experienced repeat falls sustained between 2 and 131 EMS attended falls in total (median: 2, interquartile range (IQR): 2–4). Age ranged from 18 to 112 years at the first fall; 19,843 (88%) were aged 65 years or older and 9,261 (41%) were 85 years of age or older. Overall, 13,363 (59%) of repeat falls occurred within 12 months: 3,103 (14%) of patients sustained their second fall within 30 days of their index fall, and 10,260 (46%) between 31 days to 12 months. Table 1 provides patient and case information. Some patients experienced a high number of repeat falls, with 568 (3%) of patients sustaining 10 or more falls, accounting for 8,264 (11%) of all EMS-attendances to falls. Of these 568 patients, 104 (18%) had their second fall within 30 days of their index fall, 342 (60%) had their second fall within 31 to 365 days of their index fall (total in 12 months, 446, 79%), and 52 (9%) died within 30 days of their last fall.

Injuries, Observations, and Treatments

A total of 10,456 (46%) patients who sustained repeat falls were injured at their first fall (6,371 females, 61%). Within this cohort of patients who sustained repeat falls, females had a higher reported frequency of head and neck (2,650, 59%), trunk, back and pelvis (1,166, 62%), shoulder to hand (2,011, 60%), and hip to foot injuries (2,561, 62%), than males at their first fall. Patients median GCS at their first fall was 15 [IQR 15–15], regardless of sex or whether they sustained repeat falls. For patients who experienced repeat falls, median GCS from their 2nd fall was 15 [IQR 14–15] regardless of sex. Median tRTS for all patients, male or female, was 12 [IQR 12–12]. Males had a median pain score of '0′ at their only fall (IQR: 0–4) and at their first of multiple falls (IQR: 0–1). Females had a median pain score of '1′ at their only fall (IQR: 0–6) and '0′ at their first of multiple falls (IQR: 0–3).

A higher frequency of medication administration is shown in patients who sustained one single fall (19,570, 39%) compared to patients who sustained repeat falls, at their first fall (5,322, 24%). Intravenous cannulation, 3 lead and 12 lead electrocardiogram (ECG) were the most frequently used interventions. Injuries, observations, and treatments/interventions are detailed further in Table 1.

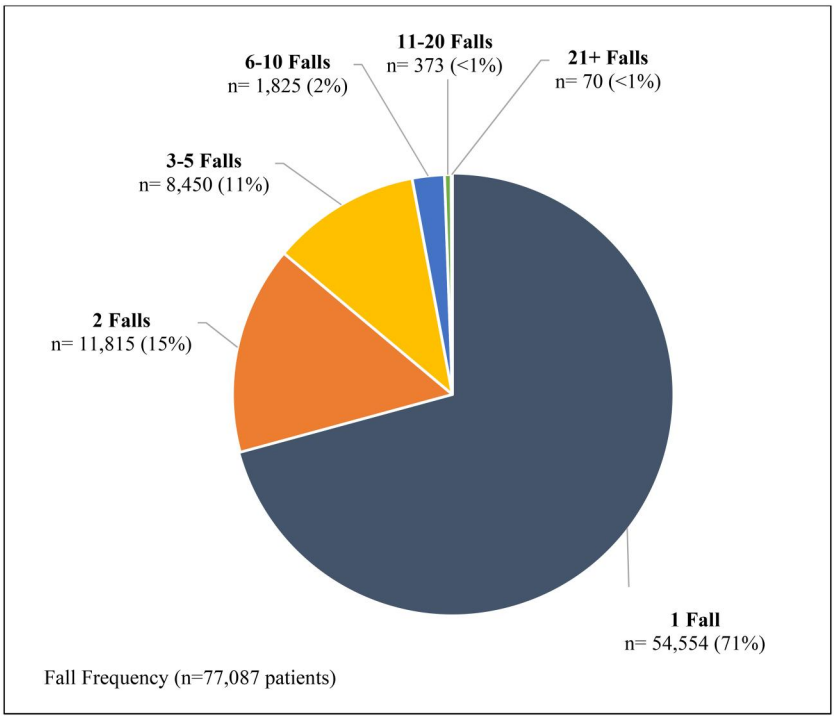

Figure 1. The total number of subsequent EMS-attended falls for the 77,087 adults who sustained an index EMS-attended fall between 1 January 2016 and 31 December 2020.

