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A Time Series Analysis of Falls and Injury in the Inpatient Rehabilitation Setting

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The purpose of this study is to assess whether falls and injuries are influenced by a temporal pattern (defined as a pattern based on the time of day) in the inpatient acute rehabilitation unit/hospital (IRU/H) setting. A retrospective chart review and analysis of falls and injuries among inpatients admitted to our facility during a 9-month period was performed. The sample consisted of 367 patients who had fallen at least once; 71 had repeated falls, bringing the total number of falls to 438. Significant variation in the prevalence of falls ($\chi^2 = 24.1$, $p < .01$) and injuries ($\chi^2 = 12.90$, $p < .01$) based on time of day and shift was observed. In addition, a temporal pattern of fall-related injuries with patients who had sustained stroke and brain injury ($\chi^2 = 12.74$, $p = .045$) was also observed. The findings from this study allow for the development of interventions that are appropriate when falls and injury are most prevalent for different clinical populations in the IRU/H setting.

KEY WORDS

fall patterns

inpatient acute rehabilitation setting

intervention

Falls are highly prevalent in inpatient acute rehabilitation units/hospitals (IRUs/Hs), with rates estimated to range between 2.92 and 15.9 falls per 1,000 patient days (Aisen, Iverson, Schwalbe, Weaver, & Aisen, 1994; Morse, 1996; Rabadi, Rabadi, & Peterson, 2008; Rogers, 1994; Suzuki et al., 2005; Sze, Wong, Leung, & Woo, 2001). The rate of falls is higher in rehabilitation relative to general hospital settings, where rates range between 2.45 and 3.73 falls per 1,000 patient days (Dunton, Gajewski, Tauton, & Moore, 2004; Halfon, Eggli, Van Melle, & Vagnair, 2001). The increased risk for falls in the IRU likely is related to the promotion of patient mobility and independence (Teasell, McRae, Foley, & Bhardwaj, 2002). Unfortunately, falls can impede the rehabilitation process by causing loss of confidence, anxiety, activity restriction, and injury (Collicutt-McGrath, 2008; Mahoney, 1998). Moreover, injuries resulting from falls are associated with increased healthcare expenditures (Amador & Loera, 2007; Bates, Pruess, Souney, & Platt, 1995; Frels, Williams, Narayanan, & Gariballa, 2002), reduced patient and family satisfaction (Dyer, Bouman, Davey, & Ismond, 2008), and legal liability (Oliver, Killick, Even, & Willmott, 2008). For these reasons, a greater understanding of the risk factors related to falls is needed so appropriate fall-prevention strategies may be developed and implemented within inpatient rehabilitation settings.

Several risk factors for falls have been identified in the IRU/H, particularly age, medical complexity, location, and functional and cognitive/neuropsychological status (Gilewski, Roberts, Hirata, & Riggs, 2007; Juneja, Czyrny, & Linn, 1998; Lee & Stokic, 2008; Rapport, Hanks, Millis, & Deshpande, 1998). Interestingly, researchers now are beginning to report that there may be a temporal pattern to falls in IRU/H settings. For example, a high prevalence of falls has been noted during daytime hours (85%) and during the first week (50%) of inpatient rehabilitation (Lee & Stokic). A study on stroke patients found a high prevalence of falls within 4 weeks of admission to inpatient rehabilitation (Suzuki et al., 2005). Similarly, it was observed that the prevalence of falls was highest during the first week (42%) of inpatient stroke rehabilitation, and then decreased with each subsequent week a patient was hospitalized (Rabadi et al., 2008). Despite these initial observations, a PubMed search (terms: rehabilitation, falls, and timing) has generated no formal studies assessing the timing of falls in IRU/H settings.

The temporal pattern of falls has been studied more systematically in other inpatient settings. A recent study on patients from various acute care hospital settings reported that falls were most prevalent in the morning (10–11:59 am) and on weekdays (Healey, Scobie, Oliver, Pryce, Thomson, & Glampson, 2008). Another study in the nursing home setting found that falls (and injuries) were most prevalent in the evening (i.e., 4–8 pm; Lester, Haq, Vadnerkar, & Feuerman, 2008). Based on the available evidence from various inpatient settings (e.g., hospital, rehabilitation, nursing home), there appears to be variation in the prevalence of falls based on time of day (Healey et al.; Lee & Stokic, 2008; Lester et al.). The purpose of this study is to formally assess whether falls and injuries are influenced by a unique temporal pattern (e.g., time of day) in IRU/H settings. Understanding the temporal

pattern of falls may allow for the development and implementation of interventions that are appropriate when falls and injury are most likely to occur.

