A description of the risk factors related to fragility fractures in adults and their associated costs

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Abstract

Objective: to identify bone fragility risk factors associated with increased total fracture care costs at a clinic in Medellín, Colombia.

Design: an observational study with retrospective and prospective measurements taken from the medical charts of patients admitted for fractures and followed until discharge.

Frame of reference: Hospital Alma Mater de Antioquia, Medellín, Colombia.

Participants: four hundred fifty-two patients diagnosed with fragility fractures on admission.

Main measurements: the prevalence of bone fragility risk factors, a description of the total care cost by risk factor and an estimate of the association between the risk factors and total costs.

Results: Diabetes (24.3%) and active or passive smoking (21%) were the most prevalent fragility risk factors. Hip fractures were the most frequent and costly (36%, Md: COP 7,882,579). Fracture care was more costly for active or passive smokers (Md: COP 7,484,185), and those 75 years old or older (Md: COP 7,057,678). According to the significant adjusted estimates ($p<0.05$), the median cost for active or passive smokers exceeds that of nonsmokers by more than COP 2,300,000, and every year of age increases the median cost by more than COP 90,000.

Conclusions: this study emphasized that bone fragility is a public health problem. Factors like active or passive smoking and age were found to increase fragility fracture care costs, implying more complications and need for services. This adds to the evidence for strengthening monitoring programs to reduce the morbidity, mortality and direct costs of this disease in Colombia. **(Acta Med Colomb 2022; 47. DOI: https://doi.org/10.36104/amc.2022.2351).**

Keywords: *fragility fractures, osteoporosis, fracture costs, morbidity, smoking*

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Introduction

Bone fragility is defined as microarchitectural bone damage, increased by reduced bone mineral density, and caused mainly by osteoporosis (1). Bone fragility increases the risk of fractures secondary to low-energy trauma, mainly of the hip, wrist, vertebrae and humerus (1).

Bone fragility fractures are estimated to cause more than five million disability-adjusted life years (DALYs) (2, 3), and therefore are a significant cause of morbidity and disability, lost productivity and increased healthcare system costs. In 2018, the estimated cost of osteoporotic fractures in Colombia was approximately 94 million dollars (USD) (4, 5). In Argentina, Mexico, Brazil and Colombia, it is estimated that there will be 4.5 million osteoporotic fractures over the next five years (4, 5).

Regarding the types of fractures, the most expensive are hip fractures, adding up to more than 205 billion COP in Colombia in 2015 (6). It is estimated that by 2050, hip fractures in Latin America may increase 700% in adults 65 years old and older and reach a cost of 13 billion USD (5, 7). The high care costs of fragility fractures are a function of their complications and greater need for diagnostic and treatment services.

Today there is ample evidence that factors such as smoking, diabetes mellitus, low body mass index, hyperthyroidism, a prior history of fractures, the use of glucocorticoids, arthritis, the use of proton pump inhibitors and alcohol consumption, among others (8), can increase the risk of fragility and lead to more complications during recovery. However, due to limited economic resources, diagnostic tests based on risk profiles are rarely performed prior to fracture, and preventive treatment is limited. Most bone fragility cases in

Colombia are detected when the fractures are more severe than expected for the triggering accident or event, or when there are recurrent fractures (9).

This suggests a high risk of fragility fractures currently in Colombia, and there may be many cases which have not been detected and therefore have not been treated, leading to high disability rates and high treatment and care costs. Fragility fractures are a relevant public health problem with an increasing trend, requiring costly and recurrent treatment, and which may be disabling. The factors which can increase the risk of complications and the need for fracture treatment services must be identified (10).

The main purpose of this study was to identify the risk factors for bone fragility associated with increased total costs for fracture care at a clinic in Medellín, Colombia, and thus strengthen the evidence for proposing new fragility fracture prevention and treatment goals to reduce their complications and consequences in Colombia.

