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CLINICAL INVESTIGATION

OPEN

Incidence and Associated Risk Factors for Falls in Adults Following Critical Illness: An Observational Study

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OBJECTIVE: To explore the incidence of falls and associated risk factors in the first year after hospital discharge in survivors of critical illness.

DESIGN: Prospective single-site observational study.

SETTING: University-affiliated mixed ICU.

PATIENTS: One hundred ICU adults who required invasive ventilation for 48 hours and in an ICU for at least 4 days.

INTERVENTIONS: Not applicable.

MEASUREMENTS AND MAIN RESULTS: Falls were monitored prospectively for 1 year with completion of monthly falls calendars. Falls data included the number of people who had falls/no falls/recurrent falls, falls rate per person per year, and time to first fall. Fall severity was classified according to the Schwenck classification scheme to examine injurious falls requiring medical intervention. Other outcomes considered included assessments of balance, strength, function, cognition, psychologic health, and health-related quality of life. One hundred participants (31% female) were recruited with a mean age of 58.3 ± 16.2 years, and a median ventilation duration of 6.3 days [4.0–9.1]. Sixty-one percent fell at least once in the first year with the majority sustaining two or more falls (81.4%) and one in four sustained an injurious fall requiring medical attention. The falls incidence rate was 4.4 falls per person-year (95% CI, 3.2–5.9), with the highest incidence occurring less than 3 months after hospital discharge (5.9 falls/person-year [95% CI, 4.4–7.8]). Time to first fall or injurious fall was 36 [11–66] and 95 (95% CI, 40–155) days, respectively. Key risk factors for falls at the time of hospital discharge include comorbidities, higher discharge medications, balance, and muscle strength.

CONCLUSIONS: There was a high falls incidence in ICU survivors. The study findings suggest a critical window may exist within the first 3 months after hospital discharge and the need for screening, pharmacological optimization, and exercise training in this patient group.

KEYWORDS: critical care; critical illness; physical impairment; postintensive care syndrome

Falls are a critical healthcare issue, with one in three older adults (>65 y) experiencing a fall annually (1, 2). Falls are associated with increased morbidity, mortality, hospitalization, and economic costs (3). Posthospital falls are a significant concern for recently discharged older adults (4, 5).

The ICU population is likely at heightened falls risk due to rapid muscle loss which occurs (~2%/d) (6) and significant weakness and physical disability which ensue postcritical illness (7–14). Survivors of critical illness can experience accelerated bone loss, fatigue, and pain, increasing their risk of fragility fractures with

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KEY POINTS

Question: Are physical falls an issue for the general adult ICU survivors after leaving the hospital?

Findings: There is a high incidence of falls in the first year in adult ICU survivors (higher than the general older population and some other neurologic/musculoskeletal populations). Key risk factors for falls at the time of hospital discharge include comorbidities, higher discharge medications, balance, and muscle strength.

Meaning: Our study demonstrates that ICU survivors have a high incidence of falls in the first year. Modifiable risk factors exist which could be targeted through tailored screening for pharmacological optimization and exercise prescription.

effects persisting years posthospital discharge (15–18). Existing studies have mainly focused on in-hospital falls, with few evaluating falls posthospital discharge (19–23). Therefore, the primary aims of this study were to 1) estimate the falls incidence in the first year posthospital discharge for adult ICU survivors and; 2) examine risk factors at hospital discharge associated with falls incidence and injurious falls requiring medical attention. Secondary/exploratory analyses reported time to first fall and associated risk factors as well as baseline and discharge characteristics of fallers, non-fallers, recurrent fallers, and those with injurious falls.

MATERIALS AND METHODS

Design and Setting

A prospective single-center cohort study was conducted at a university-affiliated hospital involving a mixed ICU population (medical, surgical, and trauma) with recruitment between April 2017 and September 2019, and final measures were completed in September 2020. Reporting is guided by the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (24) and International Consensus Guidelines for conducting falls-related research (25).

Participants

Adults requiring continuous invasive ventilation for at least 48 hours and admitted to the ICU for at least 4 days. This criterion was chosen to represent those individuals at higher risk of ICU-acquired weakness and potential for long-term impairments in physical functioning. Similar approaches have been used in prior ICU research (26, 27). Exclusion criteria related to inability to participate in assessments (e.g., insufficient English language, cognitive impairment), pre-existing health conditions such as neurologic conditions or major surgery affecting lower limb in the past 3 months which may impact on falls risk, or a history of pre-ICU falls. See **Supplementary Digital Content** (http://links.lww.com/CCM/H707) for full eligibility details.

