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ORIGINAL RESEARCH

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Chronic kidney disease and polypharmacy as risk factors for recurrent falls in a nursing home population

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Abstract

Background: It is known that nursing home patients who have sustained a previous fall are at a higher average risk for recurrent falls. Therefore, these patients require closer attention and monitoring for fall prevention.

Methods: We conducted a retrospective review in our Level 1 Trauma Center, who sustained a ground-level fall in a nursing home from January 2017 to December 2018. Inclusion criteria involved patients aged 65 or older, admitted from nursing homes. Logistic regression analysis was performed to identify factors associated with recurrent fall.

Results: A total of 445 patients were identified. Among them, 47 (10.6%) patients sustained recurrent falls, The median age was 83.3 years old and. The recurrent fall group was more likely to have chronic kidney disease (CKD) (27.1% vs. 13.1%, $p = 0.02$) and diabetes (47.9% vs. 31%, $p = 0.02$). The median number of medications taken by a patient was 8.78. Overall, 176 (39.5%) patients sustained any injury, and 25 (5.6%) patients died within the study period. The presence of CKD (odds ratio [OR], 2.34; 95% confidence interval [CI], 1.15–4.76, $p = 0.02$) and polypharmacy (number of medications of 9 or above) (OR, 2.07; 95% CI, 1.12–3.82, $p = 0.02$) were independent risk factors for recurrent falls.

Conclusions: CKD and polypharmacy were associated with a risk of recurrent falls among nursing home patients. The incidence of falls has a multifactorial etiology, and it is important to identify such risk factors to better prevent the morbidities and mortalities associated with fall-related injuries.

KEYWORDS

chronic kidney disease (CKD), falls, nursing home, polypharmacy, trauma

Impact Statement

We certify that this work is novel of recent clinical research. The results of our study on recurrent falls would have an impact in the geriatric population overall. Identification of specific risk factors will aid in the potential development of fall prevention protocols which may lead to better outcomes and improved quality of life for many elderly patients.

Why does this matter?

Identification of factors that are associated with a risk of recurrent falls among nursing home patients are integral in fall prevention strategies. These risk factors, such as CKD and polypharmacy, contribute to the increased rate of morbidity and mortality after sustaining fall related injuries and need to be recognized, especially amongst the geriatric nursing home population.

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1 | INTRODUCTION

As the average lifespan continues to increase, the establishment of nursing homes has become a critical component of healthcare. According to the Center for Disease Control (CDC) there are currently 15,600 nursing home facilities with 1.3 million nursing home residents.[1,2] This nursing home subset population tends to be frail and exhibit more comorbidities than the general population. It is known that nursing home patients who have sustained a previous fall are at a higher risk for recurrent falls.[1] Geriatric traumas are associated with higher morbidity than the general population, and those hospitalized had significantly higher rates of mortality, injury severity, prolonged hospital stays, and use of greater resources after discharge.[3,4]

There are known risk factors for index falls (Figure 1).[5–7] Patients who require assistive devices for ambulation have an obvious deficiency in stability and are more susceptible to falls.[5] In addition, chronic conditions such as cerebrovascular accident (CVA), heart disease, cancer, diabetes, arthritis, depression, and Parkinson's have disabling sequelae that contribute to the heightened fall risk amongst the subset of nursing home patients.[6] Impairments in vision and hearing, along with the decline of central integration of visual, vestibular, and proprioceptive senses, have also been confirmed to increase incidence of falls due to the central coordination required to maintain appropriate balance. Moreover, one of the most important factors directly related to fall risk is medication use, especially concomitant use of four or more medications, which is considered polypharmacy.[5,7,8] These include anti-hypertensives, sedatives, hypnotics, benzodiazepines, narcotics, and antidepressants that may cause hypotension, dizziness, or drowsiness. In addition, there have been established relationships of increased fall risk specifically seen with diuretics, antiarrhythmics, and antipsychotics.[8] Many patients living with CKD inhabit these aforementioned independent risk factors with decreased muscle strength limiting their mobility and are codependent on a robust medication regimen.[6,7,9]