Method

Sample

This study was a retrospective chart review of falls among patients in a large acute inpatient rehabilitation hospital system in the Mid-Atlantic region between January 2007 and September 2008. The sample included 367 patients (out of 5,062 patients admitted during that time period), with at least one fall recorded during the study period. Among the 367 patients, 71 had repeated falls, bringing the total number of falls in the sample to 438. The demographics of the sample are summarized in **Table 1.**

Approval from an institutional review board was not obtained and Health Information Portability and Accountability Act regulations did not apply here because of the observational nature of this study. This exception is consistent with a study previously published in this journal (Rabadi et al., 2008) in which IRB approval was not required. The data derived from our routine performance improvement audits was part of an overall fall-reduction program prompted by the Joint Commission's patient safety standard to reduce falls in hospital settings.

Table 1. Demographic and Clinical Patient Characteristics

Variables	Outcomes
Number of fallers	367
Number of falls	438
Mean age (*SD*) years	68.07 (15.74)
Gender (% female)	45%
Mean (*SD*) length of stay (days)	20.13 (16.67)
Mean (*SD*) FIM cognition	22.02 (8.48)
Mean (*SD*) FIM motor	28.85 (11.14)
Frequency of falls by diagnostic group	***n* (%)**
Stoke	151 (34.5)
Brain injury	75 (17.1)
Orthopedic	70 (16)
General debility	66 (15.1)
Spinal cord injury	27 (6.2)
Amputee	22 (5.0)
Traumatic brain injury	16 (3.7)
Other	11 (2.5)

Note. FIM = Functional Independence Measure.

Materials and Procedures

Data collected included frequency of falls and injury severity from falls. Falls were defined as an unintentional landing on a floor or being eased (lowered) to a floor (Rabadi et al., 2008). All falls were documented in the patient's medical record and tracked through an incident report as part of a risk-management program. The fall incident report contains information regarding the location, date, and time of the fall and the severity of injury resulting from the fall (**Figure 1**), along with treatment rendered to the patient.

Statistical Analysis

The frequency of falls and severity of injury were analyzed with the chi-square statistic (χ^2), and results were considered statistically significant when p was less than .05. Although the severity of injury could be analyzed at the ordinal scale of measurement, we treated this variable as a nominal variable, examining the number and percentage of cases with either no injury or with injury (minor through significant). This was based on an overall very low prevalence of injuries, the majority of which were minor. We primarily analyzed temporal data according to the shift schedules of the nursing assistant staff (referred to as rehabilitation assistants [RAs]), working day (7 am–3 pm), evening (3–11 pm), and night (11 pm–7 am) shifts. Nurses in the organization work 12-hour shifts from 7 am–7:30 pm and from 7 pm–7:30 am

Results

As seen in Table 1, the majority of falls occurred in patients (mean age: 68.07 + 15.74; women: 44.9%, men: 55.1%; mean length of stay = 20.13) who sustained stroke (34.5%), followed by those with brain injury (17.1%), orthopedic issues (16%), and general debility (15.1%). Overall, patients showed impaired cognitive (Functional Independence Measure [FIM] cognitive mean = 22 out of 35) and motor (FIM motor mean = 28 out of 91) function upon admission.