STUDY OUTCOMES

Prospective Falls Assessment

The primary endpoint was the incidence of falls during the 12-month period postacute hospital discharge. Falls were defined as an "unexpected event in which an individual comes to rest on the ground, floor or lower level" (25). The number of falls during the 12-month period was monitored prospectively daily for 1 year with patients returning falls diary monthly (**EFig. 2**, http://links.lww.com/CCM/H707) (25). If fall diaries (25) were not returned within 2 weeks of the end of each month, participants were contacted by telephone and/or followed up at in-person evaluations. Falls diary data collection was maintained regardless of whether participants returned directly home postacute hospital admission or required inpatient rehabilitation. Fall circumstances including location, activity, cause, consequences, and injuries were collected. Data were reported for patients who had a single fall, two, or more falls (defined as recurrent faller) and injurious fallers requiring medical attention (which were a subset of the faller group). This is in line with gold standard methods for reporting falls (2, 28) which has been used in other patient populations (29–31). The classification of injurious falls (falls severity) followed the Schwenk classification with i) no injury; ii) minor: bruises or abrasions; reduced physical function due to pain or fear of falls for at least 3 days not requiring health professional assistance; iii) moderate: requiring health professional examination such as x-ray or suture due to wounds, bruises, sprains, cuts; and iv) serious: medically recorded fracture, head or internal injury requiring emergency or inpatient care (32).

Pre-acute hospital discharge evaluations included sensorimotor function, physical function, balance, cognition, psychologic health, and health-related quality of life (HRQoL).

Sensorimotor Function

Monofilament sensation was tested at hospital discharge using the Semmes-Weinstein 5.07 monofilament (33). Quadriceps and tibialis anterior strength were assessed isometrically in triplicate bilaterally using a portable dynamometer with the best score reported (Lafayette Manual Muscle Testing System Model 01165A, Lafayette Instrument Company, Lafayette, IN) (34).

Physical Function and Balance

Physical function was assessed using the Short Physical Performance Battery (SPPB) and balance was assessed using the Mini-Balance Evaluation Systems Test (MiniBESTest) measure, which assesses 14 tasks across four domains: anticipatory, reactive postural control, sensory orientation, and dynamic gait, with an overall score of 28 (higher scores indicating better balance) (35). Time in seconds to complete normal and dual timed-up-and-go tests were also reported. Frailty was assessed using the Clinical Frailty Scale, with scores of 5 or more classified as frail (36).

Cognition, Psychologic Health, and HRQoL

Cognition was screened using the Montreal Cognitive Assessment Score (37). Anxiety and depression symptoms were screened using the Hospital Anxiety and Depression Scale (38) using a score of 8 or above to indicate clinically significant symptoms (38). Post-traumatic stress disorder symptoms were screened using the Impact of Event Scale-revised (IES-R), with cutoff score of greater than or equal to 1.6 points out of 4 (39, 40). HRQoL was measured using the Euro-QOL 5 Dimensions (EQ-5D) five level (41).

Data were collected on each participant's medical history, for example, demographics and comorbidities (42), Katz Activities of Daily Living Index (43), acute illness, hospital course including discharge destination, ICU-related interventions, medications including falls risk inducing medications (44), ICU-acquired weakness (ICU-AW) (45), delirium and physical function in the ICU test scored results (46).

Sample Size

A precision-based sample size calculation was undertaken based on the primary research aim to estimate falls incidence. Data from the respiratory literature were used for this purpose (31, 47). Assuming an incidence rate of 1.2, a total of 70 participants followed up for 12 months would provide an exact Poisson two-sided 95% CI of 0.96–1.49. Allowing for 30% of the participants not completing the 12-month study due to loss to follow-up or death, our target sample size was 100 participants.

Statistical Analysis

To address the primary research question, negative binomial regression models were used to calculate the incidence rate for falls with the duration of follow-up (person-years) included in the models as an offset (48). This was reported overall and at 3-, 6- and 12 months postdischarge considering the amount of follow-up time as years on each timepoint (25). Subsequently, separate univariable negative binomial regression models were fitted to examine associations between each prespecified falls risk factor and injurious falls (**ETable 1**, http://links.lww.com/CCM/H707). Negative binomial regression results were summarized using incidence rate ratios and 95% CIs. The small sample size did not allow for the development of a prediction model for falls risk as it was not possible to include all prespecified risk factors in a model for assessment, nor to internally validate the model (49, 50). However, in addition to the univariable models, age and sex were added to the models as these are known risk factors, the sample size allowed for adjustment for these covariates, and they have been included as risk factors elsewhere (51). Adjusted estimates (incidence rate ratios and hazard ratios) with 95% CIs were reported. This exploratory analysis enabled the identification of candidate factors for consideration in future research to predict falls risk.

