Falls are a serious and common health concern for older adults. In the United States, 34% of people 65 years of age or older, 50% of community-dwelling people 80 to 89 years old, 26% of hospital inpatients and 43% of people living in nursing homes experience at least one fall a year. A previous study reported that the annual prevalence of having fallen in the last 12 months in community-dwelling patients older than 65 is between 28% and 35%; it reaches 40% for people 75 years of age or older. Falls are responsible for 56% of the hospitalizations for trauma and for 6% of urgent hospitalizations in patients older than 65 years of age.

Falls not only result in injury, disability, hospitalization and inability to live independently; they also result in death. According to a previous report, the rate of fall mortality in those 65 years and older is increasing every year. The rate for that age group is higher in Minnesota (at 110/100,000) than in the nation as a whole (48/100,000). The rate of fatal falls is climbing faster in Minnesota than in the United States, 34% of people 65 years of age or older, 50% of community-dwelling people 80 to 89 years old, 26% of hospital inpatients and 43% of people living in nursing homes experience at least one fall a year. A previous study reported that the annual prevalence of having fallen in the last 12 months in community-dwelling patients older than 65 is between 28% and 35%; it reaches 40% for people 75 years of age or older. Falls are responsible for 56% of the hospitalizations for trauma and for 6% of urgent hospitalizations in patients older than 65 years of age.

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United States as a whole as well. It doubled between 2000 and 2013. The rate of hospitalization for nonfatal falls increased by 450/100,000 from 2004 through 2008, and the rate of emergency department (ED) visits for falls doubled from 1999 to 2013. This stands in contrast to the overall decrease in mortality and to the noted decreases in the number of preventable deaths due to heart disease, cancer and cerebrovascular disease.5

In this study, we investigated hospital-treated (both ED treatment and hospitalization) falls in the 65 and older population in Minnesota during the 2010 to 2014 period. This study’s main aims were fourfold: 1) to describe the five-year trend in hospital-treated falls among older adults in Minnesota by various characteristics (eg, age group, treatment location); 2) to analyze whether there has been an increase in the percentage of comorbidities among those receiving hospital treatment for a fall; 3) to investigate whether having comorbidities is independently associated with the odds of hospitalization (vs ED treatment only) or death during hospital treatment for a fall; and 4) to investigate the consequences of falls and the relationship of each consequence with subsequent mortality from any cause during the hospital treatment.

Methods
We analyzed Minnesota Hospital Association (MHA) hospital discharge data on adults who were treated in the ED or hospitalized for falls in Minnesota during the 2010 to 2014 period. We used the following inclusion criteria:

- ICD-9-CM External Cause Codes: E880.0-E886.9, E888.(0-.9) – Accidental Falls
- Treated in acute care hospitals
- Date of discharge occurring from January 1, 2010 to December 31, 2014
- Minnesota residents
- Patient age 65 or older
- Emergency department-treated or admitted as an inpatient

- Discharged from hospitals reporting to MHA continuously throughout the period (There are 147 hospitals in the state, including nonacute-care facilities; 137 are members of MHA; 135 are included in the all-age injury hospital discharge database at MDH; 130 hospitals reported older adult fall cases; 127 of these hospitals reported continuously throughout the period.)
- All ED visits and hospitalizations for the same injury event were linked and analyzed together as one unique case. Multiple injury dates within the same month were treated as one injury event. Multiple injury events occurring in separate months were analyzed as separate cases.

Consequences
We identified both injury and noninjury consequences of falls. We categorized the injury consequences by type using the Barell Injury Diagnosis Matrix.13 We identified the noninjury consequences of falls using the most frequent noninjury complications during hospital treatment after falls in the elderly: urinary tract infection (UTI), pneumonia, pressure ulcer and sepsis.15

Comorbidities
Hospital discharge data does not contain a direct measure of frailty, although frailty has been found to be predictive of hospitalized fall injury.7 Comorbidity does overlap with frailty,14 and comorbidities are included with hospital discharge data. Thus, we used the number of comorbidities in each patient as a proxy for frailty. We identified a set of commonly occurring comorbidities in the study population.10,11 These included hypertension, hyperlipidemia, diabetes, dementia, osteoporosis, osteoarthritis, depression, ischemic heart disease, asthma, rheumatoid arthritis, cerebral infarction, COPD and chronic renal failure.