Disposition

A total of 66,121 (86%) patients were transported to hospital at their index fall, shown in Table 1. Of the 22,533 patients who experienced repeat falls, 18,075 (80%) were transported at their index fall. A total 8,636 (48%) patients experienced a repeat transport (transported at first and second fall) within 12 months: 1,714 within 30 days and 6,922 within 31 days to 12 months of their initial transport. Further details about patient disposition are shown in Table 2.

Table 1 reports total patient deaths within 30 days, or 365 days of their index and final fall. In patients who sustained one fall, 3,012 (6%) died within 30 days of their fall and 8,604 (16%) within 365 days of their fall. In patients who sustained repeat falls, fewer died within 30 days of their index fall (206, 1%), and within 365 days of their index fall (2,614, 12%) compared to those who sustained one fall.

Kaplan-Meier

Time between calls decreased significantly the more falls a patient sustained ($p < 0.001$), as shown in Figure 2. The Kaplan-Meier estimates for median time between the second and third fall was 558 days (18 months) [25%: 135 days; 75%: 1,913 days]. The median time between third and fourth fall was 310 days (10 months) [25%: 76 days; 75%: 1,090 days]. The median time between fourth and fifth fall was 199 days (6 months) [25%: 53 days; 75%: 697 days].

Multivariable Logistic Regression: Likelihood of Experiencing a Repeat Fall

The odds ratios of second EMS-attended fall following an index fall, are shown in Table 3. All assessed variables were found to be independently associated with the odds ratio of a patient sustaining a second fall within 30 days or 31 days to 12 months of their index fall.

Male patients attended by the EMS for an index fall had an increased odds of sustaining a second fall within 30 days and 31 days to 12 months. Older adults (>65 years of age) and patients attended *via* low dispatch priority (2 vs 1, 3 vs 1) at their index fall had an increased odds of a second EMS-attended fall within 30 days and 31 days to 12 months. Patients with a reported injury at their first fall had a reduced odds of sustaining a second EMS-attended fall within 30 days and 31 days to 12 months. Patients who were transported, *via* any urgency, at their index EMS-attended fall, had a reduced odds of sustaining a second EMS-attended fall within 30 days and 31 days to 12 months, compared to non-transported patients.

Discussion

Patients who experienced repeat EMS-attended falls accounted for 29% of all patients attended in response to fall-related incidents, and accounted for nearly 60% of all EMS-attendances to fall-related incidents, in the same time period. The results of this study confirm previous findings that a large proportion of EMS workload relating to falls is attending the same patients repeatedly.

There is a growing body of literature indicating that older adults are increasingly using EMS services in response to falls, as they are a vulnerable population at risk of repeat falls (23). Our findings are consistent with a study from the USA that showed nearly one third of older adults who called 911 for a fall, called EMS again for fall assistance (9). Similarly, our results showed that time between subsequent

Table 1. Characteristics of all 77,087 EMS-attended patients who fell.