Baseline characteristics were summarized overall and by status (individuals who fell at least once or sustained no falls), falls recurrence (0–1 falls or 2 or more falls), and injurious faller status. Differences in baseline participant characteristics were compared using Student *t* or Mann-Whitney *U* tests depending on data

distribution for continuous variables and chi-square test for categorical variables. Additionally, time to first fall was calculated with participants followed from hospital discharge until their first community fall, loss to follow-up, study withdrawal, or last follow-up time, whichever came first. The Kaplan-Meier method was used to calculate the cumulative probability of community falls over time by fall frequency. Cox regression was used to examine factors associated with time to first fall, accounting for censoring at 12 months for those who did not experience a fall. Separate univariable models were fitted for each risk factor, and hazard ratios with 95% CIs were reported (49–51).

A complete case analysis was undertaken, with participants with missing data on any of the prespecified falls risk factors, age, and sex, omitted from the analyses. A two-sided *p* value less than or equal to 0.05 was considered statistically significant. No adjustment for multiple comparisons was undertaken in this exploratory study. Analyses were performed using STATA (Version 17.0, StataCorp, College Station, TX) and SPSS (Version 29.0 for Windows, SPSS Inc., Chicago, IL).

Ethics

The procedures followed were in accordance with the ethical standards of local institution and the Helsinki Declaration. The project (NCT03141762) was approved by The Melbourne Health Human Research Ethics Committee (2016.365 February 2017) with all participants providing written informed consent.

