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Zero-Inflated Poisson Modeling of Fall Risk Factors in Community-Dwelling Older Adults

Dukyoo Jung[1], Younhee Kang[1], Mi Young Kim[1], Rye-Won Ma[1], and Pratibha Bhandari[1]

Abstract

The aim of this study was to identify risk factors for falls among community-dwelling older adults. The study used a cross-sectional descriptive design. Self-report questionnaires were used to collect data from 658 community-dwelling older adults and were analyzed using logistic and zero-inflated Poisson (ZIP) regression. Perceived health status was a significant factor in the count model, and fall efficacy emerged as a significant predictor in the logistic models. The findings suggest that fall efficacy is important for predicting not only faller and nonfaller status but also fall counts in older adults who may or may not have experienced a previous fall. The fall predictors identified in this study—perceived health status and fall efficacy—indicate the need for fall-prevention programs tailored to address both the physical and psychological issues unique to older adults.

Keywords

fall prevention, aged, nursing strategies, Poisson modeling

[1]Ewha Womans University, Seoul, South Korea

Corresponding Author:
Dukyoo Jung, Division of Nursing Science, Ewha Womans University, 309, Helen-hall, 52, Ewhayeodae-gil, Seodaemun-gu, Seoul 120-750, South Korea.
Email: dyjung@ewha.ac.kr

Injuries resulting from falls are a serious health problem in older adults. In the United States, one in every three adults above the age of 65 years experiences a fall (Centers for Disease Control and Prevention [CDC], 2011). Approximately 33% of members of the older population fall at least once per year (Fletcher, Berg, Dalby, & Hirdes, 2009). Although not all falls are associated with serious injuries and mortality, falls in older adults have serious economic, psychological, and social consequences that significantly reduce their quality of life (Hartholt et al., 2011). Approximately 10% to 20% of the injuries following a fall require hospitalization (Rubenstein, 2006); the most commonly reported injury following a fall is a fracture (Fletcher et al., 2009). Other negative consequences of falls among older adults include fear of falling (K. R. Shin et al., 2010), reduction in physical activity (Stevens, Mack, Paulozzi, & Ballesteros, 2008), anxiety, depression, and low levels of self-efficacy (Hellstróm, Vahlberg, Urell, & Etmner, 2009). The physical, economic, and psychological burden is even higher with non-ground-level falls (e.g., falling from a ladder), which occur in approximately 14% of older adults (Gelbard et al., 2014).

Multiple physiological, psychological, cognitive, behavioral, and environmental factors increase older adults' susceptibility to falls. The Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society (2010) has classified the risk factors for falls as intrinsic and extrinsic. The intrinsic risk factors include physical, mental, and cognitive changes in older adults that can be age related or secondary to a disease process. Examples of intrinsic risk factors include a previous history of falls, gait, balance, mobility problems, visual impairments, including cataracts, neurological impairments, decreased muscle strength, hypotension, and rate and rhythm abnormalities of the heart. The use of sedative-hypnotics, psychotropic drugs, polypharmacy, and problems with feet or footwear also increase the risk of falls. The extrinsic risk factors include the hazards associated with environmental factors, such as inadequate lighting, slippery floors, uneven floors, a lack of infrastructure providing adequate support (e.g., handrails), and poor signage (Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2010). Consistent with this list are the significant risk factors reported in previous studies of older adults that include visual impairment (Källstrand-Ericson & Hildingh, 2009), urinary incontinence (Yamashita, Jeon, Bailer, Nelson, & Mehdizadeh, 2011), impaired mobility (Stevens et al., 2008), depression (Hellstróm et al., 2009; Hong, Cho, & Tak, 2010), cognitive deficits (Hong et al., 2010), fear of falls, gait and (or) balance problems (Yamashita et al., 2011), and poor sleep quality (Hill, Cumming, Lewis, Carrington, & LeCouteur, 2007).

Falls also are one of the leading causes of injuries among older adults in South Korea, a country with a high percentage (12.2%) of older adults (Statistics Korea, 2013). With advancing age, the risk for falls and related injuries increases (Hong et al., 2010). The prevalence of falls among older Korean adults has been reported to range between 15% and 55% (K. R. Shin, Kang, Hwang, & Jung, 2009; Yoo, 2011). Hence, identifying the risk factors of falls and planning appropriate fall-prevention strategies are of paramount importance for health care providers. Accordingly, over the past few years, several studies have been conducted to assess the prevalence and risk factors of falls (Hong et al., 2010; D. Jung, Lee, & Lee, 2009; K. R. Shin et al., 2009; Yoo, 2011); however, there are a limited number of studies that have considered falls as a count variable.