Materials and methods

Data

The study data were taken from a study performed by Hospital Alma Máter in Antioquia from September 2019 to February 2020. The study included data taken from the medical charts of 489 adult patients 18-94 years old who were included in the study on admission to the hospital for low-impact fractures and were followed until their discharge from the clinic or their death.

Information on exposures prior to the fractures and events after the fracture were extracted from the medical chart. The costs incurred in caring for each person were taken from the clinic's records. The objectives of this study were to identify the most common fractures and risk factors for fragility fractures and determine the costs associated with their treatment. Patients with a history of cancer were excluded.

Data for this study were taken from the 452 patients with fragility fractures diagnosed by the attending physician on admission to the institution.

Study variables

The study outcome is the total cost to the system due to fragility fracture care. This total cost variable is continuous, expressed in Colombian pesos. To create this variable, a professional in economics gathered the data of total costs generated for each care provision in the various services. The included services were the blood bank, internal costs, consults, operating room time, hospital stay, fees, materials and supplies, medications not included in the Mandatory Health Plan (POS in Spanish), POS medications, nonsurgical and surgical diagnostic procedures, therapeutic surgical procedures, prosthetics and orthotics, patient transfers and physical therapy.

Exposure variables which are risk factors for fragility and could lead to greater costs and use of fracture care services were taken from the medical chart. These factors (diabetes, passive or active smoking, type of fracture, hyperthyroidism, hyperparathyroidism, alcohol consumption, anticoagulants, prior osteoporosis treatment, use of proton pump inhibitors, arthritis and use of steroids), were measured as dichotomous variables with "yes" or "no" values denoting their presence or absence. Body mass index (BMI) in kg/m^2 is a continuous variable and age is a discrete variable, because it was measured in full years. The United Nations World Health Organization reviewed and officially updated the age standards in 2015, establishing young age as 25-44 years, middle age as 44-60 years old, advanced age as 60-75 years old and senile age as 75 years and older (11). Thus, patients 75 years old or older in this study were considered to be of advanced age, as this was an age close to the Colombian life expectancy in 2019 (considered to be 74.5 for men and 80 for women) (12).

Data analysis

The absolute and relative frequencies of the sociodemographic variables, the types of fractures, the main costs of fracture care and the known fragility risk factors were examined. Continuous variables were organized in quartiles. Risk factors with a prevalence of at least 10% were included in the bivariate analysis with the total care cost.

The most frequent types of fractures for advanced and non-advanced age patients were reported based on the relative frequencies. A Chi^2 test was used to prove the null hypothesis (H_0) of no differences in the type of fracture between patients with advanced and non-advanced age at a 5% alpha level (H_0: $p_{(advanced\ age)} = p_{(non\text{-}advanced\ age)}$, gl=1, α=0.05).

The null hypothesis was rejected when the calculations had a p value <0.05.

A graphical analysis of the total fracture care cost variable, the outcome of interest variable, showed a bimodal distribution with high positive asymmetry. Logarithmic and square root transformations were applied; however, this did not result in a normal distribution of the variable, and therefore the mean was rejected as the most appropriate measure of central tendency. Thus, quantile regression (which does not have the distribution assumptions of linear regression and allows an analysis using the median and other quantiles), was selected for the bivariate and multivariate analysis (13).

Bivariate analysis was conducted using quantile regression of the median total care cost against the most prevalent fragility risk factors in the study sample. The H_0 was no difference in the medians of presence vs. absence of risk factors with a 5% alpha level (H_0: $\beta_{(yes)} = \beta_{(no)}$, gl=1, α=0.05). The fragility risk factors with significant differences were taken as main predictors in the multivariate analysis, adjusting for common confounders of the associations between fragility risk factors and the total cost of fracture treatment (Table 1). The H_0s were rejected with a $p<0.05$ and the confidence intervals were considered in the interpretations.

