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ORIGINAL PAPER

Prevalence, Severity, and Risk of Future Falls in Community-Dwelling Older Adults Living in a Rural Community: The Atahualpa Project

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Abstract

Accidental falls are a leading cause of disability and death in older adults living in urban centers. However, little is known about the consequences of falls in rural communities. We aimed to assess characteristics and risk of falls in community-dwellers aged ≥ 60 years living in rural Ecuador. Of 463 older adults enrolled in the Atahualpa Project, 327 (71%) were included. Multivariate logistic regression models were fitted to assess factors associated with history of falls and risk of future falls. Sensitivity analysis was conducted to determine which component of the Downton fall risk index (DFRI) better predicts risk of future falls. A history of falls was reported by 173 (53%) individuals. Most were related to stumbling due to uneven (non-paved) streets. Only three individuals had bone fractures after the fall. Previous falls were not associated with any of the investigated covariables. The DFRI was positive in 87 (27%) participants, and was associated with age ($p < 0.001$) and history of stroke ($p < 0.001$). None of the subjects were taking tranquilizers/sedatives. The most reliable component of the DFRI was the presence of sensory/motor deficits. History of falls in our population is similar to that reported elsewhere. However, the risk of future falls is lower. Such discrepancies are probably because the DFRI does not take into account environmental factors resulting in falls. There were almost no severe complications from falls, which could be partly related to the lack of use of tranquilizers/sedatives.

Keywords Falls · Downton fall risk index · Older adults · Population study · Rural communities

Introduction

Accidental falls in older adults have been the leading cause of fatal and non-fatal injuries treated in hospital emergency departments in the US, by a factor of 10 over the second leading cause (https://www.cdc.gov/injury/wisqars/LeadingCauses.html). One study based on data obtained from the Center for Disease Control and Prevention and the Medicare fee-for-service claims found that the direct medical costs for fatal fall related injuries in 2015 totaled $637.5 million and $31.3 billion for non-fatal injuries [1]. The latter amount comes from around 3.2 million non-fatal fall related injuries of which 800,000 required hospitalization, most often due to head injury or hip fractures (https://www.cdc.gov/injury/wisqars/). These data underscore the importance of conducting studies to identify factors that influenced previous accidental falls as well as risk factors that may increase the likelihood of future falls. Identifying such factors will help to pinpoint individuals with an overall increased risk of falls. It is also important to note that most of this data comes from industrialized nations, and that little is known about fall prevalence, associated risk factors, injury breakdown, and risks for future falls in older adults living in remote rural communities. In the latter, lifestyle and risk factors are different from populations living in large urban centers. Furthermore, factors influencing previous falls as well as risk factors for future falls may also differ. By means of data available through the Atahualpa Project, an ongoing population-based cohort study, we aimed to assess prevalence, severity, and risk of future falls in community-dwelling older adults living in a rural Ecuadorian village.

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Methods

Study Population

Atahualpa is a rural village located in Coastal Ecuador, where previous epidemiological studies have been conducted [2]. As detailed elsewhere, residents are homogeneous regarding race/ethnicity, overall living conditions, and dietary habits [3]. These consistencies reduce the risk of unexpected confounders at the time of analyses.

Study Design

Atahualpa residents aged ≥ 60 years identified during door-to-door surveys were invited to participate, and those who signed a comprehensive informed consent were enrolled. Baseline interviews and procedures were designed to assess demographics and cardiovascular risk factors according to criteria proposed by the American Heart Association [4]. A history of falls in the year before the study was assessed by a structured questionnaire. In addition, the risk of future falls was assessed by means of the Downton fall risk index (DFRI). Using a population-based cross-sectional study design, we aimed to assess whether prevalence and severity of previous falls, as well as the risk of future falls, are associated with relevant confounders by fitting multivariate logistic regression models using history of falls and future risk of falls as independent outcomes. The I.R.B. of Hospital-Clínica Kennedy, Guayaquil, Ecuador (FWA 00006867) approved the study.