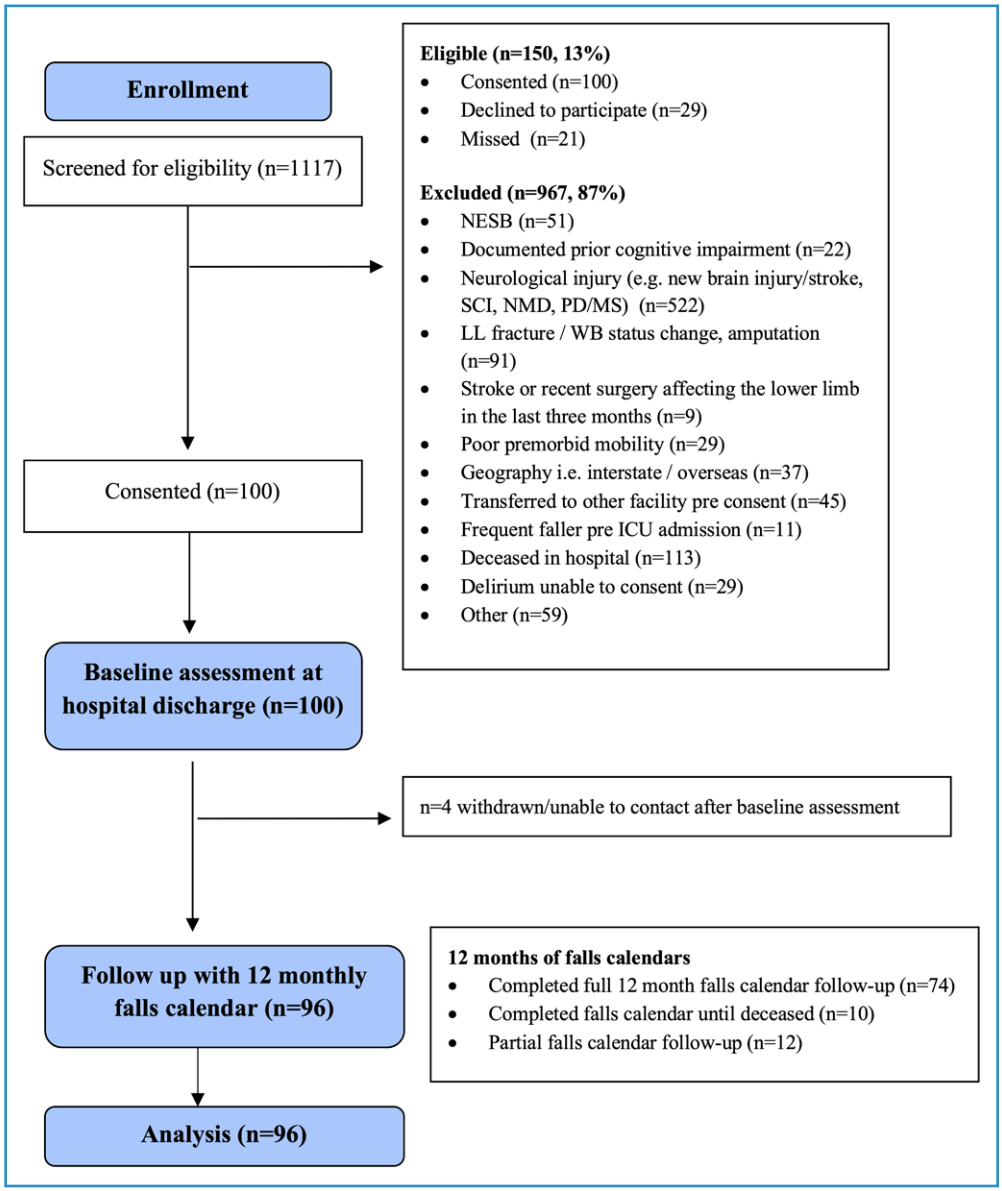

Figure 1. The flow of participants through the study. LL = lower limb, MS = multiple sclerosis, NESB = non-English speaking background, NMD = neuromuscular disease, PD = Parkinson's disease, SCI = spinal cord injury, WB = weight-bearing.

RESULTS

Participant Flow and Demographics

One hundred participants were enrolled and 96 were included in the final analyses. Four participants were lost to follow-up prior to the first month and had unknown falls status (**Fig. 1**). Participants were 58.7 ± 16.3 years, 32% female, had a mean Acute Physiology and Chronic Health Evaluation II score of 21.0 ± 7.4 and median [interquartile range (IQR)] mechanical ventilation duration of 6.0 days [3.9–9.1]. Forty-two percent were diagnosed with ICU-AW, and 59% were discharged home. **Tables 1** and **2** and **ETable 2** (http://links.lww.com/CCM/H707) summarize

TABLE 1.
Baseline Demographic and Medical Characteristics of Participants

Characteristic	Overall (*n* = 96)	Non-Faller (*n* = 37)	Faller (*n* = 59)	0–1 Falls (*n* = 48)	≥2 Falls (*n* = 48)
Age, yr	58.7 ± 16.3	55.2 ± 15.6	60.9 ± 16.5	57.5 ± 15.8	59.9 ± 17
Female, *n* (%)	31 (32.3)	6 (16.2)[a]	25 (42.4)[a]	10 (20.8)[a]	21 (43.8)[a]
Ethnicity, *n* (%)					
European	86 (89.6)	35 (94.6)	51 (86.4)	46 (95.8)	40 (83.3)
Asian	4 (4.2)	1 (2.7)	3 (5.1)	1 (2.1)	3 (6.3)
Other	6 (6.3)	1 (2.7)	5 (8.5)	1 (2.1)	5 (10.4)
Independent on Katz Scale, *n* (%)	93 (96.9)	36 (97.3)	57 (96.6)	47 (97.9)	46 (95.8)
Body mass index, kg/m^2	28.9 [24.8–34.4]	26.8 [24.7–34.2]	29.1 [24.8–34.7]	29.4 [24.9–34.3]	28.7 [24.8–34.6]
Clinical frailty score	3.0 [2.0–4.0]	3 [1.5–4]	3 [2–4]	3 [2–4]	3 [2.3–4]
Comorbidity number	4.5 [3.0–7.0]	4 [2–6][a]	5 [3–8][a]	4 [2.3–6][a]	6 [3–8][a]
Functional comorbidity index score	2.0 [1.0–4.0]	2 [1–3.5]	3 [1–5]	2 [1–3]	3 [1.3–5]
Married or de facto, *n* (%)	58 (60.4)	26 (70.3)	32 (54.2)	35 (72.9)[a]	23 (47.9%)[a]
Type of admission, *n* (%)					
Medical	53 (55.2)	23 (62.2)	30 (50.8)	32 (66.7)	21 (43.8)
Surgical	32 (33.3)	10 (27.0)	22 (37.3)	12 (25.0)	10 (41.7)
Trauma	11 (11.5)	4 (10.8)	7 (11.9)	4 (8.3)	7 (14.6)
Acute Physiology and Chronic Health Evaluation II score	21.0 ± 7.4	21.0 ± 7.7	21.0 ± 7.3	21.4 ± 7.7	20.5 ± 7.2
Mechanical ventilation, d	6.0 [3.9–9.1]	5.7 [3.8–7.4]	6.6 [3.8–10.6]	5.8 [4.0–8.5]	6.6 [3.8–10.4]
Delirium incidence, *n* (%)	48 (50.0)	17 (45.9)	31 (52.5)	21 (43.8)	27 (56.3)
Tracheostomy, *n* (%)	14 (14.6)	4 (10.8)	10 (16.9)	6 (12.5)	8 (16.7)
Inpatient faller, *n* (%)	6 (6.3)	1 (2.7)	5 (8.5)	1 (2.1)	5 (10.4)
ICU-acquired weakness diagnosis, *n* (%)[b]	37 (41.6)	9 (26.5)[a]	28 (50.9)[a]	17 (19.1)	20 (22.5)
Physical function in ICU test scored on awakening[c]	4.9 [2.5–5.9]	5.4 [4.4–5.9]	4.4 [1.0–5.4]	4.9 [3.6–5.9]	4.4 [2.9–5.4]
ICU length of stay, d	8.0 [6.0–14.8]	7 [5–12]	9 [6–15]	7.5 [5–14.8]	8 [6–14.5]
Hospital length of stay, d	25.0 [15.3–42.5]	20 [13.5–33.5]	27 [16–43]	21 [15–42.3]	26 [16–46.3]
Number of discharge medications, *n* (%)	9.0 ± 4.2	7.0 ± 3.9[a]	10.2 ± 4.0[a]	7.83 ± 4.1[a]	10.2 ± 4.1[a]
Discharge location, *n* (%)					
Home	57 (59.4)	30 (81.0)	27 (45.7)	34 (35.4)	23 (24.0)
Rehab facility	33 (34.4)	6 (16.2)	27 (45.8)	13 (13.5)	20 (20.8)
Other hospital	6 (6.3)	1 (2.7)	5 (8.5)	1 (1.0)	5 (5.2)