The type of fracture and initial treatment variables were not included as covariables in the multivariate analysis

Table 1. *Estimated median total fracture care cost by age and smoking status.*

Predictors	Adjusted β (Model 1)	95% CI		Adjusted β (Model 2)	95% CI	
		Lower limit	Upper limit		Lower limit	Upper limit
Age	100,035			91,391,136	29,924	152,858
p-value	0.001**	43,367	156,703	0.004**		
Smoker	2,383,710			2,886,453	718,122	5,054784
p-value	0.020**	379,286	4,807,134	0.009**		

Model 1: adjusted for diabetes, a history of fractures and proton pump inhibitor use.
Model 2: adjusted for diabetes, a history of fractures, proton pump inhibitor use and BMI.
**significant at 1%

because, as fragility consequences, they are considered mediators between the risk factors and total fracture care costs, rather than confounders.

IBM SPSS version 26 software was used for all the statistical analyses (14).

Missing data

The BMI variable had 10% missing data which were not used because the information was not available in the medical chart. Although there was no apparent pattern in the missing data, a loss mechanism due to unobserved variables cannot be ruled out (e.g., use of a wheelchair, which could make height and weight measurements difficult). These patients may have needed other treatments and incurred other expenses, which could cause some biases in the estimate of the association between risk factors and costs in the models which include BMI. Therefore, models adjusted and unadjusted for BMI are presented.

The other variables of interest included in this study do not have missing data.

Results

As seen in Table 2, the sample was mostly composed of women (79%) over the age of 65 (73.4%), who were affiliated with the contributive health insurance system (84.3%), were prescribed surgical treatment (68.4%) and survived their fracture (90.93%). Almost half of the patients were of advanced age, being 75 years old or older (49.1%), and were overweight or obese (47.6%). Only 0.88% of the fractures were given expectant treatment; that is, they were not treated but their progress was followed. The most frequent fragility risk factors in this sample were diabetes (24.3%), passive or active smoking (21%), and using proton pump inhibitors (20.1%).

The most frequent length of hospital stay among the patients was one day. Half of the patients spent at least four days in the hospital, and the longest recorded hospital stay was 49 days.

The most common initial types of fracture in patients of advanced and non-advanced age are shown in Table 3. At a 1% significance level ($p < 0.01$), patients of non-advanced age had a significantly greater risk of forearm fractures than those of advanced age, and patients of advanced age had a significantly greater risk of hip fractures than patients of non-advanced age.

Regarding the total fracture care costs, a minimum cost of 17,899 COP and a maximum cost of 75,305,298 COP were found between September 2019 and February 2020. In 75% of the cases, fragility fracture care cost at least 441,946 COP; in 50% the care cost at least 6,217,863 COP, and in 25% the care cost more than 9,834,428 COP. The mean was 7,793,869 COP and the standard deviation was 10,395,098 COP. Due to the dispersion of costs and extreme values, the median of the costs is a more appropriate measure of central tendency than the mean.

Table 4 shows the median cost of total care for patients according to the type of fracture and fragility risk factors. People with hip fractures (median 7,882,579 COP), and active or passive smokers (median 7,484,185 COP) were found to have the costliest care.

On bivariate analysis with quantile regression of the median at an alpha level of 5%, the risk factors significantly associated with costs were age and active or passive smoking. Therefore, these were selected as predictors for the multivariate analysis, as detailed in Table 5.

Although the estimated associations between total cost and other variables were not significant, they were included in the multivariate analysis models as confounding variables due to their theoretical relevance (Table 1). Models adjusted and unadjusted for BMI were derived, as more than 10% of the BMI data was missing.

The variables of age and active or passive smoking were found to be significantly associated at a 1% level ($p < 0.01$) with the total fracture care costs, controlling for diabetes, hypothyroidism, a history of fractures, type of fracture, use of proton pump inhibitors, and BMI.

It was estimated that every year of age increases the median total fracture care cost by more than 90,000 COP. The adjusted median of increased total costs per year of age will lie between 43,367 and 156,703 COP 95% of the time without adjusting for BMI, and between 29,924 and 152,858 adjusting for BMI.