Literature currently establishes risk factors associated with recurrent fall risk to include: age with limited functionality, fear of falling, disability, minimized physical strength, limited knowledge and awareness of falls, and other environmental conditions. However, there are inconsistencies with published research on these independent risk factors due to the multifactorial etiology and difficulties in controlling for confounding variables.[7,10] These factors could be

Key points

- Chronic kidney disease (CKD) and polypharmacy are associated with an increased risk of recurrent falls among nursing home patients.
- Understanding whether CKD is independently associated with falls in nursing homes could help identify those residents who maintain a higher risk for falls despite management of traditional fall risk factors and in whom management of CKD-specific fall risk factors may be particularly important for fall prevention.
- This data will help establish the clinical need to implement standardized protocols for those nursing home patients previously hospitalized for falls to prevent recurrence and subsequent injury, including patient/family education and medical chart designation of high-risk fall status.

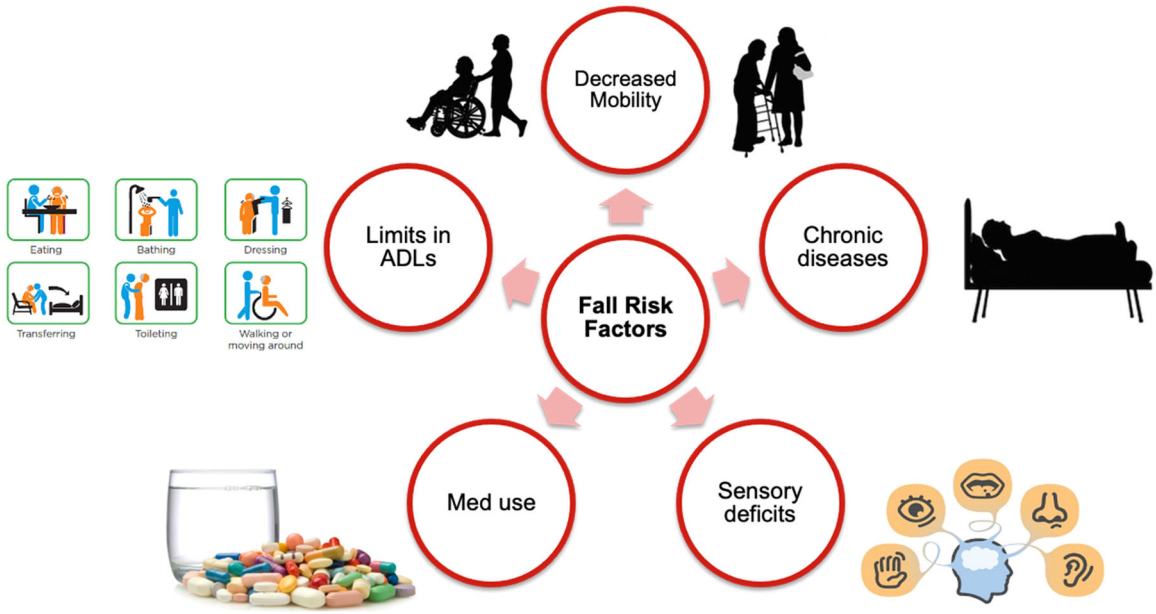

FIGURE 1 Diagram represents the various established risk factors for falls among the geriatric population.

further differentiated with risks of single fall or factors particularly associated with fall recurrence. Moreover, there is limited published literature on risk factors specifically in the nursing home subset of the geriatric population. The overall aim of our investigation is to identify factors associated particularly with recurrent, or secondary falls among elderly population from nursing homes.

2 | METHODS

The institutional review board approval was obtained with waiver of consent as this was a retrospective study. We conducted a retrospective review in our Level 1 Trauma Center in consecutive adult patients who sustained a ground-level fall in a nursing home from January 2017 to December 2018. Subsequently, we identified patients who had a history of previous falls.