Falls Assessment

The structured questionnaire for falls assessment consisted of four questions that included: (1) Have you experienced an unintentional fall in the year before this test (if positive, how many falls could you recall)?; (2) What was (were) the most likely cause of the fall(s)?; (3) Did a fall resulted in hospitalization?; and (4) Were there any bone fracture(s) due to a fall? (specify which bones). The risk of future falls was assessed by means of the DFRI, a five-question instrument inquiring about history of previous falls, use of specific medications (tranquilizers/sedatives, non-diuretic anti-hypertensives, diuretics, anti-parkinsonians, and antidepressants), sensory or motor deficits (visual impairment, hearing impairment, paresis), gait abnormalities (with or without aid), and confusion [5, 6]. Using the DFRI, a score ≥ 3 is considered positive, indicating a high risk of future falls.

Clinical Covariables Investigated

Demographics and cardiovascular risk factors relevant to the outcomes investigated were chosen as clinical confounding variables, and were assessed through interviews and procedures previously described in the Atahualpa Project. These variables have been shown to modify fall risk and patterns in similar studies conducted elsewhere [7, 8]. To assess cardiovascular risk factors, we used the American Heart Association criteria for poor physical activity, body mass index, and blood pressure levels [4]. To identify overt stroke cases, all participants were screened by rural doctors with the use of a validated field questionnaire, and then, certified neurologists confirmed the diagnosis. An overt stroke was defined as a rapidly developing event lasting more than 24 h with no apparent cause other than vascular. Individuals with an overt stroke were invited to undergo a brain MRI to confirm the diagnosis.

Statistical Analysis

Data analyses were carried out by using STATA version 15 (College Station, TX, USA). In univariate analyses, continuous variables were compared by linear models and categorical variables by the x^2 or Fisher exact test as appropriate. A multivariate logistic regression model was fitted to assess the independent association between history of falls (as the outcome) and the aforementioned covariables. In another multivariate logistic regression model, we assessed factors associated with the risk of future falls by the use of the DFRI. Sensitivity analysis was conducted to determine which of the individual components of the DFRI better predicts an increased risk of future falls.

Results

This study included 327 (71%) out of 463 individuals aged ≥ 60 years enrolled in the Atahualpa Project—by means of door-to-door surveys—between 2012 and 2018. The remaining 136 subjects had either died, moved out of the village or declined consent between enrollment and the present study (January 2019).

Characteristics of participants are depicted in Table 1. The mean age was 70.4 ± 7.9 years (median age: 69 years; age range: 60 to 95 years), 186 (57%) were women, 253 (77%) had primary school education only (mean years of education: 6.7 ± 2.8 years), and 52 (16%) reported high intake of alcohol (all men). Blood pressure levels ≥ 140/90 mmHg were recorded in 139 (43%) individuals. A body mass index ≥ 30 kg/m^2 was present in 77 (24%)

Table 1 Characteristics of Atahualpa residents aged ≥ 60 years according to whether they had history of falls in the year before the study (univariate analysis)

Variable	Total series (n = 327)	History of falls (n = 173)	No falls (n = 154)	*p* value
Age, years (mean ± SD)	70.4 ± 7.9	71.1 ± 8.3	69.7 ± 7.5	0.112
Women, n (%)	186 (57)	104 (60)	82 (53)	0.211
Primary school education, n (%)	253 (77)	137 (79)	116 (75)	0.404
Severe alcohol intake, n (%)	52 (16)	28 (16)	24 (16)	0.882
Blood pressure ≥ 140/90 mmHg, n (%)	139 (43)	78 (45)	61 (40)	0.317
Body mass index ≥ 30 kg/m^2, n (%)	77 (24)	39 (23)	38 (25)	0.650
Poor physical activity, n (%)	28 (9)	13 (8)	15 (10)	0.472
Overt stroke, n (%)	24 (7)	16 (9)	8 (5)	0.161

Table 2 Multivariate logistic regression model showing no independent association between history of falls and any of the covariables investigated

History of falls	Odds ratio	95% confidence interval	*p* value
Age, years	1.02	0.99–1.06	0.138
Being women	1.58	0.93–2.67	0.088
Primary school education	1.06	0.61–1.83	0.829
Severe alcohol intake	1.55	0.75–3.18	0.235
Blood pressure ≥ 140/90 mmHg	1.13	0.71–1.80	0.606
Body mass index ≥ 30 kg/m^2	0.90	0.52–1.57	0.715
Poor physical activity	0.52	0.22–1.24	0.140
Overt stroke	2.18	0.85–5.59	0.105