Figure 1. Fall Grading System at Kessler Institute for Rehabilitation

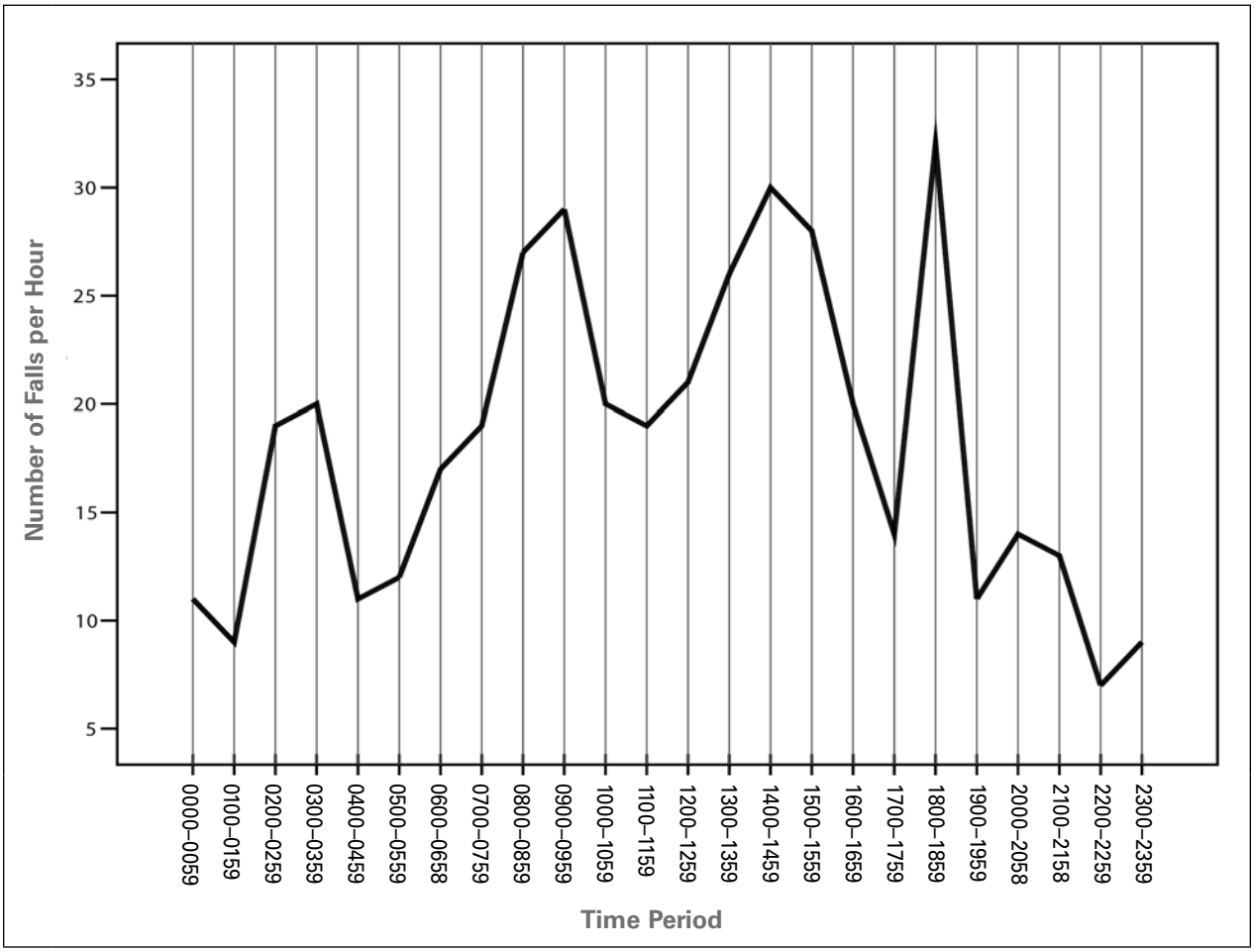
Grade 1: No injury noted

Grade 2: Minor injury—requires first aid or follow-up treatment

Grade 3: Significant injury—requires increased length of stay and/or invasive medical management

Grade 4: Serious injury—loss of limb or body part or death

Figure 2. Number of Falls per Hour Within 24 Hours



χ^2 analysis revealed the proportion of falls was statistically significant with respect to RA shift ($\chi^2 = 24.1$, $p < .01$). Specifically, there were 191 falls (43.6%) during the daytime shift (7 am–3 pm), 139 falls (31.7%) during the evening shift (3–11 pm), and 108 falls (24.7%) during the night shift (11 pm–7 am). **Figure 2** displays five time frames/peaks (i.e., 2–3:59, 8–9:59, 14–15:59, 18–18:59, 20–21:59 [military time was used to collect data]) during which the frequency of falls was highest in a 24-hour period. Of these times, the peaks at 8–9:59 and 14–15:59 were significantly higher than the other three peaks ($\chi^2 = 81.23$, $p < .01$), and represented the time frame during which 26% of reported falls occurred within a 24-hour time period.