Statistical Challenges in Data Analyses of Falls

Falls among older persons occur with low frequency and older people have a low response rate to questions assessing their frequency of falls. Therefore, most researchers have applied linear or logistic regression models for causality analysis of count data (whole numbers, such as 0, 1, 2, and 3) (K. R. Shin et al., 2009; Yamashita et al., 2011). In such cases, the error term of the dependent variable in a linear regression model (LRM) is measured, given the assumption of a normal distribution (that is, a continuous probability distribution); it is inappropriate to conduct the analysis of a dependent variable on count data with a nonnormal distribution. Another problem associated with logistic regression analysis is the increased possibility of losing data from various frequencies because LRM analyzes data by collapsing it to form dichotomous categories (Jang & Jang, 2004; Zaninotto & Falaschetti, 2011). Therefore, an LRM is not the proper method for analyzing count data, such as fall frequencies.

In this study, we used the more sensitive zero-inflated Poisson (ZIP) regression model to identify the risk factors predictive of falls among older persons. The LRM has issues related to the overdispersion of count data and unobserved heterogeneity of the variables, in addition to the requirement to fulfill the assumptions described above. The ZIP model can analyze comprehensively the logarithm of the odds (logit) model, which predicts the possibility of having a future problem, and the count model, which predicts the risk factors affecting the severity of existing problems among the participants (Jang & Jang, 2004; Zaninotto & Falaschetti, 2011). In other words, the results of this statistical approach can be applied to the design of selective and effective intervention programs due to a greater understanding of the risk factors.

Purpose

The aim of this study was to examine the risk factors for falls by using appropriate methods of analysis of count data. A related goal was to contribute to the development of effective strategies for the prevention of falls among older persons. The specific research questions were as follows:

> **Research Question 1:** What are the risk factors that predict falls in community-dwelling older adults who have not experienced a fall?
> **Research Question 2:** What are the risk factors that predict the possibility of experiencing a subsequent fall(s) in community-dwelling older adults who have experienced a fall?

Method

A cross-sectional descriptive study design was employed to examine the predictors of falls among older adults in South Korea.

Participants

This study was a secondary analysis of data from a longitudinal study that explored falls and related factors among community-dwelling older adults. The original study adopted a descriptive cross-sectional design to explore falls among Korean older adults. Previously published studies have focused on the prevalence of falls among Korean community-dwelling older adults (K. R. Shin & Lee, 2011) and the effects of depression and activities of daily living (ADLs) on the fear of falling in this population (K. R. Shin et al., 2010). This study includes the investigation of fall counts and related factors, such as fall efficacy, ADLs, depression, sleep quality, and physical functioning (e.g., joint flexibility) among the participants.

Prior to data collection, the Institutional Review Board (IRB-No 2009-3-4) of the related university approved the research. The study's participants were recruited from among the older adults who visited the health center of a local (district) community welfare center located in the southern region of Seoul and Y city of Gyeonggi-do between September 2009 and May 2011. The participants were healthy community-dwelling older adults who were visiting the health center for a general checkup or for other reasons, for example, health education, exercise. The participants were informed of the purpose and procedure of the study; those willing to participate voluntarily and who fulfilled the inclusion criteria were asked to sign an informed written consent form before their participation in this study.

Data on the participants' falls were obtained through self-reports of fall experiences in their answers to the study's questionnaire, which took approximately 30 min to complete. Research assistants, who visited the local health centers and administered the structured questionnaire on a one-on-one basis to each participant, collected the data. All the assistants had a master's degree or higher level of education and were given detailed instructions about the use and scoring of each instrument prior to the data collection period.

The inclusion criteria were (a) older adult men and women 65 years of age and older who understood the study's objectives and procedures and have signed the written consent form, (b) individuals capable of communication (able to read and write in Korean) and in possession of mental clarity, (c) individuals with a Mini-Mental State Examination (MMSE) score of ≥24 (the cutoff score was based on education and age), and (d) individuals capable of walking independently and performing ADLs without assistance. The exclusion criteria were (a) individuals younger than 65 years of age and (b) a self-reported diagnosis of dementia.