[a]Differences between groups.

[b]*n* = 8 participants unable to complete Medical Research Council sum-score at awakening due to alertness/confusion level.

[c]*n* = 5 participants unable to complete physical function in ICU test scored at ICU discharge.

Data are reported as mean (SD) or median [interquartile range] or *n* (%).

TABLE 2.
Additional Clinical Factors at Hospital Discharge

Characteristic	Overall (*n* = 96)		Non-Faller (*n* = 37)		Faller (*n* = 59)		0–1 Falls (*n* = 48)		≥2 Falls (*n* = 48)	
	n	Outcome	*n*	Outcome	*n*	Outcome	*n*	Outcome	*n*	Outcome
Sensory and musculoskeletal domains										
Poor sensation	94	34 (36.2%)	36	10 (27.0%)	58	24 (40.8%)	47	13 (27.7%)	47	21 (44.7%)
Quadriceps strength, kg	93	18.0 ± 7.3	36	21.3 ± 7.4[a]	57	15.9 ± 6.5[a]	46	20.3 ± 7.7[a]	47	15.8 ± 6.3[a]
Tibialis anterior strength, kg	93	10.4 [8.3–14.7]	36	14.1 [9.8–16.2][a]	57	9.9 [7.8–13][a]	46	12.5 [9.1–15.1][a]	47	9.9 [7.8–13][a]
Short Physical Performance Battery score	94	5.0 [3.9–8.0]	36	8.5 [5–11][a]	58	3 [0.8–6.3][a]	47	7 [3–10][a]	47	3 [1–6][a]
4-m gait, s	74	5.7 [3.3–7.7]	33	4.7 [4.2–6.3][a]	41	6.4 [5–8.4][a]	40	4.8 [4.2–6.8][a]	34	6.4 [5.1–8.7][a]
Mini-Balance Evaluation Systems Test Score	94	7.5 [2.0–17.0]	36	13.5 [7.3–20][a]	58	5 [0–16.3][a]	47	13 [5–18][a]	47	5 [1–16][a]
Timed-up-and-go test, s	67	13.5 [9.1–23.5]	28	10.9 [9.4–13.6][a]	39	17.5 [12.5–27.5][a]	35	11.3 [9.8–17.5][a]	32	16.7 [12.7–27.9][a]
Dual-task timed-up-and-go test, s	67	18.9 [13.2–28.2]	28	15.6 [11.7–20.6]	39	20.6 [14.5–36.5]	35	16.1 [11.8–21.1]	32	21.1 [14.7–35.1]
Clinical frailty score	96	6.0 [1.8–7.0]	37	5 [3–6][a]	59	6 [5–7][a]	48	5 [3.3–7][a]	48	6 [4.3–7][a]
Cognitive, psychological, and quality of life domains										
Montreal cognitive assessment score	92	21.3 ± 4.3	36	21.9 ± 4.6	56	20.9 ± 4.1	46	21.7 ± 4.6	46	20.9 ± 4
Anxiety (HADS ≥8)	91	29 (30.2%)	36	10 (27.8%)	55	19 (34.5%)	47	13 (27.7%)	44	16 (36.4%)
Depression (HADS ≥8)	91	36 (37.5%)	36	13 (36.1%)	55	23 (41.8%)	47	17 (36.2%)	44	19 (43.2%)
Posttraumatic stress disorder (impact of event scale-revised ≥1.6)	89	30 (33.7%)	36	11 (30.6%)	53	19 (35.8%)	47	14 (29.8%)[a]	42	16 (38.1%)[a]
EuroQOL 5 dimensions Visual Analogue Score	92	50.0 [21.3–70.0]	36	52.5 [41.3–70]	56	50 [40–73]	47	50.0 [40–70][a]	45	50.0 [42.5–74.5][a]