2.1 | Data

The patient population was obtained from our trauma registry database and included nursing home residents who were seen after a mechanical fall. The trauma registry database includes all patients who were seen by the Trauma Surgery Service in the Emergency Department (Figure 2). Demographics that were collected include age, sex, race, comorbidities, medication type, and labs on arrival. Comorbidities included coronary artery disease, stroke, hypertension, dementia, depression, chronic kidney disease, diabetes mellitus, and dependent functional status. Dependent functional status is defined as complete dependency in performing routine activities of daily living. All comorbidities, including chronic kidney disease, were defined as a pre-existing diagnoses before patient's arrival. Inclusion criteria involved patients aged 65 or older, exclusively from nursing homes who sustained a ground-level fall and were evaluated by the trauma surgery service.

2.2 | Outcomes

The primary endpoint was recurrent fall. The secondary endpoints were in-hospital mortality (i.e., whether the patient expired during index admission after trauma), overall mortality (i.e., whether patient expired at any time point after trauma), and injuries. Last contact date was obtained from our chart review. Follow-up period was determined by the duration from the date of index fall to the date of last contact. Patients were censored on December 31, 2018 without any interest of event. In-hospital mortality was calculated for patients who were admitted to hospital while all-cause mortality included all patients who presented to the emergency room.

2.3 | Statistics

All statistical test values were two-sided and $p < 0.05$ was taken to indicate significance in all analyses. Data are expressed as frequencies and percentages for categorical variables. Continuous variables are expressed as either mean (standard deviation) or median (interquartile range) depending on normality, which was