Table 3 Multivariate logistic regression model showing the independent association between the risk of future falls (by the use of the Downton fall risk index), increasing age and history of overt stroke

Downton Fall Risk Index	Odds ratio	95% confidence interval	*p* value
Age, years	1.16	1.11–1.21	< 0.001*
Being women	1.12	0.55–2.26	0.753
Primary school education	0.61	0.29–1.28	0.189
Severe alcohol intake	1.74	0.66–4.59	0.266
Blood pressure ≥ 140/90 mmHg	1.80	0.99–3.28	0.054
Body mass index ≥ 30 kg/m^2	1.12	0.53–2.37	0.762
Poor physical activity	1.92	0.69–5.33	0.208
Overt stroke	7.01	2.41–20.4	< 0.001*

* Statistically significant result

persons, and 28 (9%) referred poor physical activity. Twenty-four participants (7%) had a clinically overt stroke (confirmed by MRI in all cases).

A history of falls in the year before the study was reported by 173 (53%) individuals. Of these, 75 had a single fall, 59 had two, 20 had three, 14 had four to five, and the remaining five participants had six or more falls. Most falls were related to stumbling due to irregularity of the non-paved streets (63% of cases), while other rather common causes were loss of balance (15%), bicycle falls (8%) and transient dizziness (6%). Less common causes included alcohol intoxication, hammock fall, bed falls, motor weakness and syncope. Only three individuals required hospitalization after the fall. These cases were related to bone fractures (shoulder in two cases and fingers in another). There were no recorded cases of hip or skull fractures in the present series.

In univariate analyses, a history of falls was not associated with any of the aforementioned covariables (Table 1). A multivariate logistic regression analysis (using falls as the outcome) also showed no independent significant association between a history of falls and any of the investigated covariables (Table 2).

Regarding the risk of future falls, the mean score of the DFRI was 1.8 ± 1.6 points (median score: 1 point; score range: 0 to 9 points). The DFRI was positive in 87 (27%) participants, and was significantly associated with increasing age ($p < 0.001$) and history of stroke ($p < 0.001$) in a multivariate logistic regression model, adjusted for all the aforementioned covariables (Table 3). The most common positive component of the DFRI was history of falls (173 cases, 53%), followed by use of medications (142 cases, 43%), sensory or motor deficits (140 cases, 43%), gait abnormalities (55 cases, 17%), and confusion (13 cases, 4%). Of the investigated medications, 135 participants were on non-diuretic anti-hypertensive drugs, five were on diuretics, and two on anti-parkinsonian agents. None of the subjects were taking sedatives or antidepressants.

Sensitivity analyses showed different reliability of the five individual components to predict a positive result of the DFRI (Table 4). The most reliable component was the presence of sensory or motor deficits (95% confidence intervals of the area under the curve were higher and did not overlap with those of the other components), and the less reliable was the presence of confusion (95% confidence intervals of

Table 4 Estimates of sensitivity, specificity, positive predictive value, negative predictive value and ROC curve analysis (with 95% confidence intervals) showing reliability of the individual components of the Downton Fall Risk Index (DFRI)

Individual component of the DFRI	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Area under the curve
History of falls	74.7 (64.1–83.2)	55 (48.5–61.4)	0.38 (0.30–0.45)	0.86 (0.79–0.91)	0.649 (0.593–0.700)
Use of medications	82.8 (72.8–89.7)	70.8 (64.6–76.4)	0.51 (0.42–0.59)	0.92 (0.87–0.95)	0.768 (0.718–0.812)
Sensory or motor deficits	98.9 (92.9–99.9)	77.5 (71.6–82.5)	0.61 (0.53–0.69)	0.99 (0.97–1)	0.882 (0.841–0.914)
Gait abnormalities	57.5 (46.4–67.9)	97.9 (94.9–99.2)	0.91 (0.79–0.97)	0.86 (0.82–0.90)	0.777 (0.728–0.821)
Confusion	11.5 (5.9–20.6)	98.8 (96.1–99.7)	0.77 (0.46–0.94)	0.75 (0.70–0.80)	0.551 (0.495–0.605)

the area under the curve were lower than those of the other components).