χ^2 analysis revealed that the proportion of falls was not statistically significant with respect to days of the week (χ^2 (6) = 8.6, $p < .20$). There were 65 (14.8%) falls on Monday, 66 (15.1%) falls on Tuesday, 51 (11.6%) falls on Wednesday, 61 (13.9%) falls on Thursday, 77 (17.6%) falls on Friday, 67 (15.3%) falls on Saturday, and 51 (11.6%) falls on Sunday. Because weekdays outnumber weekend days, it is not surprising that the proportion of falls is significantly higher on weekdays (73.1%) relative to weekends (26.9%; $\chi^2 = 93.16$, $p < .01$).

Overall, 129 (29.5%) of falls resulted in injury, and only 25 (19%) of these falls resulted in significant (e.g., fractures) injuries. There was a significant difference in whether the falls resulted in injury based on shift ($\chi^2 = 12.90$, $p < .01$). Specifically, both the day (31.4%) and night (31.5%) shifts had a higher proportion of injuries resulting from falls relative to the evening shift (25.2%). χ^2 analysis revealed that the proportion of fall-related injuries was not statistically significant with respect to days of the week (χ^2 [6] =

Table 2. Percentage of Fall-Related Injuries as a Function of Diagnostic Group by Shift

Group	Day	Evening	Night
Stroke	48%	32%	20%
Brain injury	40%	12%	48%
General debility	36%	55%	9%
Orthopedic	32%	32%	36%

6.01, $p < .50$). There were 18 (14%) fall-related injuries on Monday, 20 (15.5%) fall-related injuries on Tuesday, 16 (12.4%) fall-related injuries on Wednesday, 19 (14.7%) fall-related injuries on Thursday, 26 (20.2%) fall-related injuries on Friday, 18 (14%) fall-related injuries on Saturday, and 12 (9.3%) fall-related injuries on Sunday. As expected, there is a significantly higher proportion of injuries resulting from falls on the weekday (76%) relative to the weekend (24%; $\chi^2 = 36.63$, $p < .01$).

An analysis of falls by shift for the stroke, brain injury, orthopedic, and general debility (all four clinical populations being the most frequent fallers) groups is not statistically significant ($\chi^2 = 11.89$, $p = .07$). However, injuries are overall statistically significant within these diagnostic groups as a function of time/shift (**Table 2**; $\chi^2 = 12.74$, $p = .045$). In particular, stroke patients are more likely to develop an injury during the day (48%) followed by the evening (32%) and night (20%) shifts. Patients with brain injury are more likely to develop an injury from falls during the night (48%), followed by the day (40%) and evening (12%) shifts. Patients with general debility are more likely to develop an injury during the evening (55%), followed by the day (36%) and night (9%) shifts. Orthopedic patients are more likely to develop an injury during the night (36%) relative to the day (32%) and evening (32%) shifts.

Among all falls, 71% (309) occurred within residents' rooms, with a significantly higher proportion of in-room falls during the day (42%) relative to the evening (33%) and night (25%; $\chi^2 = 12.8$, $p < .01$). Eighteen percent (78) of falls occurred within the resident's bathroom, with a higher, yet nonsignificant, proportion of in-bathroom falls occurring during the day (40%), evening (31%), and night (29%, $\chi^2 = 1.48$, $p < .50$). Nine percent (40) of falls occurred in rehabilitation gyms. Because patients usually are in therapy during the day between 9 am and 3 pm and only for 1 hour in the evening (3–4 pm), it is not surprising that a higher proportion (65%) of in-gym falls occurred during the day shift. However, it is interesting that a high proportion (35%) of gym falls occurred during the 3–4 pm time frame (representing only 14% of total gym time during the day). Two percent (11) of falls occurred near the nursing station and other locations in the rehabilitation unit, with no trend identified according to time or shift. χ^2 analysis revealed severity of injury was not related to fall location as a function of shift or time ($\chi^2 = 7.63$, $p = .27$). However, we did observe a significantly higher proportion of fall-related injuries in patient rooms (64%) relative to the bathroom (23%), gym (11%), and nursing station/other localities (2%; $\chi^2 = 117$, $p < .01$).