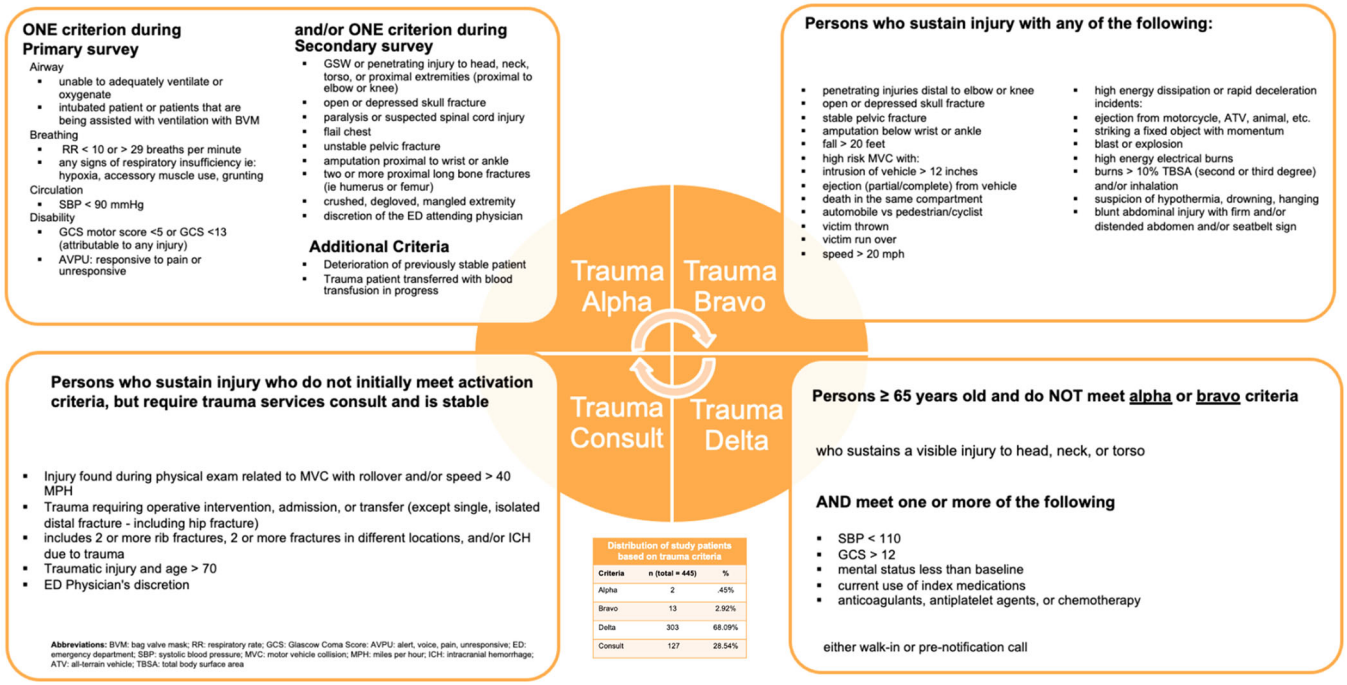

FIGURE 2 Trauma activation designation and criteria for the trauma surgery department.

TABLE 1 Patient characteristics ($n = 445$).

Variable	One-fall group ($n = 398$)	Recurrent-fall group ($n = 47$)	p-Value
Age (mean ± SD)	83.1 ± 10.7	85.1 ± 9.52	0.20
Sex (%)			
Males	147 (37.0)	21 (43.8)	0.43
Females	250 (63.0)	27 (56.2)	
Race (%)			0.10
White	223 (56.2)	19 (39.6)	
Black	38 (9.6)	5 (10.4)	
Asian	106 (26.7)	18 (37.5)	
Hispanic	23 (5.8)	6 (12.5)	
Comorbidities (%)			
Coronary artery disease	99 (24.9)	18 (37.5)	0.08
Stroke	73 (18.4)	7 (14.6)	0.70
HTN	317 (79.8)	44 (91.7)	0.05
Dementia	224 (56.4)	33 (68.8)	0.12
Depression	107 (27.0)	11 (22.9)	0.61
Dependent functional status	251 (63.2)	37 (77.1)	0.08
Chronic kidney disease	52 (13.1)	13 (27.1)	0.02
Diabetes mellitus	123 (31.0)	23 (47.9)	0.02
Medication type	8.55 (3.85)	10.40 (4.35)	0.002
Alpha-blocker (%)	23 (5.8)	5 (10.4)	0.21
Beta-blocker (%)	170 (42.8)	27 (56.2)	0.09
Anticoagulation/ antiplatelet (%)	261 (65.7)	38 (79.2)	0.07
Laboratory			
Hemoglobin (g/dL, median)	11.60 [10.30, 12.70]	11.00 [9.45, 13.05]	0.324
BUN (mg/dL, median)	27.1 [10.3, 43.9]	32.6 [13.0, 52.2]	0.04
Creatinine (mg/dL, median)	1.24 [0.76, 1.91]	1.72 [0.78, 2.72]	0.03
Sodium (mg/L, median)	140 [137, 142]	141[137, 142.75]	0.99
WBC (x10^9/L, median)	8.62 [6.75, 11.10]	7.71 [6.71, 9.38]	0.1

Abbreviations: BUN, blood urea nitrogen; HTN, hypertension; SD, standard deviation; WBC, white blood cells.

tested via Kolmogorov–Smirnov test, and were compared using the t-test (if normally distributed) or Mann–Whitney U test (if non-normally distributed) respectively. Categorical variables were compared using the χ^2 or Fisher exact test depending on size (> 5). We compared baseline characteristics and outcomes between patients who sustained recurrent fall and those who did not. Missing data were excluded since only less than 5% of data were missed and case-complete analysis was performed. We performed multivariable analysis using the logistic regression model.

3 | RESULTS

3.1 | Baseline characteristics

A total of 445 patients were included during the study period (Table 1). Among them, 47 (10.6%) patients sustained recurrent fall. The mean age of the entire study population is 84.1 years old with majority female gender ($n = 277$, 62.2%) and white race ($n = 242$, 54.4%). There was no significant difference in age, sex, and ethnicity between the one-fall and the recurrent-fall groups. With regard to

TABLE 2 Outcomes ($n = 445$).