Discussion

This study shows a high prevalence of falls (53%) among community-dwelling older adults living in a remote rural setting, which is comparable to the prevalence of 30% to 60% that is widely reported in both retrospective and prospective studies conducted in large urban centers [9–11]. However, the majority had only one or two falls, which were most often related to stumbling due to irregularity of the village's non-paved streets. This factor is not commonly faced by subjects included in the aforementioned studies.

Of those individuals who fell, less than 2% (3 out of 173) had fractures, which is considerably less than the percentage of falls associated with fractures in community-based studies [11]. Furthermore, hospitalization after a fall was exceedingly rare, and always related to shoulder girdle or finger fractures, perhaps from falling on stretched arms in an attempt to reduce the impact from the fall. Of interest, there were no cases of hip or skull fractures in the study population. This contrasts with the relative frequency of falls associated with major injuries such as hip fractures and traumatic brain injury in other studies [11]. This is of notable importance due to the high mortality, morbidity and other implications of hip fracture and traumatic brain injury [9]. None of the investigated covariables were significantly associated with history of falls, supporting the concept that falls in Atahualpa were not related to intrinsic conditions but to environmental factors.

The risk of future falls according to the DFRI (27%) is lower than that reported in older adults living in urban centers, and was only associated with increasing age and history of an overt stroke (Table 3). The fact that the DFRI does not take into account environmental factors, i.e., non-paved roads, may explain the lower risk of future falls in a setting of high history of falls, when compared to urban centers.

Of major interest is the near absence of severe falls in the study population. Indeed, less than 2% of individuals (3/173) suffered fractures related to falls and in none these fractures involved the hip or skull. Such fractures are major threats in older adults living in urban centers, even among institutionalized individuals, despite the implementation of several preventive strategies (anti-slip floors, grab bars, physical training to improve balance) that aim to reduce complications from falls [12, 13]. While the present study was not specifically designed to address this issue, the lack of use of tranquilizers/sedatives and antidepressants in our population may have represented a protective factor for severe falls. Indeed, a recent study showed that the use of non-benzodiazepine hypnotics was associated with a significant increase in the occurrence of severe falls in Sweden [14]. Non-sedated individuals can respond better to a fall by instinctively protecting their bodies, thus avoiding severe injuries. Of further note along these lines, the use of opioid analgesics is practically non-existent in the village, where pain is typically relieved by acetaminophen or nonsteroidal anti-inflammatory drugs.

Previous studies conducted in Atahualpa have demonstrated that villagers are frequent oily fish consumers, with a median intake of 8.6 ± 5.3 oily fish servings per week in the older adult population [15]. It is well established that oily fish intake reduces the risk of osteoporosis [16], which, in turn, is associated with an increased risk of bone fractures [17]. Another possible protective factor that might help explain the lack of skull fractures among participants of the current study is the thickness of skull bones in this population of Amerindians. During the course of a study attempting to assess blood flow velocity of intracranial arteries by the use of transcranial Doppler, we noticed poor acoustic windows (insonation failures) related to abnormal thickness of the temporal bones in one-third of the population, which could be related to the Amerindian ethnicity of the villagers [18]. Further studies, preferably using a longitudinal design, are needed to determine which of the aforementioned factors are protective for the occurrence of bone fractures in the population of Atahualpa. Two of these factors, minimal use of sedatives/narcotics and increased oily fish intake, could be encouraged in other populations as a way to reduce the risk of severe complications related to falls in older adults.

Major strengths of the present study include the population/based design with unbiased selection of participants as well as the methods used to assess history of falls, associated risk factors, and risk of future falls. However, our study has potential limitations, particularly its cross-sectional design, which does not allow for an assessment of the DFRI's power to predict falls in the follow-up. Also, we cannot rule out the presence of some hidden confounders that may have influenced our results. Finally, the very low number of participants with fall/related severe injuries precluded an analysis of factors associated with such poor outcomes.

Conclusions

In summary, the present study shows a prevalence of falls among older adults living in a remote rural community that is similar to that reported in urban centers. At the same time, the risk of future falls is relatively low according to the DFRI. This discrepancy is probably related to the fact that the DFRI does not take into account distinct environmental conditions that may result in falls. More importantly, there were almost no severe complications from falls, which is probably related to the lack of use of tranquilizers/sedatives, antidepressants and narcotic analgesics, or to lesser degrees of osteoporosis due to the high amount of oily fish intake by villagers. Further studies are needed to confirm these findings.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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