Discussion

This retrospective study demonstrated variation in the prevalence of falls and injury in the IRU/H based on time of day. Specifically, falls and subsequent injuries were significantly more prevalent during the day relative to the evening and night nursing shifts. This finding is compatible with previous studies reporting an increased risk of falls during the day for both inpatient rehabilitation (Lee & Stokic, 2008) and hospital (Healey et al., 2008) settings. The importance of the temporal pattern of falls is further underlined by the fact that fall-related injuries are equally prevalent during the day (31.4%) and night (31.5%), and both time periods had fall-related injuries that were significantly higher than during the evening shift (25.2%). The high prevalence of injuries during the day shift partially can be explained by the frequent falls observed during the 8–9:59 and 14–15:59 time periods (Figure 1). Generally, these time periods are associated with patients preparing to attend therapy sessions, requiring transfers to wheel chairs and bathroom commodes as well as increased personal care needs (e.g., dressing and meals). The time between 14 and 15:59 also represents RA change of shift and potentially fewer staff members are availabile to supervise patient activities. The high prevalence of injuries during the night shift can be partially attributed to frequent falls observed during the 2–3:59 night period (Figure 1). During the night, there may be reduced staffing to meet patients' needs such as toileting. In addition, this is approximately 4–6 hours after the average patient's bedtime—a likely time to awaken to void. Patients may be going to the bathroom unassisted and are at increased risk for falls and injuries. Consequently, fall-prevention strategies should be targeted for "peak" time periods to reduce a good percentage of falls and their related injuries.

This study's findings also reveal that patients in the stroke group are most likely to fall. These findings are compatible with other research reporting that falls are a common occurrence in patients admitted to rehabilitation after stroke (Dromerick & Reding, 1994; Nyberg & Gustafson, 1997; Rabadi et al., 2008). However, our findings are unique in showing a specific temporal pattern of fall-related injuries among the different clinical groups (see Table 2). For example, we found that stroke patients were significantly more likely to sustain a fall-related injury during the day, whereas our patients with brain injury were more likely to sustain injuries at night. Although our data do not address the sleep-wake cycles of patients with stroke and brain injury, there is evidence that patients with brain injury exhibit sleep-wake cycle disturbances

in acute rehabilitation. Makley and colleagues (2008) observed a high prevalence (68%) of sleep-wake cycle disturbances in their inpatient rehabilitation brain injury population. These researchers concluded that the high prevalence of nighttime wakefulness in this population may lead to increased falls and injury, especially when there are fewer staff members on duty (Makley et al.). Our data highlight the importance of targeting fall-prevention strategies for different clinical populations at different time points.

Our analysis also demonstrates that falls are significantly more common in patient rooms relative to other locations (e.g., bathroom, gym, nursing station). These findings are not surprising because patients spend the majority of their time in their rooms. Even though patients have therapy for 3 hours per day (mainly between 7 am and 3 pm), our data are unique because a higher proportion of in-room falls occurred during the day (42%) relative to the evening (33%) and night (25%). Moreover, we observed a significantly higher proportion of fall-related injuries in patient rooms (64%) regardless of time. Consequently, one potential way to reduce falls and injuries may be to promote patient use of common spaces such as lounges or day rooms with staff oversight, and limited alone time in rooms. Strategies that focus on out-of-room activities, particularly for patients with cognitive impairment such as stroke or brain injury, should be used. Hourly rounding of all patients already was in place at the time of this data collection. In addition, strategic rounding during high-risk times by more nursing and ancillary staff may help to reduce falls. Moreover, there is evidence that many in-room falls and injuries occur because of falls from bed (Bowers, Lloyd, Lee, Powell-Cope, & Baptiste, 2008; Gurwitz, Sanchez-Cross, Eckler, & Matulis, 1994). A recent study found that height-adjustable beds positioned at the lowest height along with use of floor mats can significantly reduce fall-related injuries (Bowers et al.). Our rehabilitation unit uses bedside floor mats and height-adjusted beds for patients at risk for falling, and these interventions may partially account for the low prevalence of total (129 of 438; 29.5%) and significant or major (severity > 3) injuries (25 of 438; 6%) in our rehabilitation hospital. The spike in falls between 18 and 18:59 correlates with dinner breaks for RAs and less patient supervision. Modifying RA break times to more effectively limit gaps in patient supervision may reduce falls during this time frame.