Variable	One-fall group ($n = 398$)	Recurrent-fall group ($n = 47$)	p-Value
Admission (%)	214 (53.9)	26 (54.2)	1.00
LOS (mean ± SD)	3.07 ± 5.80	3.29 ± 5.09	0.80
Any cause of death (%)	23 (5.8)	2 (4.2)	1.00
ISS (mean ± SD)	3.67 ± 3.56	4.46 ± 4.20	0.16
Any injury (%)	155 (39.0)	21 (43.8)	0.54
ICH (%)	28 (7.1)	5 (10.4)	0.38
Any intervention (%)	76 (21.6)	12 (27.3)	0.44
Surgery	59 (14.9)	7 (14.6)	1.00
Intubation	6 (1.5)	1 (2.1)	0.16
Transfusion	31 (7.8)	7 (14.6)	0.16

Abbreviations: ICH, intracranial hemorrhage; ISS, injury severity score; LOS, length of hospital stays; SD, standard deviation.

TABLE 3 Multivariate analysis with logistic regression model for recurrent fall.

Variable	Odds ratio (95% CI)	p-Value
CKD	2.29 (1.15–4.76)	0.02
Diabetes mellitus	1.64 (0.88–3.07)	0.12
Polypharmacy	2.07 (1.12–3.82)	0.02

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; p-value significance < 0.05.

comorbidities, patients experiencing recurrent falls were more likely to have CKD (27.1% vs. 13.1%, $p = 0.02$) and diabetes (47.9% vs. 31%, $p = 0.02$). Rest of the comorbidities were similarly observed in the two groups. Furthermore, there was a significant association between the number of medications prescribed and elevated creatinine (Cr)/BUN lab values with fall recurrence ($p = 0.031$, $p = 0.044$). The median number of medications taken by a patient was 10.4 in the recurrent fall group (vs. 8.55 in the one-fall group, $p = 0.002$).

3.2 | Outcomes

Overall, 176 (39.5%) patients sustained any injury, and 25 (5.6%) patients died within the study period. Hospital admission was required in 53.9% of the one-fall group and 54.2% of the recurrent-fall group. The median injury severity score was comparable between the two groups (3.67 in the one-fall group vs. 4.46 in the recurrent-fall group, $p = 0.16$). A similar frequency of interventions was performed between two groups (21.6% in the one-fall group and 27.3% in the recurrent-fall group, $p = 0.44$) (Table 2).

3.3 | Risk factor analysis

Multivariable analysis was performed to evaluate likelihood of recurrent falls amongst, age, gender, race, and specific comorbidities. Our analysis revealed the presence of CKD (odds ratio [OR], 2.34; 95% confidence interval [CI], 1.15–4.76, $p = 0.02$) and polypharmacy (number of medications > median number of medications of 8.78, 9 or above) (OR, 2.07; 95%CI, 1.12–3.82, $p = 0.02$) as independent risk factors for recurrent falls (Table 3).

4 | DISCUSSION

The current study investigated the nursing home population who sustained ground-level mechanical fall using prospectively collected our institutional trauma registry. The main findings are the following. (1) the incidence of recurrent fall was 10.6%, (2) morbidity and mortality rates were similar between the two groups despite the recurrence of fall, and (3) CKD and polypharmacy were independently associated with recurrent fall.