	Sustained one fall (only fall) ($n = 54,554$)		Patients who sustained repeat falls (first fall of multiple) ($n = 22,533$)									
					Total number of falls sustained (data from final fall)							
			Index fall		2		3		4		5+	
	Index fall		$n = 22,533$		$n = 11,815$		$n = 4,848$		$n = 2,310$		$n = 3,560$	
Age at first call, mean (SD) years	68 (21)		80 (14)		79 (14)		81 (13)		81 (12)		79 (13)	
Age at first call, median (IQR) years	73 (55-84)		83 (74-89)		83 (73-89)		84 (76-89)		83 (75-89)		82 (74-88)	
Age at first call (years) (*n* %)												
<=65	19,254	35	2,658	12	1,413	12	417	9	194	8	299	8
65-75	9,536	17	3,254	14	1,531	13	552	11	266	12	474	13
75-85	12,773	23	7,328	33	3,477	29	1,378	28	623	27	1,041	29
85+	12,392	23	9,261	41	5,379	46	2,495	51	1,227	53	1,745	49
Sex (*n* %)												
Female	30,280	56	13,248	59	6,961	59	2,883	60	1,368	59	2,032	57
Male	23,768	44	9,255	41	4,839	41	1,958	40	942	41	1,527	43
Dispatch priority (*n* %)												
1	13,941	26	4,070	18	2,343	20	871	18	392	17	504	14
2	28,299	52	12,308	55	5,938	50	2,487	51	1,183	51	1,819	51
3	12,215	22	6,135	27	3,486	30	1,472	30	729	32	1,222	34
Reportedly injured (*n* %)[a]												
Yes	29,825	55	10,456	46	5,593	47	2,224	46	1,004	43	1,422	40
Head/neck	12,750	23	4,503	20	2,428	21	942	19	437	19	609	17
Trunk/back/pelvis	5,492	10	1,881	8	1,003	8	372	8	189	8	259	7
Hip/foot	9,745	18	4,142	18	1,809	15	729	15	328	14	457	13
Shoulder/hand	11,824	22	3,362	15	2,206	19	914	19	385	17	591	17
First GCS (*n*, %)												
13-15	50,611	93	21,676	96	11,118	94	4,547	94	2,164	94	3,327	93
9-12	1,171	2	350	2	358	3	153	3	85	4	126	4
6-8	230	<1	46	<1	60	1	15	<1	9	<1	14	<1
3-5	232	<1	19	<1	34	<1	16	<1	6	<1	6	<1
Treatments (*n*, %)[b]												
Any medication	19,570	39	5,322	24	3,033	26	1,100	23	429	19	664	19
IV cannulation	5,603	10	1,683	7	754	6	277	6	101	4	130	4
ECG	4,213	8	2,148	10	1,336	11	534	11	269	12	403	11
Oxygen	1,518	3	537	2	323	3	103	2	45	2	41	1
Pain score (*n*, %)												
0	29,666	54	14,944	66	7,967	67	3,482	72	1,716	74	2,770	78
1-3	6,755	12	2,934	13	1,467	12	586	12	255	11	377	11
4-6	5,968	11	1,772	8	914	8	316	7	135	6	185	5
7-9	8,187	15	2,051	9	1,017	9	325	7	154	7	163	5
10	3,472	6	802	4	435	4	132	3	50	2	64	2
Transported (*n* %)												
Yes	48,046	88	18,075	80	9,960	84	3,980	82	1,816	79	2,567	72
Transport urgency (*n* %)												
1	1,158	2	186	1	152	1	47	1	15	1	25	1
2	11,187	21	3,087	14	1,711	14	623	13	274	12	358	10
3	29,108	53	11,745	52	6,435	54	2,640	54	1,197	52	1,726	48
4-5	5,887	11	2,887	13	1,593	13	647	13	324	14	447	13
Transport destination – State Trauma Services (*n* %)												
Other	12,309	23	4,188	19	2,266	19	899	19	376	16	538	15
Urban Trauma	14,282	26	5,844	26	3,210	27	1,271	26	647	28	891	25
Metropolitan Trauma	14,470	27	5,820	26	3,259	28	1,323	27	563	24	812	23
Major Trauma	6,985	13	2,223	10	1,225	10	487	10	230	10	326	9
Not transported (*n* %)												
Yes	6,508	12	4,458	20	1,855	16	868	18	494	21	993	28
Died within (days) of 'index fall' (*n* %)												
30 days	3,012	6	206	1	183	2	18	<1	3	<1	2	<1
365 days	8,604	16	2,614	12	1,789	15	508	10	202	9	115	3
Died within (days) of 'final fall' (*n* %)												
30 days	3,012	6	2,103	9	1,090	9	492	10	230	10	291	8
365 days	8,604	16	6,473	29	3,285	28	1,488	31	711	31	989	28
Second fall within (days) (*n* %)												
30 days	-		3,103	14	1,522	13	666	14	348	15	567	16
365 days	-		13,363	59	6,270	53	2,998	62	1,515	66	2,580	72

This table shows a summary of 77,087 SJWA attended patients. Patients who sustained more than or equal to 2 falls: All patients' data from their first fall of those who sustained multiple falls, is reported in "Index fall (first fall of multiple)".

Transport destination level was coded according to the Western Australian state trauma service organizational chart. 536 (0.007%) patients had unknown sex demographic data. Glasgow Coma Scale (GCS). 2,752 (0.03%) patients had unknown GCS data at first fall. Due to some patients having incomplete demographic and/or clinical data, some reported characteristics may be unknow. All patients who sustained exactly two falls are reported in "2 falls". All patients who sustained exactly three falls are reported in "3 falls". All patients who sustained exactly four falls are reported in "4 falls". All patients who sustained five or more falls are reported in "5+ falls". The reported data reflects what information was recorded at the patient's final fall, whether they had 2, 3, 4, or 5+ falls total.