One new nursing strategy has been implemented as result of these findings. The spike in falls between 2 am and 3 am was targeted as an opportunity to implement proactive toileting strategy. Patients who have sustained stroke or brain injury who are most at risk for bladder urgency are placed on a bladder-training protocol with toileting every 4 hours. At bedtime, nurses contact patients to schedule awakening for toileting at 2 am. This strategy is intended to decrease the likelihood that a patient will awaken and attempt to self-toilet between 2 am and 3 am. Because this strategy recently was implemented, the results are not yet available for analysis.

Several limitations exist in this study. We analyzed retrospective data from one rehabilitation hospital system that consists of three campuses with more than 325 beds and a high number of patients with severe physical and cognitive deficits. This population may not be representative of small general acute rehabilitation units or hospitals. In addition, data were reviewed during a 9-month period. A 12-month period would allow for an analysis of falls by season.

The relative role of intrinsic (e.g., sensory orientation, gait and balance impairment, cognitive impairment) or extrinsic (e.g., safety rails, bed alarms, medication types, use of hip protectors) factors on falls and related injuries (Quigley, Bulat, & Hart-Hughes, 2007) was not assessed. Subject and environmental factors may have influenced the temporal nature of falls and related injuries in the present study (Quigley et al.). For example, our patients demonstrated evidence of cognitive impairment as measured by FIM (Table 1). It is important to note that FIM is not an adequate or valid instrument for capturing intrinsic factors such as cognitive impairment. However, evidence shows that cognitive impairment is a strong predictor of falls in the rehabilitation setting (Rabadi et al., 2008). Moreover, patients with cognitive impairment (e.g., brain injury) can exhibit sundowning syndrome, and this could explain why a peak incidence of falls was observed during 20–21:59 and a high prevalence of injury during the night for patients with brain injury.

Key Practice Points

1. Analysis of fall risk factors is vital to the success of any fall intervention protocol.
2. Fall risk assessment should be performed at the time of admission and then should be repeatedly monitored during the rehabilitation stay.
3. Staff education is a central component of fall prevention programs.
4. Determining the trends for time of falls provides important data for redesigning processes to focus on fall reduction.
5. Fall reduction programs are dynamic and must be actively reevaluated for effectiveness and possible modification.

Future research should examine the temporal pattern of falls and injury in relation to important intrinsic factors such as cognitive impairment and sleep-wake cycle disturbances in inpatient rehabilitation settings.

Finally, it should be noted that the present study did not include an analysis by type of fall (accidental, anticipated physiological, or unanticipated physiological). Accidental falls may not have a temporal relationship, but could be linked to spills, clutter, and tubing. An analysis of the relationship of fall risk factors as a function of "type of fall" should be examined in future research.

Conclusion

This study reveals variation in the prevalence of falls and injuries based on time of day. The temporal pattern observed in this study may allow for the development and implementation of interventions that are appropriate when falls and injury are most prevalent. A unique pattern of fall-related injuries between patients was observed, which may allow for specific interventions that can be applied at peak times for brain injury and stroke populations in the IRU/H setting.

Repeat falls serve as an important patient safety indicator that is linked to the effectiveness of a multidisciplinary approach to falls. Postfall huddles are becoming a standard of practice in rehabilitation units, with the goal of reducing repeat fall rates. Within our own institution, patients who sustain falls immediately are reassessed by a multidisciplinary team that includes (although is not limited to) a physician, nurse, rehabilitation assistant, and therapist. A postfall assessment tool is used to perform an in-depth review of the circumstances involving the incidents, review the interventions in use, and determine intervention changes that may be warranted. Although not a focus of the present study, we have found our multidisciplinary postfall huddle approach highly effective in reducing repeat falls.

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continued on page 166

Consensus-Validation Study Identifies Relevant Nursing Diagnoses, Nursing Interventions, and Health Outcomes for People with Traumatic Brain Injuries

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A Time Series Analysis of Falls and Injury in the Inpatient Rehabilitation Setting *continued from page 146*

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