HADS = Hospital Anxiety and Depression Score.

[a]Baseline demographics were different between groups.

Data are reported as mean (SD) or median [IQR] or *n* (%). Mini-BESTest assesses four domains of balance: anticipatory, reactive postural control, sensory orientation, dynamic gait with higher scores indicating better balance.

the demographics of those who had a fall and those with recurrent falls. Both those who fell at least once or had recurrent falls were more likely to be female, have more comorbidities, a higher number of hospital discharge medications, and require a period of inpatient rehabilitation prior to home discharge. People who had a fall were also more likely to have ICU-AW and poorer physical function in the ICU and poorer self-report scores on the EQ-5D mobility domain (**ETable 3,** http://links.lww.com/CCM/H707). Individuals who had recurrent falls were also more likely to be living home alone and have higher proportion of comorbidities such as vision impairment.

Falls Prevalence and Incidence Among Individuals Who Had a Single Fall or Recurrent Falls

Falls outcomes are presented in **Table 3**. During the 12-month follow-up period, 360 fall events were reported, with 44 (12.2%) of those classified as moderate to serious injurious falls. Overall, 37 participants (38.5%) did not fall, and 59 (61.5%) fell at least once. Among those who fell, the majority sustained two or more falls (48/59, 81.4%). The incidence rate of falls overall was 4.4 falls per person-year (95% CI, 3.2–5.9), with the highest incidence occurring within the first 3 months after hospital discharge (5.9 falls/person-year [95% CI, 4.4–7.8]). The median [IQR] time to first fall among those with at least one fall was 36 [11–66] days (**EFig. 1a**, http://links.lww.com/CCM/H707). Three-quarters of all falls among those that had recurrent falls occurred within the first 2 months but falls continued to occur up to 12 months.

Fall Circumstances

ETable 4 (http://links.lww.com/CCM/H707) presents the circumstances of the individual fall events. Over half of the falls occurred indoors at home (190 falls, 52.8%). The primary self-reported cause of falls was most commonly loss of balance (130 falls, 36.1%) or fatigue/weakness (84 falls, 23.3%). Almost half of all falls occurred during walking (157 falls, 43.6%), and one third occurred during a change in position (e.g., sit to stand, turning) (117 falls, 32.5%). Over half of all falls led to participants feeling more concerned (204 falls, 56.7%), followed by increased or new use of a gait aid (57 falls, 15.8%).

Injurious Falls

Among the 360 individual fall events, 181 falls (50.3%) were associated with an injury (137 minor, 31 moderate, 13 serious) (Table 3). The incidence of moderate to severe injurious falls was 0.5 falls per person-year (95% CI, 0.3–0.8) (Table 3). There were 13 serious injuries suffered across nine participants: six fractures, five ligamentous/neuromuscular injuries requiring hospitalization, two significant lacerations/wounds requiring emergency/inpatient care. The median time to first moderate to serious injurious fall was 95 days [40–155] (Table 3; and **EFig. 1b**, http://links.lww.com/CCM/H707). Twenty-three participants (24.0%) had at least one moderate or serious injurious fall (defined as those who had injurious falls). **ETables 5–7** (http://links.lww.com/CCM/H707) present the demographics of those who had injurious falls compared with non-injurious falls.

Risk Factors for Falls

In age and sex-adjusted negative binomial regression models, participants with higher FCI score and higher number of hospital discharge medications had a higher falls incidence while better balance was protective (**Table 4**). In the unadjusted model, better quadriceps strength was protective (Table 4).