Statistical Analysis
Rates were age-adjusted to the U.S. 2000 Standard Population for those 65 and older (age groups: 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85+).14 A multiple logistic regression model (Model 1) was fitted twice to examine the strength and direction of the association between certain outcomes (fatal vs nonfatal, hospitalized vs ED-treated) and factors that predicted the outcomes; indicator variables for 0 comorbidities, 1 comorbidity, 2 comorbidities, and 3 or more comorbidities; and for age groups. For all models, p is the probability of poor outcome (fatal or hospitalized).

Model 1: logit(p) = \( \beta_0 + \beta_1\text{comorbidities} + \beta_2\text{age-group} \)

A subsequent multiple logistic regression model (Model 2) was applied to assess the odds of death for specific comorbidities and consequences of fall injury, adjusting for age group. Variables univariately associated with death were included in a multivariate logistic model. A final model with six parameters was chosen on the basis of univariate analysis and clinical knowledge. The predictors were hip fractures, pneumonia, sepsis, age group, an interaction term of hip fractures and age group, and an interaction term of pneumonia and age group. We decided not to include TBI, UTI and pressure ulcer in the final model because they were not statistically significant in the preliminary multivariate models.

Model 2: logit(p) = \( \beta_0 + \beta_1\text{hip-fracture} + \beta_2\text{pneumonia} + \beta_3\text{sepsis} + \beta_4\text{age-group} + \beta_5(\text{hip-fracture*age-group}) + \beta_6(\text{pneumonia*age-group}) \)

Odds ratios and 95% confidence intervals were computed. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA).
Results

Trends

The total number of hospital-treated falls (fatal and nonfatal, hospitalized and ED-treated) in Minnesotans over 65 years of age was 199,364 for the entire study period; this represents a five-year annualized rate of 5,281.4/100,000. The annual number has been increasing. (For example, there were 7,283 more cases in 2014 than in 2010.) Since 2010, the average annual increase has been 178.8/100,000 (Figure 1). In these patients, 72% of total cases were treated in the ED, and 28% of total cases were hospitalizations. The rate of ED-treated falls increased by 810.2/100,000 over the study period, while the rate of hospitalizations for falls decreased by 94.6/100,000.

Ninety-nine percent of hospital-treated falls were nonfatal. The number and rate of fall injury cases increased with each age group. The rate of falls among people age 85+ years (13,698/100,000) was the highest of any age group; this is 1.8 times the rate in 80- to 84-year-olds, 2.8 times the rate in 75- to 79-year-olds, 4.2 times the rate in 70- to 74-year-olds, and 5.8 times the rate in 65- to 69-year-olds (Figure 2). Women represent two-thirds of total fall cases. Rates in women are higher than rates in men across all age groups.

Comorbidities

Among hospital-treated fall cases, the percentage having one or more comorbidities has been increasing, while the percentage having no comorbidities has decreased (Figure 3). Notably, the percentage having 3 or more comorbidities among cases of hospital-treated falls has increased 37%.

Using the first logistic model, having comorbidities was strongly associated with increased odds of hospitalization (vs ED treatment) and death among fall cases. Having 3 or more comorbidities had an odds ratio of 3.8 for death among cases, and an odds ratio of 24.1 for hospitalization (vs treatment in the ED). Age group was not statistically significant in this model.
Consequences
Among total hospital-treated falls, 25.8% did not have a principal (first listed) diagnosis of injury. Fractures were the principal diagnosis in 31.7% of cases, followed by superficial wounds/contusions (14.7%), open wounds (10.9%) and traumatic brain injury (TBI) (3.9%) (Figure 4). Among those with fractures, hip fracture was the most frequent, accounting for 29.1% of total fractures, followed by fracture of upper extremities (27.3%).