In the initial study, a total of 706 participants were initially contacted of whom 32 were excluded (unable to read and write = 14, refused participation = 20, insufficient response = 8). Of the remaining 664 participants, 2 individuals required assistance in ADLs and 4 had MMSE score below 24. After their exclusion from the study, the final sample consisted of 658 participants.

Measures

General demographic and health information data were collected using questionnaires developed by the authors. Gender, age, years of education, type of residence, living arrangements, and self-perceived economic status were assessed. Information about the daily intake of all of the participants' medications (e.g., vitamins and medications for diabetes, hypertension, arthritis, and other health issues) was recorded. Hypertension, diabetes, myocardial infarction, chronic obstructive pulmonary disease (COPD), cerebrovascular accident (CVA), and a history of cancer were assessed and recorded as comorbid diseases.

A "fall" was defined as an inadvertent coming to rest on the ground or floor, or other lower surface. The recurrence of falls was defined as ≥1 fall in the past 12 months. The nonfallers, however, were defined as those without any experiences of falls. The participants' history of falls within the past year was recorded using a standardized question to ascertain their fall status: "Have you fallen in the past 12 months?" The participants' answers were recorded as either a yes or no.

Perceived health status, or how individuals' perceive their own health, is an integrative concept that reflects an individual's evaluation of their own general health. Perceived health status was measured using the Korean version (Hwang, 2000) of the Perceived Health Status Scale (Speake, Cowart, & Pellet, 1989), which consists of 3 items. Each item was rated on a 5-point Likert-type scale ranging from 1 (*completely disagree*) to 5 (*completely agree*). The possible mean score ranged from 1 to 5, with higher scores indicating a better or more positive perception of health status. Cronbach's alpha for the study of older adults conducted by Hwang (2000) was .87, and it was .78 for the current study.

Cognitive status was measured using the Korean Mini-Mental State Examination (K-MMSE; Folstein, Folstein, & McHugh, 1975; Kang, Na, & Hahn, 1997) and the Korean Dementia Screening Questionnaire–5 (KDSQ-5; Yang, Cho, Chey, Kim, & Kim, 2002). These measures were used in tandem because their accuracy improves when they are administered at the same time (M. H. Shin et al., 2011). The KDSQ-5 is not affected by age, gender, or educational background, and measures areas of functioning that are not included on the K-MMSE, such as ADLs (Yang et al., 2002). The K-MMSE, a screening test, is a quantitative assessment of the severity of cognitive impairment used to document cognitive changes that occur over time. The total score for the K-MMSE ranges from 0 to 30, with higher scores indicating better cognitive functioning; a score of ≤23 was used as a cutoff point to indicate the presence of cognitive impairment. The Cronbach's alpha for the current study was .83. The KDSQ-5 was developed by Yang et al. (2002) for evaluating an individual's personal perception of his or her cognitive status. Each question is answered by selecting "Never" (0 points), "Occasionally/partly" (1 point), or "Frequently/mostly" (2 points). The total possible points range from 0 to 10, with higher scores indicating lower cognitive functioning. The Cronbach's alpha for the current study was .81.

Functional physical ability was assessed using the Korean version (Park, Shon, & Cho, 1995) of the Barthel Index (Mahoney & Barthel, 1965). This instrument is an ordinal scale that measures functional independence in the domains of personal care and mobility (e.g., eating, toileting). The highest possible score on the Barthel Index is 100 points, which indicates complete independence. In our study, Cronbach's alpha was .61.

The Korean version (Kim, 2003) of the Fall Efficacy Scale (FES; Tinetti, Richman, & Powell, 1990) was used to measure fall-related self-efficacy. The FES measures an individual's confidence in performing a range of ADLs without falling (Tinetti et al., 1990). The range of possible points on the scale is 10 to 100 points, with lower scores indicating a high level of fall-related efficacy. This scale was used by Kim (2003) with an older population (Cronbach's $\alpha = .93$; Kim, 2003). Cronbach's alpha in our study was .89.

Perceived sleep quality was assessed using the Korean version (Joo et al., 2005) of the Epworth Sleepiness Scale (ESS), developed by Johns (1991). This eight-item instrument measures the individual's general level of daytime sleepiness. Respondents report the likelihood of falling asleep in a particular situation using a 4-point Likert-type scale. Their responses are summed, and the higher scores indicate greater sleepiness; scores greater than 10 suggest excessive daytime sleepiness. Cronbach's alpha for this study was .71.