4.1 | CKD

CKD poses an increased risk in older persons (age > 65) and minority groups who have a medical history of diabetes, hypertension, and obesity as these comorbidities serve as the most common etiology of CKD in older adults.[6,11,12] Our study investigated both an older and diverse subset of the nursing home population. In our investigation, CKD has a greater impact on recurrent fall risk than both diabetes or hypertension, Downstream complications of these conditions, such as autonomic insufficiency, visual impairment, and stroke, are known and well-established risk factors (Figure 1).[11,12] It may be that patients who develop CKD have severe progression of these diseases, which may associate CKD with falls in our data. Moreover, while not statistically significant, patients with fall recurrence had lower levels of both hemoglobin and hematocrit, which can be attributed to anemia causing weakness coupled with the debilitating effects of CKD.[13] Based on the World Health Organization (WHO), anemia is defined as hemoglobin levels < 12 g/dL for women and < 13 g/dL for men.[14] The average hemoglobin and hematocrit levels in the single fall and recurrent fall group (11.5 g/dL and 35.3% vs. 11.1 g/dL and 34.2%) are consistent with anemia. In a prior study, over half the patients in nephrology clinics not undergoing renal replacement therapy had anemia that was shown to increase in prevalence with decreased GFR.[15] These trends and the presence of anemia may result in an increase of complications such as weakness and orthostatic hypotension among CKD patients that can be attributed to the increase in falls in our study.

These disabilities, coupled with the effects of CKD, highlight the importance of identifying nursing home residents who require more involved care and specific targeted preventative measures to reduce fall risk in these populations.

4.2 | Polypharmacy

The next independent risk factor to consider is polypharmacy, mutually defined as the concurrent and regular use of four or more medications.[16–18] When comparing the incidence of polypharmacy with the incidence of falls, certain pharmacological agents—such as adrenergic blockers, diuretics, and psychotropics—have well-established associations with increased fall risk. The mechanisms of adverse reactions among those with polypharmacy are mostly attributable to drug–drug interactions that can cause undesired side effects of delirium, renal failure, or hypotension. Since many patients in our study were on multiple drugs for their concomitant diseases, polypharmacy could have exacerbated their comorbidities and lead them to an increased fall risk.[16] Drug–drug interactions may also affect medication compliance, thus, it is integral to study potential ways to optimize and streamline medications. This is especially important amongst our target elderly population as geriatric patients already suffer from age-related changes in pharmacokinetics and pharmacodynamics.[19,20] These side effects include cognitive and physical impairments known to be associated with recurrent falls as reflected by our study.

With regard to multiple medication use, there is limited published literature on the degree of polypharmacy and its association with recurrent fall risk among nursing home residents. However, a prior report showed that investigated recurrent fall risk amongst the general community demonstrated that patients with 4 or greater medications had an 18% chance increase in recurrent fall risk than those without, and patients with 10 or greater medications subsequently had a 50% chance increase in recurrent fall risk.[17] Our study is able to ascertain that the degree of polypharmacy is related to recurrent fall risk in the nursing home population. If a patient had greater than the median number of medications (median = 8.78, 9, or above), then that patient is twice as likely to have a recurrent fall in comparison to a patient with less than nine medications. Our threshold was based on the median number of nine medications of our geriatric trauma population. This is an important finding in our study, as it is not only the presence of polypharmacy that increases risk, but higher numbers of medication-use that is associated with increased chance of recurrent fall risk.

In our study, we stratified for alpha-blockers, beta-blockers, and anticoagulation/antiplatelet drugs. Evaluation of each separate category of drugs in our review showed there was no significant associated risk with recurrent falls. However, this may be due to the cumulative effect of interactions among these agents that may increase recurrent fall risk, though we did not specifically evaluate this relationship in our study.[20,21]

There was also a significant association between the number of medications prescribed and elevated Cr/BUN levels with fall recurrence. However, elevated Cr and BUN was not differentiated between those patients who had prior history of CKD versus new diagnosis of CKD versus acute kidney injury (AKI). This will be further discussed as one of the limitations of our study. The synergistic effect of polypharmacy can have many downstream implications for CKD due to various dynamics between drug metabolism and renal function. For instance, in patients undergoing hemodialysis, the disturbance in fluid balance and increased levels of uremic toxins can change the pharmacokinetics of medications. This alteration can lead to variable metabolization of these drugs that can increase half-life and potency, resulting in the increase of falls.[22] There are also associations with lower estimated glomerular filtration rates (eGFR) and enhanced fall risk. Polypharmacy can potentiate these effects independently as multiple medication use is known to lower eGFR over time.[23] Unfortunately, patients with CKD carry a heavy burden of polypharmacy and as demonstrated in our study, patients amongst the recurrent fall group have a greater average number of medications (10.4 medications daily).