Similarly, from age and sex-adjusted models, higher FCI was associated with higher risk of moderate to serious injurious falls (Table 4). Better quadriceps strength was found to be protective (Table 4). Associations that did not reach statistical significance in the age/sex-adjusted models (but were statistically significant in the unadjusted model) for injurious falls were number of medications, falls risk inducing medications, balance as measured by the Mini-BEST score, physical function as measured by SPPB score, and frailty level at time of hospital discharge (Table 4). Risk factors associated with time to first fall are shown in **ETable 8** (http://links.lww.com/CCM/H707).

DISCUSSION

This study found a high incidence of falls among adult ICU survivors in the first year post-discharge. Over 50% experienced falls, with most having multiple falls. One-third sustained injurious falls requiring medical attention. Falls were most frequent within the first 3

TABLE 3.
Description of Falls and Injurious Falls Over the 12-Month Follow-Up Period

Outcome	*N* = 96
Number of falls, total number	360
Number of moderate to serious injurious falls, *n*	44
Overall incidence of falls reported as per person-year [95% CI]	4.4 [3.2–5.9]
Incidence of falls reported as per person-year at 3 mo [95% CI]	5.9 [4.4–7.8]
Incidence of falls reported as per person-year at 6 mo [95% CI]	4.2 [3–6]
Incidence of falls reported as per person-year at 9 mo [95% CI]	3.3 [2–5.5]
Incidence of falls reported as per person-year at 12 mo [95% CI]	3.4 [2.2–5.1]
Incidence of injurious falls reported as per person-year [95% CI]	0.5 [0.3–0.8]
Number of fallers (at least 1 fall in 12 mo), *n* (%)	59 (61.5)
Number of recurrent fallers (2 or more falls), *n* (%)	48 (81.5)
Number of injurious fallers (from the cohort of fallers who sustained moderate to serious injury), *n* (%)	23 (39.0)
Falls per participant, *n* (%)	
0	37 (38.5)
1	11 (11.5)
2	6 (6.3)
3–4	12 (16.7)
5–6	9 (9.4)
>6	21 (21.8)
Injury severity, *n* (%), across 360 fall events	
None	179 (49.7)
Minor (bruises, abrasions, reduction in function with no medical consult)	137 (38.1)
Moderate (wounds, bruises, sprains cuts, requiring medical consult)	31 (8.6)
Serious (fracture, head, internal injury requiring inpatient/emergency care)	13 (3.6)
Fractures (all), *n* (%)	6
Upper limb	1 (16.7)
Rib	1 (16.7)
Vertebral including coccyx	2 (33.3)
Maxillofacial including dental injury	2 (33.3)
Time to first fall in days among those with at least 1 fall, median [IQR]	36 [11–66]
Time to first moderate to serious injurious fall in days, median [IQR]	95 [40–155]

IQR = interquartile range.

months post-discharge (median time to first fall 36 days). Several modifiable risk factors at hospital discharge were identified. Our findings have important clinical implications for posthospital care of ICU survivors.

Within the literature, the falls incidence in the general older population (>65 y) is 0.3–1.6 falls/person-year with a prevalence of ~27% falling at least once a year and 15% being recurrent fallers (52). Our findings highlight a high falls incidence within ICU survivors, similar to other patient groups such as dementia or intellectual disability (53, 54), or neurologic diseases (55–57). This high incidence occurred in a relatively young cohort with 40% under 65 years. Falls incidence exceeds that reported in respiratory disease (31) or post joint replacement (29, 30). Within the general older population, it is estimated that 10% of falls result in serious injury requiring hospitalization (58). We

TABLE 4.
Risk Factors at Hospital Discharge Associated With the Incidence of Falls and Incidence of Moderate to Serious Injurious Falls