Depression was assessed using the Korean version (I. K. Jung, Kwak, Cho, & Lee, 1997) of the Geriatric Depression Scale (K-GDS; Yesavage, Brink, Ros, Lum, & Huang, 1982). According to the scale, depressed mood refers to a negative and unpleasant affect. The K-GDS consists of 30 yes/no items and has a maximum score of 30 points. K-GDS scores of 14 to 18, 19 to 21, and >22 points are indicative of borderline, moderate, and severe depression, respectively. Cronbach's alpha for this study was .89.

Data Analysis

The SPSS, version 17.0 Windows (SPSS, Chicago, IL, USA) and Stata 11.0 (Stata Corp, Texas, USA) were used to analyze the data. Descriptive statistics, chi-square tests, and *t* tests were used to describe and compare the participants in the faller and nonfaller groups. As we were interested in identifying the predictors of falls and fall counts, we analyzed the data with fall as a dichotomous variable in the logistic regression and as a count variable in the ZIP regression.

The dependent variable in this study was the frequency of falls among older persons. Due to the characteristics of the data on falls, the answer of "no fall experience" was coded as 0 (zero count). In line with the ZIP regression method, it was assumed that those who reported a zero count were either older adults who had no experience of falling or older persons with a high risk of falling, that is, those with one or more risk factors included in this study but who had not fallen at the time of the survey. In this study, the probability of participants answering 0 to the question assessing the frequency of older persons' fall experience was 71.4%, which represents "zero-inflation."

The ZIP model is a statistical analysis strategy that increases the explanatory power of the entire model by explaining excessive 0 answers. The estimation is conducted with two arbitrary groups: The group with at least a "1" answer is examined using the count model and the "0" group is treated using a mixed-model strategy for a comprehensive analysis of the logit model (Azagba & Sharaf, 2011).

The logit model analysis was based on the factors influencing the participants' inclusion in the "0" group; therefore, the coefficient value in this model is the estimation of the probability that a fall would not occur (i.e., zero probability). The logit model analyzes the probability of "0" group membership, in other words, the change in not having a fall experience. This analysis evaluates the possibility of inclusion of a participant who had not previously experienced a fall at the time of the survey in a group with a future risk of falling.

Results

Demographic Characteristics

The results of the demographic information analysis are presented in Table 1. Among the 658 participants, 62.5% (n = 411) were female; the mean age was 70.63 (SD = 4.61) years; 23.7% completed elementary education, and the mean years of education was 10.48 (SD = 4.64). Most of the participants lived in an apartment (55.3%), and the majority of them (81.3%) lived with their spouse or family member(s). The participants described their economic status as middle class (n = 357, 34.5%), lower class (n = 182, 34.3%), or middle-to-lower class (n = 119, 22.4%).

In the current study, nearly 30% (n = 188) of the 658 participants reported having an experience of falling. There were statistically significant differences between the participants in the faller and the nonfaller groups based on gender, and females reported a higher fall rate compared with their male counterparts (Table 1).

Comparison of the Participants in the Faller and Nonfaller Groups

The results of this analysis are presented in Table 2. Older adults who had experienced a fall reported lower health status and cognitive functioning than the older adults who had not experienced a fall. In addition, the group that had experienced falls reported more fear and depression than the group that had not experienced a fall.

Factors Predicting Falls

The predictors of falls were analyzed as dichotomous variables using logistic regression (Table 3). The Hosmer–Lemeshow test of the model predicting falls yielded a value of χ^2 = 12.166, df = 8, and p = .144, confirming the suitability of the regression model used for the present study. The explicability of the dependent variables in the regression model was 3.6% (Nagelkerke R^2 =

Table 1. Demographic Characteristics of Subject (N = 658).