Nursing home residents suffer from chronic conditions such as neurocognitive disorders, strokes, cardiac disease that require the use of these pharmacological agents that make these persons susceptible to falls at an exceedingly high rate.[22,24] It is important to be able to identify individuals amongst this population and to provide fall prevention measures and mitigate these risks. Moreover, it is important to routinely re-evaluate medication administration amongst the elderly population to assess which are absolutely necessary to optimize patient's treatment regimens and minimize undesired sequelae.

4.3 | Limitations and future considerations

One of the limitations of our study is that we did not perform trends on Cr level to evaluate whether a patient at baseline had undiagnosed CKD. In addition, our study stratified laboratory values associated with renal disease amongst both fall groups. The results revealed that the average serum Cr and BUN levels were significantly elevated in both the single fall and recurrent fall group, and much more pronounced in the recurrent fall group (1.24 mg/dL and 27.1 mg/dL vs. 1.72 mg/dL and 32.6 mg/dL). The prevalence of CKD within our study population was defined as a pre-existing condition, and our results showed that CKD was an independent risk factor for fall. However, there are many factors that can result in elevated Cr/BUN levels, such as acute kidney injury, such as sepsis and dehydration or postrenal causes such as obstruction. Since the lab results were collected on the first day of hospitalization, these elevations in serum Cr and BUN are therefore confounded by those patients who presented with AKI, acute on chronic kidney injury, or undiagnosed chronic kidney injury. Due to the multifactorial nature of developing an AKI, elevated BUN/Cr is associated with recurrent falls, but can not be distinguished as an independent risk factor for falls. Therefore, it is important to investigate the impact of AKI on recurrent fall risk in future studies.

Future studies considering the synergistic effect of CKD and polypharmacy on increased fall risk may be warranted. In addition, nursing homes may employ fall prevention protocols that take into consideration inherent patient risk factors, such as CKD and polypharmacy, and develop quality improvement investigations to

assess its effectiveness in reducing falls. This may include identifying the network of nursing homes that care for these patients and implementing a fall prevention protocol to train staff, along with designated alerts on discharge summaries identifying certain patients as high-risk for recurrent falls. Furthermore, if such investigations demonstrate a positive effect on fall reduction, standardized educational programs could be introduced for those patients and families who are at high risk for recurrent falls.

5 | CONCLUSION

Our study demonstrates that CKD and a high degree of polypharmacy are associated with a significantly independent increased risk of recurrent falls among nursing home patients. The incidence of falls has a multifactorial etiology. and it is important to identify such risk factors to better prevent the morbidities and mortalities associated with fall-related injuries. As both decreased glomerular filtration rates and CKD can be a product of polypharmacy, a more confounded relationship between these two variables may exist and warrants further study. It is important to continue efforts to reduce fall incidence and strive to eliminate these preventable traumatic injuries.

AUTHOR CONTRIBUTIONS

Nakia Sarad: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; validation; visualization; writing—original draft; writing—review & editing. **Syeda Y Jannath**: Formal analysis; writing—original draft; writing—review & editing. **Takuya Ogami**: Conceptualization; data curation; formal analysis; investigation; methodology; writing—review & editing. **Shahenda Khedr**: Writing—review & editing. **Hala Omar**: Data curation; formal analysis. **Teagan Thorson**: Data curation; formal analysis. **Miroslav Kopp**: Supervision; validation; writing—review & editing.

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All authors have read and approved the final version of the manuscript. Miroslav Kopp, DO, FACS had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis. There was no funding provided for this research.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest to disclose that is either directly or indirectly related to the work that is described in this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

DISCLOSURES

This manuscript was presented at the American College of Surgeons Regional Committee on Trauma in New York.

TRANSPARENCY STATEMENT

The lead author Miroslav Kopp affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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