We assessed the frequency of UTI, pneumonia, pressure ulcer and sepsis. Among those, UTI was the noninjury consequence seen most frequently (in 7.2% of cases), followed by pneumonia (2.2%), pressure ulcer (1.2%), and sepsis (0.9%) (Figure 5).

Using the second logistic model, we found patients with sepsis had the greatest risk of death (odds ratio of 9.9 for death in those with hospital-treated falls). The patient’s age was also significantly associated with risk of death after a fall.

Discussion
Our findings on hospital-treated falls for older adults in Minnesota are consistent with previous reports that found the rate of falls and the risk of fall mortality increase with age, and the rate of hospital-treated falls is higher in women compared to men. We showed that the rate of falls is double in women compared to men, and, after age 70 years, the rate increases rapidly for every five years of age, with those aged 85+ years having the highest rate of fall mortality. The rate of ED-treated falls has been increasing, while the rate of hospitalized cases has been decreasing. One possible reason for this is that Medicare encourages hospitals to hold patients for observation, often for more than 48 hours; as a result, there may be a shift in how patients are being classified. Also, hospitals may be reluctant to admit patients a second time following a fall, as they can incur penalties for readmissions.

Among those treated in the hospital for falls, our results showed that the percentage of those with at least one comorbidity increased, while the percentage of those with no comorbidity decreased during the study period. Having one or more comorbidities was associated with more severe falls. A larger number of comorbidities was strongly associated with being hospitalized (vs treated in the ED) and/or fatality. This may be related to the fact that hospitalized patients tend to have more diagnoses on hospital discharge than do ED-treated patients. Nonetheless, clinicians should consider the number of comorbidities in their fall risk assessment of seniors as a proxy for frailty. As mentioned above, this is consistent with a previous study looking at frailty as a predictor of fall injury.

Our results show that the major injury consequences of falls were fractures, superficial wounds/contusions, open wounds and TBI. The most frequent non-injury consequences were UTI, pneumonia, pressure ulcer and sepsis. Pneumonia, pressure ulcer and UTI often develop because of prolonged immobility after a fall-related injury and can result in sepsis. TBIs and hip fractures are also associated with high rates of morbidity because of prolonged immobility, surgical risk and functional disability, and can result in pneumonia or other conditions as well as death. Age-related changes and comorbidities are associated with the risk of falls, and result in immobilization and severe outcomes. Among those consequences, sepsis had the highest odds (9.9) for death, followed by pneumonia.

Evidence-Based Fall Prevention
The American Academy of Family Physicians recommends home hazard assess-
Study Limitations

There are several limitations of this study. First, we could not directly measure the relationship between frailty and falls incidence. A cohort study or case control study would be necessary to further evaluate the relationship between falls and frailty. Furthermore, while we used three or more comorbidities as a proxy for frailty, this relationship has not been widely established for public health surveillance. Second, we could not distinguish between deaths directly attributable to a fall and those attributed to another cause. In a future study, the MHA data could be linked to death certificate data to determine which deaths were caused by falls. Third, fall victims who did not present to the hospital and Minnesota residents who fell outside of the state were not included. This would result in an underestimate of fall rates. Finally, the rates reported in this paper are likely conservative because we excluded the hospitals that were not present in the data consistently throughout the five years. Submission of hospital discharge data is voluntary, and not all hospitals did so constantly from 2010 to 2014. For example, 16 North Dakota hospitals treating Minnesota patients began reporting to the MHA after the beginning of the study period and are not included in the analysis.

Conclusion

The rapid increase in hospital-treated falls is very concerning. The increase in falls was seen among older adults with one or more comorbidities. Moreover, having comorbidities is a predictor of the severity of falls for adults 65 years of age and older. As noted, having a larger number of comorbidities is associated with a greater odds of hospitalization (vs ED treatment) and/or death. To the extent that three or more comorbidities can be used as a proxy for frailty, our analysis suggests that the increase in fall rates may be due to the increasing frailty among elders; older adults may not be dying from heart disease, diabetes or other conditions but rather living with these conditions and becoming increasingly frail. Finally, because sepsis, hip fractures and pneumonia were associated with higher mortality after falls, they provide a potential basis for clinical mortality risk assessment.

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