Categories	Fallers (n = 188) n (%)	Nonfallers (n = 470) n (%)	Total n (%)	χ^2/F	p
Gender					
Male	59 (23.9)	188 (76.1)	247 (37.5)	4.253	.041*
Female	129 (31.4)	282 (68.6)	411 (62.5)		
Age (years)					
65-74	143 (27.4)	378 (72.6)	521 (79.4)	1.393	.241
75 and older	44 (32.6)	91 (67.4)	135 (20.6)		
Education (years)					
None/less than elementary school	20 (3.0)	50 (7.6)	70 (10.6)	0.200	.655
Elementary	46 (7.0)	110 (16.7)	156 (23.7)		
Middle school	23 (3.5)	64 (9.7)	87 (13.2)		
High school	56 (8.5)	117 (17.8)	173 (26.3)		
College/university	35 (5.3)	108 (16.4)	143 (21.7)		
Graduate school	8 (1.2)	21 (3.2)	29 (4.4)		
Residential types					
Detached house	34 (5.2)	88 (13.4)	122 (18.6)	0.315	.575
Apartment	108 (16.4)	255 (38.8)	363 (55.3)		
Multiunit house	40 (6.1)	109 (16.6)	149 (22.7)		
Others	5 (0.8)	18 (2.7)	23 (3.5)		
Living arrangement					
Lives with family or relatives	155 (23.6)	380 (57.8)	535 (81.3)	0.660	.361
Lives alone	33 (5.0)	90 (13.7)	123 (18.7)		
Perceived economic state					
High	3 (0.6)	8 (1.5)	11 (2.1)	0.002	.961
Upper middle	10 (1.9)	26 (4.9)	36 (6.8)		
Middle	54 (10.2)	129 (24.3)	183 (34.5)		
Lower middle	33 (6.2)	86 (16.2)	119 (22.4)		
Low	53 (10.0)	129 (24.3)	182 (34.3)		

*$p < .05$.

.036), and the classification accuracy of falls in the model was 72%. The associated independent variables presented in Table 2 were perceived health status, cognitive functioning, depression, and fall efficacy. Among the four variables, fall efficacy emerged as a statistically significant predictor of falls.

Table 2. Comparison of Fallers and Nonfaller Group of Each Variable (*N* = 658).

	Fallers (*n* = 188)	Nonfallers (*n* = 470)		
Variables	*M* ± *SD*	*M* ± *SD*	*t*	*p*
Number of diseases	4.11 ± 2.41	3.81 ± 1.99	1.496	.136
Number of medications	2.47 ± 1.48	2.35 ± 1.44	0.980	.327
Perceived health status (PHS)	8.59 ± 2.29	9.07 ± 2.24	−2.471	.014**
Perceived cognitive function (KDSQ-5)	2.72 ± 2.11	2.23 ± 1.98	2.771	.006**
Cognitive function (K-MMSE)	27.32 ± 1.60	27.49 ± 1.71	−1.218	.224
Independence in performing (BI)	99.80 ± 1.86	99.91 ± 1.15	−0.874	.382
Fall efficacy (FES)	27.18 ± 19.24	22.24 ± 16.19	3.075	.002**
Perceived sleep quality (ESS)	7.21 ± 4.71	6.70 ± 4.53	1.283	.201
Depression (K-GDS)	10.93 ± 6.02	9.50 ± 5.86	2.807	.005**

Note. PHS = perceived health status; KDSQ-5 = Korean Dementia Screening Questionnaire–5; K-MMSE = Korean Mini-Mental State Examination; BI = Barthel index; FES = Fall Efficacy Scale; ESS = Epworth Sleepiness Scale; K-GDS = Korean version of the Geriatric Depression Scale.
**p <.001.

Fall incidents in the nonfaller group decreased by a factor of 0.989 for every 10-point increase in fall efficacy.

ZIP Regression

The frequency of falls is shown in Table 1. The mean fall count was 0.04 and there was a presence of excess zero counts (71.4%). The Vuong statistic was $z = 2.77$ and $p > z = 0.0028$; accordingly, the model was confirmed as suitable because overdispersion was dissolved. In the analysis of the count

Table 3. Logistic Regression Analyses of Predictor for Fall (N = 658).

Predictor	B	SE	Wald	p	Exp(B)	95% CI RR
Perceived health status (PHS)	0.033	0.049	0.459	.498	1.034	[0.939, 1.137]
Perceived cognitive function (KDSQ-5)	−0.049	0.050	0.959	.328	0.952	[0.864, 1.050]
Fall efficacy (FES)	−0.011	0.005	4.496	.034*	0.989	[0.979, 0.999]
Depression (K-GDS)	−0.018	0.019	0.899	.343	0.982	[0.946, 1.020]
Constant	1.207	0.585	4.253			

Note. −2 log likelihood = 739.964. Nagelkerke R^2 = .036. Hosmer–Lemeshow test: χ^2 = 12.166, df = 8, p = .144. CI = confidence interval; RR = Relative risk; PHS = perceived health status; KDSQ-5 = Korean Dementia Screening Questionnaire–5; FES = Fall Efficacy Scale; K-GDS = Korean version of the Geriatric Depression Scale.
*p <.05.

model, only perceived health status was significantly associated with falls; therefore, lower perceived health status (b = −.103, p = .021) was associated with an increased possibility of falling. The results of the logit model analysis indicated that the "0" group had lower scores on fall efficacy (b = −.044, p = .021). High fall efficacy was associated with an increased possibility of not falling because lower scores indicated high fall efficacy status (Table 4).