[a]The injury locations are not mutually exclusive. Injury location was extracted and allocated into the following categories: head and neck (cervical, forehead, ear, eye, mouth, nose, occipital, parietal; and throat regions); hip to foot (groin, ankle, foot, knee, lower leg, neck of femur and upper leg regions); trunk, back and pelvis (central front, back, buttock, flank, lower chest, lower quadrant, upper chest, pelvis, sacral, thoracic, upper quadrant, and lumbar regions); and shoulder to hand (elbow, hand, lower arm, shoulder, upper arm, and wrist), as described in the ePCR.

[b]These groups are not mutually exclusive. Electrocardiogram (ECG) includes 3 lead and 12 lead. IV – intravenous. Oxygen administered *via* nasal cannula.

Table 2. Repeat transport to hospital within 30 days and 12 months of index fall in patients who sustained repeat falls.

	Patients who sustained repeat falls (multiple falls)	Repeated transport in 30 days	Repeated transport in 31 days to 12 months	Repeated transport total (12 months)
	Index fall, $n = 22{,}533$ (first fall of multiple)			
All transports	$n = 18{,}075$ (80)	1,714 (9)	6,922 (38)	8,636 (48)
Age (Mean, SD)	80 (14)	80 (14)	81 (13)	81 (14)
Age (Median, IQR)	83 (75-89)	84 (75-89)	84 (76-90)	84 (76-89)
Sex (female), (*n* %)	10,648 (59)	920 (54)	4,030 (58)	4,950 (57)
Injured (*n* %)	9,699 (54)	892 (52)	3,708 (54)	4,600
Transport urgency (*n* %)				
1	186 (1)	9 (<1)	74 (1)	83 (1)
2	3,087 (17)	245 (14)	1,109 (16)	1,354 (16)
3	11,745 (65)	1,093 (64)	4,586 (66)	5,679 (66)
4&5	2,887 (15)	341 (20)	1,091 (16)	1,432 (17)
Transport destination – State Trauma Services (*n* %)				
Other	4,188 (23)	408 (24)	1,580 (23)	1,988 (23)
Urban Trauma	5,844 (33)	573 (33)	2,258 (33)	2,831 (33)
Metropolitan Trauma	5,820 (32)	526 (31)	2,243 (32)	2,769 (32)
Major Trauma	2,223 (12)	207 (12)	841 (12)	1,048 (12)

This table shows a summary of 22,533 SJWA attended patients. 170 (0.007%) patients had a Non-Australian Triage scale case (scheduled transfer to residential aged care facility or home) and are not included under transport urgency. Transport destination level was coded according to the Western Australian state trauma service organizational chart.

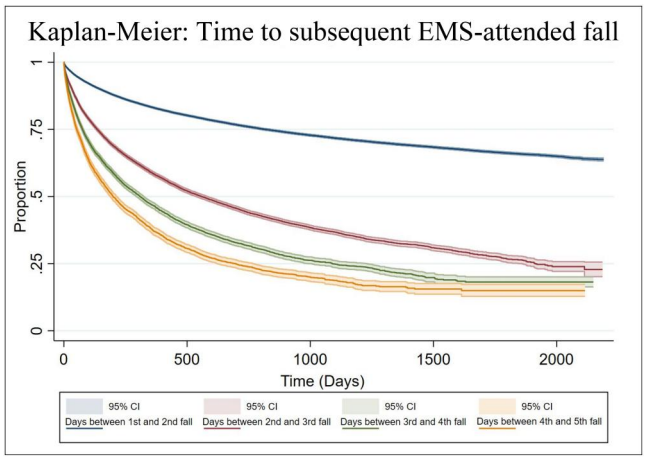

Figure 2. Days between subsequent falls for patients who experienced between 1 and 5 EMS-attended repeat falls. As the *p*-value for the log-rank test is <0.001, we conclude that there is a significant difference in the time to event between the four different groups.

falls decreases, with consecutive falls (9). We found that older, uninjured, non-transported patients had an increased odds of sustaining a second EMS-attended fall within 30 days and 12 months of their initial fall. In our study, 9% of patients who sustained repeat falls, experienced a repeat transport within 30 days of their index fall. Evans et al., (USA) found 18.3% of EMS-attended patients who fell experienced a repeat transport in 30 days, higher than our findings at 30 days (11). This difference may be due to geographical differences in study location, as WA has a much larger area than North Carolina, with North Carolina accounting for only 5% of the square kilometers of WA.