	Falls		Moderate to Serious Injurious Falls	
	Unadjusted Model	Age and Sex-Adjusted Model	Unadjusted Model	Age and Sex-Adjusted Model
Risk Factor	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Hospital length of stay, d	1.00 (0.99–1.01)	1.00 (0.99–1.01)	1.00 (0.99–1.02)	1.00 (0.99–1.02)
Comorbidity number, as measured by Functional Comorbidity Index	1.14 (0.99–1.31)	1.17 (1.01–1.36)[a]	1.46 (1.16–1.85)[a]	1.39 (1.09–1.76)[a]
No. of discharge medications	1.07 (0.99–1.15)	1.07 (1.00–1.15)[a]	1.13 (1.00–1.28)[a]	1.11 (0.98–1.25)
No. of falls risk inducing medications medications	1.10 (0.92–1.31)	1.14 (0.95–1.37)	1.34 (1.03–1.74)[a]	1.25 (0.96–1.63)
ICU-acquired weakness at ICU awakening	1.07 (0.56–2.02)	1.03 (0.56–1.89)	0.77 (0.31–1.95)	0.63 (0.25–1.55)
Physical function in ICU test scored at ICU awakening	0.98 (0.86–1.12)	0.95 (0.84–1.08)	1.03 (0.85–1.24)	1.07 (0.89–1.29)
Quadriceps strength, kg	0.94 (0.90–0.98)[a]	0.95 (0.91–1.00)	0.89 (0.82–0.97)[a]	0.92 (0.84–1.00)[a]
Mini-Balance Evaluation Systems Test score	0.97 (0.94–1.01)	0.94 (0.90–0.99)[a]	0.93 (0.88–0.98)[a]	0.94 (0.88–1.01)
Short Physical Performance Battery score	0.94 (0.87–1.03)	0.90 (0.81–1.01)	0.85 (0.74–0.98)[a]	0.89 (0.77–1.03)
4-m gait speed	1.09 (0.97–1.22)	1.06 (0.93–1.21)	1.20 (0.96–1.51)	1.10 (0.89–1.36)
Clinical frailty score	1.09 (0.91–1.31)	1.15 (0.93–1.42)	1.41 (1.04–1.91)[a]	1.28 (0.92–1.79)

IRR = incidence rate ratio.
[a]$p < 0.05$.

found that 12% of all individual falls events resulted in an injury requiring medical attention. This has important repercussions for healthcare costs and hospital readmissions, which need further exploration.

The median time to first fall was 30 days, and 95 days to first moderate/serious injurious fall, suggesting a critical window for screening and intervention ideally within 30 days post-discharge. Several identified risk factors are modifiable (e.g., strength, balance, physical function, polypharmacy). Exploratory models suggest prioritizing screening for those with comorbidities, frailty, polypharmacy, ICU-AW, deficits in balance/mobility at discharge, though caution is needed as these are not from a multivariable model.

In the general falls literature, gait and balance impairments consistently predict future falls (1, 2). Recommended screening measures include the timed-up-and-go test and SPPB (2), which were found in our study to characterize those who had falls including recurrent and injurious falls. The Stopping Elderly Accidents, Deaths, and Injuries algorithm evaluating modifiable risks (gait, strength, balance, medications, cardiovascular stability, vision, home environment) could be adopted for ICU survivors (59, 60). In settings where follow-up care exists such as ICU follow-up clinics, we recommend screening measures are implemented with referral to pharmacists (61, 62) and exercise health professionals such as physiotherapists to delivered targeted interventions in medication management and exercise prescription. In community-dwelling older people, high certainty evidence exists for the benefit of exercise interventions to reduce falls rate (63, 64). Exercises that target balance, walking, and muscle strength have been found to prevent falls in community-dwelling older people over a minimum of 12 weeks, with greater benefit seen with longer-duration interventions (63, 64). The next step is to test whether such falls prevention programs are beneficial for the ICU population.

Strengths and Limitations

The strengths of this study are that falls data were collected prospectively with high follow-up retention of daily falls reporting in line with the recommended standards for collecting falls data (25). Limitations include single-center design and exclusion of some subgroups (pre-ICU fall history, neurologic/musculoskeletal conditions) and thus may not reflect falls rate more broadly among ICU survivors where there may higher fall rates in these subgroups. The sample size calculation was determined from a non-ICU population (chronic obstructive pulmonary disease) as there was no data on posthospital ICU falls to inform the sample size calculation at the time of designing the study. While powered for the primary outcome, a larger multicenter study is needed to develop and validate a multivariable risk prediction model to confirm these exploratory results. Furthermore, our exploratory analyses did not account for multiple testing. As there were several tests undertaken, this increases the likelihood of false positive findings. However, we have presented the modeling results with corresponding CIs to allow examination of potential effect sizes. Future studies will need to consider collinearity between predictor variables when developing a multivariable model as it may be that some of the risk factors identified are correlated with each other. Despite data coming from a single center, findings were consistent with a prior small follow-up study in the United States (23). Future studies should examine socioeconomic and environmental risk factors and impact of assistive devices/rehabilitation. Our study however provides the necessary impetus for falls to be of concern in the ICU population and the need to now consider how we deliver screening and exercise interventions in the early posthospital recovery phase to minimize the health and economic consequences of falls.

CONCLUSIONS

High falls incidence exists for ICU survivors across the first year after hospital discharge. The window for intervention may be within the first 3 months. Several modifiable factors can be optimized through tailored fall prevention strategies, including pharmacological optimization, targeted strengthening, and balance training implemented post-hospital discharge.

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