Discussion

Of the 658 older adults in our study, 28.6% (n = 188) reported having one or more falls in the past year. Fall prevalence rates reported from previous studies (assessed as occurring within the previous year and measured using a single-item question) conducted outside of Korea, were between 14% and approximately 35% (Fletcher et al., 2009; Gelbard et al., 2014). In Korea, the percentage has been reported to range from as low as 6.3% to as high as 55.7% for single falls, and up to 44.2% for more than two falls (Hong et al., 2010; Yoo, 2011). The varied rates of fall prevalence could, in part, be due to the recall bias associated with reporting fall incidents.

A significant difference was observed between the male and female participants (p = .04), with more female participants in the faller category. This finding is in line with previous reports (Hong et al., 2010; Stevens et al., 2008). Yoo (2011) also reported higher rates of single and multiple falls among women.

Table 4. Zero-Inflated Poisson Regression of Fall Counts (N = 658).

Fall Frequency	Coefficient	*SE*	*z*	*p* > |z|	95% CI
Count model					
Perceived health status (PHS)	−0.103	0.045	−2.31	.021*	−[0.191, −0.016]
Perceived cognitive function (KDSQ-5)	0.076	0.047	1.63	.102	[−0.015, 0.168]
Fall efficacy (FES)	−0.009	0.005	−1.87	.062	[−0.018, 0.000]
Depression (K-GDS)	0.025	0.019	1.33	.185	[−0.012, 0.062]
Constant	0.355	0.577	0.62		
Logit model					
Perceived health status (PHS)	−0.090	0.096	−0.94	0.350	[−0.277, 0.098]
Perceived cognitive function (KDSQ-5)	0.048	0.097	0.50	0.620	[−0.142, 0.238]
Fall efficacy (FES)	−0.044	0.019	−2.37	0.021*	[−0.082, –0.007]
Depression (K-GDS)	0.019	0.039	0.49	0.623	[−0.057, 0.095]
Constant	1.169	1.271	0.97		

Note. Vuong test of ZIP versus standard Poisson: z = 2, 77, $p > z$ = .0028. Inflation model = logit. Log likelihood = −536.4014. Likelihood ratio $\chi^2(5)$ = 14.43. $p > \chi^2$ = 0.01. ZIP = zero-inflated Poisson; CI = confidence interval; PHS = perceived health status; KDSQ-5 = Korean Dementia Screening Questionnaire–5; FES = Fall Efficacy Scale; K-GDS = Korean version of the Geriatric Depression Scale.
*p <.05.

In our study, the older adults who reported at least one fall had a significantly lower perceived health status than did those who did not report a fall. In addition, perceived health status was a significant factor in the count model of the ZIP regression. Perceived health status has been identified previously as a predictor of falls (Yoo, 2011). Similarly, older adults who had repeated falls reported lower perceived health status compared with those who had a single fall (Tak & An, 2011). Older persons with a lower perceived health status may be less attuned to health maintenance, which can lead to lower physical functioning, which ultimately results in falls.

According to our results, there was no difference between the fall and nonfall groups in the degree of cognitive functioning, as measured by the K-MMSE. However, self-perceived cognitive functioning, as measured by the KDSQ-5, was found to be significantly lower in the fall group, and the group that experienced falls had a higher degree of problems in cognitive functioning, such as memory deterioration. As a fall is related to self-perceived cognitive functioning, this suggests the need for several intervention strategies for older persons in local communities. However, it must be noted that even though there was a statistically significant difference based on perceived cognitive functioning between the fall and nonfall groups, this difference was small and may not be clinically relevant. This finding must be interpreted and applied with caution. Further studies on the association of falls and decreased self-perceived cognitive functioning should be conducted, regardless of other indicators of normal cognitive functioning.