Transport to hospital became progressively less frequent with subsequent EMS responses, which is consistent with findings from Quatman et al. in a study based in the USA (9), which showed a reduction in transport frequency from 75% of first calls to 21% after the fourth call. We found that patients transported (*via* any urgency) at their first EMS-attended fall, have a reduced odds of a second EMS-attended fall within the subsequent 30 days or 31 day to 12-month period. Tiedemann et al., (23, 24) recommended that the identification of individuals in Australia at high risk of future falls, for onward referral to prevention interventions may reduce EMS-attendances for repeat falls. Our findings show that patients transported at their first fall were less likely to sustain repeat falls. This is potentially the result of patients experiencing onward referrals to preventative interventions during emergency departments or hospital admission, although this requires further research (23, 24). While some patients who fall and require EMS, do not require transport to the hospital, guidelines for EMS clinicians to identify and target these high-risk patients, and to refer to alternative falls programs, could be beneficial in addressing this growing demand (25–29).

For patients who experienced repeat EMS-attended falls in WA, time between EMS-attendances decreased significantly, the more falls the patient sustained. Given this, the need to identify those patients at risk of sustaining repeat EMS-attended falls is crucial. Our findings show that demographic information can be used to identify patients at risk of repeat EMS-attended falls. Specifically, males have a high risk of sustaining repeat falls, and the older a patient is at their first EMS-attended fall, the more likely they are to sustain repeat EMS-attended falls. Our findings identified that patients who were uninjured and not transported at their first EMS-attended fall, are more likely to sustain repeat falls. Clinical practice guidelines and prehospital personnel training could potentially benefit from including these patient factors to support prehospital personnel in their identification of patients at a high risk of sustaining repeat EMS-attended falls. Our findings reinforce the urgency of developing and implementing onward referrals to prevention interventions from the prehospital setting and identifying high-risk patients in a timely manner (23, 24).

The effectiveness of falls prevention programs has been demonstrated globally (9, 12, 30–32). A systematic review and meta- analysis (32), indicated that RCT's of falls prevention programs effectively demonstrate a reduction in falls

Table 3. Factors associated with a second EMS-attended fall within 30 days and 31 to 365 days following the index fall: a Multivariable logistic regression model.

Patients who sustained a second ambulance-attended fall within 30 days or 12-months of their initial ambulance-attended fall

	Second ambulance-attended fall within 30 days				Second ambulance-attended fall within 31 to 365 days			
	aOR	*p* value	95%CI		aOR	*p* value	95%CI	
Sex								
Female	1				1			
Male	1.31	<0.001	1.22	1.42	1.24	<0.001	1.19	1.30
Age (years)								
<=64.9	1				1			
65-74.9	2.29	<0.001	1.99	2.63	2.89	<0.001	2.65	3.14
75-84.9	3.81	<0.001	3.38	4.31	5.33	<0.001	4.95	5.74
>=85	5.31	<0.001	4.71	5.98	9.73	<0.001	9.04	10.47
Dispatch priority								
1	1				1			
2	1.33	<0.001	1.19	1.48	1.20	<0.001	1.13	1.27
3	1.46	<0.001	1.29	1.64	1.18	<0.001	1.10	1.27
Shoulder to hand injury								
No reported injury	1				1			
Yes	0.85	0.005	0.76	0.95	0.93	0.019	0.87	0.99
Head and neck injury								
No reported injury	1				1			
Yes	0.84	<0.001	0.76	0.92	0.84	<0.001	0.79	0.89
Trunk, back and pelvis injury								
No reported injury	1				1			
Yes	0.80	0.002	0.69	0.92	0.95	<0.001	0.77	0.91
Hip to foot injury								
No reported injury	1				1			
Yes	0.84	0.001	0.76	0.93	0.82	<0.001	0.77	0.87
Transported status and Urgency								
Not transported	1				1			
Urgency 1	0.17	<0.001	0.10	0.27	0.45	<0.001	0.36	0.57
Urgency 2	0.20	<0.001	0.18	0.23	0.45	<0.001	0.41	0.49
Urgency 3	0.27	<0.001	0.25	0.30	0.59	<0.001	0.56	0.63
Urgency 4&5	0.37	<0.001	0.32	0.42	0.67	<0.001	0.62	0.73

aOR: Adjusted odds ratio. Patient data from their first ambulance-attended fall was used for this model. 95%CI: 95% confidence interval.

Reference group: patients who sustained one ambulance-attended fall during the study period and survived to 30 days (model 1) and 365 days (model 2). A total of $n = 3{,}103$ patients sustained a second ambulance attended fall within 30 days of their index fall and $n = 10{,}260$ within 31 to 365 days. A total of $n = 51{,}542$ patients who sustained one ambulance attended fall survived to 30 days without a second fall, and $n = 45{,}950$ survived to 365 days without a second fall.

Head and neck refer to injuries of the: cervical, forehead, ear, eye, mouth, nose, occipital, parietal; and throat regions.

Hip to foot refers to injuries of the: groin, ankle, foot, knee, lower leg, neck of femur and upper leg regions.

Trunk, back and pelvis refers to injuries of the: central front, back, buttock, flank, lower chest, lower quadrant, upper chest, pelvis, sacral, thoracic, upper quadrant, and lumbar.

Shoulder to hand refers to injuries of the: elbow, hand, lower arm, shoulder, upper arm, and wrist.

rates by between 9% and 10% in multifactorial interventions (25, 26, 32, 33). The Falls Decision tree with the London Ambulance service (34) and the St John New Zealand's referral to their falls prevention service (35) are established examples of alternate referral pathways in the prehospital setting. Demand for EMS by older adults who fall, when not addressed with interventions to foster falls prevention, has increased since 2000 (1, 2, 4, 13, 25). Research into the implementation of referral pathways by EMS identified facilitators and barriers when implementing prehospital guidelines (25–27). Further exploration of EMS organizational structures that currently work effectively with referral pathways, could assist in diversifying strategies to approach the development of prehospital guidelines for referral to other services (25–27). Despite the evidence supporting the efficacy of falls prevention programs, a communication gap exists between EMS and community-based allied health and alternative health care pathways (9, 24, 29, 32, 33).

Future research exploring EMS-attended falls would benefit by identifying repeat falls, to expand on contributing factors to EMS demand. It is important to consider patients attended by EMS repeatedly for falls when addressing prehospital falls management guidelines. Further exploration of the role EMS clinicians play in identifying and referring patients who sustain repeat falls into alternative pathways is needed. This could potentially be supported by the development of specific education, protocols and guidelines for the prehospital management and referral of older adults who fall.

Limitations

There are several limitations of our study. This study only included those falls patients who were attended by EMS and who called '000'; patients who experienced falls or repeated falls and were privately transported, did not call EMS, received care or support in residential aged care facilities only are not included. Socioeconomic, disability, comorbidity status and general medication use are not recorded in the ePCR or CAD and therefore, were not included in this study. It is possible that some EMS attended falls were missed. However, we are confident that all efforts have been made to identify all falls through a combination of manual searching by multiple researchers (PMW, HT, PB, DM), machine learning and natural language processing for data identification (17). Machine learning and natural language

processing to identify falls in electronic patient care records from EMS-attendances is a strength of this study, as only 60% of falls cases identified through manual review were actually dispatched as 'falls'. This is particularly novel as several previous studies have identified falls solely on the basis of a 'falls' EMS dispatch code (4, 36, 37). Finally, the results of our study may not be applicable to other EMS with different EMS staffing profiles and policies.

Conclusions

Considering all EMS-attended adults who fell, nearly a third experienced repeat falls. Of these patients, 59% sustained their second EMS-attended fall within 12 months of their first fall. EMS-attended adults sustained falls in a shorter time frame with every additional fall experienced. This reinforces the importance of having specific prehospital clinical practice guidelines to identify high risk patients at risk of sustaining additional falls in the future. The development of alternative referral pathways to refer patients to allied health and falls prevention programs could support prehospital personnel in their management of patients who sustain, or are at risk of, repeat falls.

Disclosure Statement

RB is a current employee of St John WA and DB is a past employee. JF holds an adjunct research professor position with St John WA and receives research funding from St John WA.

Funding

PMW was awarded a 2020 Australian Government Research Training Program (RTP) Stipend Scholarship. AMH is supported by a National Health and Medical Council of Australia Investigator (EL2) grant and the Royal Perth Hospital Research Foundation. JF receives salary support from a NHMRC-funded Leadership Fellowship, and research funding from St John Western Australia Ambulance Service.

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