According to our results, the depression scores of the fall-experienced group were significantly higher than the scores of the nonfall group. This finding supports the results of a study conducted by Sai, Gallagher, Smith, and Logsdon (2010) on the risk of falls in older persons in local communities. Although the depression scores were higher in the fall-experienced group in this study, they were not a significant factor in predicting falls. The overall levels of depression across the full sample were normal, and depression did not have a direct effect on falls.

The aim of this study was to identify the predictors of fall counts. The risk factors included in this study were physical factors (number of diseases, use of polypharmacy, perceived health status, sleep quality, independence in performing ADLs), mental state (depression, mental status), cognitive factors (cognitive status), and behavioral factors (fall efficacy). We analyzed our data using two discrete methods: fall as a dichotomous variable and as a count variable. Interestingly, fall efficacy emerged as a significant predictor in both methods. The predictive ability of fall efficacy in both methods signifies its importance in predicting faller and nonfaller status, as well as fall counts in older adults who may or may not have experienced a recent fall. A previous study conducted by D. Jung et al. (2009) found that fall efficacy acts as a mediator in reducing falls among older adults by reducing the fear of falls (D. Jung et al., 2009). Low fall efficacy limits older adults in their ability to carry out ADLs; furthermore, impaired ADLs can independently pose a risk for falls or it can cause poor physical and mental health as rated by older adults (Garber et al., 2010). Fall efficacy also is positively correlated with the quality of life of older adults (Ganz, Bao, Shekelle, & Rubenstein, 2007). Our study further emphasizes that future fall-prevention strategies should target ways to improve fall efficacy in older adults.

In the LRM results, fall efficacy was found to be the most influential risk factor. In the results derived from the count model using ZIP analysis, perceived health status was the only risk factor for falls in the count model. However, only fall efficacy was significant in the logit model. Simply put, older persons with low fall efficacy had a higher probability of falling according to the logit model. However, older persons with high-perceived health status had a reduced number of fall experiences according to the result of the count model, and this eventually lowered the possibility of experiencing continuous falls.

In previous studies, fall efficacy and perceived health status were reported as major predictors of falls (Hadjistavropoulos et al., 2007). However, our results using the ZIP model analysis differ from the results of existing studies. The use of ZIP regression is more sensitive for identifying fall count predictors when the data contain an excessive number of zero counts. The details found in the results cited above have not been found in previous studies using logistic analysis. The ZIP analysis allowed an increase in the explanatory power of the excessive zero-score group (Zaninotto & Falaschetti, 2011). This study assessed the problem through analysis, and it found that (a) older persons without fall experience, but with low fall efficacy, were more likely to be in the fall risk group, and (b) older persons in the fall-experienced group with low perceived health status were most likely to be at risk for another fall. In addition, the effects of the study's significant findings and strengths are important to nursing science because the results obtained from our data using the ZIP regression method should guide nurses' development of tailored strategies to prevent falls, based on fall counts and fall experience. The results were verified through the count data analysis with excessive zero scores regarding the predictors of falls. This study found independent risk factors based on the possibility of inclusion in the fall risk group even in the absence of previous fall experience. In the fall-experienced group, the level of severity of future falls was heightened. Therefore, this study provides an empirical basis on which to establish a differentiated preventive intervention strategy, which we consider to be the most significant result of this study.

Our study has some limitations. First, the cross-sectional design precludes causal interpretation, and the use of a convenience sample from one health center located in an urban area limits the generalizability of the study's findings. Second, the physiological risk factors for falls were not assessed in this study. The inclusion of physiological factors in future studies may provide objective research results. Third, the reliability of the Barthel index was low in our study. Fourth, recall bias may have affected the fall counts reported by the participants. However, a previous study reported the accuracy of self-reports of falls to be as high as 84% (Mackenzie, Byles, & D'Este, 2006).

There are three key implications of these results. First, despite the number of studies on predictors of falls in older adults, it is important to consider falls as a count variable instead of a dichotomous one because a fall does not occur necessarily as an isolated, one-time event, and the outcomes related to falls can be equally devastating with each incident. Second, because the ZIP regression model explains the overdispersion due to the presence of a structural zero, it was found to be more sensitive in identifying the predictors of fall counts and accurate incidence rates. Obtaining accurate incidence rates should improve the projection of falls in older adults and contribute to long-term health care planning. Third, the fall predictors identified in our study—perceived health status and fall efficacy—indicate the need for prevention programs to address both the physical and psychological issues unique to older adults.

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