Active or passive smokers were estimated to have a median total fracture care cost more than 2,300,000 COP

Table 2. *Sociodemographic data and risk factors for fragility fractures*.

		n	%
Sex			
Female		357	78.98
Male		95	21.02
Age`			
Under 65 years		120	26.55
65 to 84 years old		232	51.33
85 years old or older		100	22.12
Advanced age (75 years or more)			
Yes		222	49.1
No		230	50.9
Health insurance affiliation			
Contributive		381	84.29
Not reported		1	0.22
Subsidized		69	15.27
Linked		1	0.22
Fragility risk factors			
Diabetes		110	24.34
History of fractures		102	22.57
Active or passive smoking		95	21.02
Alcohol		24	5.31
Arthritis		16	3.54
Anticoagulants		20	4.42
Steroids		16	3.54
Treatment for osteoporosis		19	4.20
Hyperthyroidism		2	0.4
Hyperparathyroidism		6	1.3
Proton inhibitors		91	20.13
Body Mass Index (BMI)			
Low (less than 18.5)		13	2.88
Average (18.5 to 24.9)		175	38.72
Overweight (25 to 29.9)		154	34.07
Obesity (more than 30)		61	13.50
No data		49	10.80
Discharge Status			
Alive		411	90.93
Deceased		13	2.88
Referred		28	6.19
Type of Treatment			
Immobilization		109	24.12
Pharmacological		30	6.64
Surgical		249	55.09
Deferred surgical		23	5.09
Referred surgical		37	8.19
Other (expectant treatment)		4	0.88
Required hospitalization			
Yes		395	87.39
No		57	12.61
Hospital Stay (in days)			
Minimum	1	Quartile 1	2
Maximum	49	Median	4
Mode	1	Quartile 3	8

Table 3. *Types of fractures in advanced and non-advanced age*.

Type of fracture and patient	n	% type of fracture	(gl)	p-value
Forearm	132			
Advanced age	43	32.6	20.41 (1)	<0.01*
Non-advanced (ref.)	89	67.4		
Hip	163			
Advanced age	109	66.9	32.16 (1)	<0.01*
Non-advanced (ref.)	54	33.1		
Spinal column	24			
Advanced age	14	58.3	0.8621)	0.353
Non-advanced (ref.)	10	41.7		
Other	133			
Advanced age	56	42.1	3.71(1)	0.054
Non-advanced (ref.)	77	57.9		
*significant at 1%				

higher than non-smokers. The difference in the adjusted median total cost between smokers and non-smokers will lie between 379,286 and 4,388,134 COP 95% of the time without adjusting for BMI, and between 718,122 and 5,054,784 adjusting for BMI.

Table 4. *Median fragility fracture care costs*.

Type of care	Median (in COP)
Stay	465,236
Procedures	698,434
Prosthetics and orthotics	2,785,694
Surgeries	4,237,909
All	6,217,863
Total costs by type of fracture	
Forearm	1,011,985
Spinal column	4,280,175
Hip	7,882,579
Other	693,504
Total costs in patients with	
Proton pump inhibitors	4,434,691
History of fractures	6,322,020
Overweight or obesity	6,331,851
Diabetes	6,937,094
Advanced age (75 years or more)	7,057,678
Active or passive smoking	7,484,185

Table 5. *Estimated medians of total fracture care costs for fragility risk factors.*

	β	SE	t	gl	p-value	95% CI	
						Lower limit	Upper limit
Diabetes	907,372	1,138,938.5	0.797	450	0.426	-1,330,926.6	3,145,670.6
Age	107 ,86	29,608.5	3.640	450	0.000**	49,598.2	165,974.2
Smoking	2,325,103	1,134,748.2	2.049	450	0.041*	95,039.5	4,555,166.5
History of fractures	177,089	1,197,175.2	0.148	450	0.882	-2,175,659.1	2,529,837.1
BMI	123,430	108,629.7	1.136	401	0.257	-90,124.9	336,984.9
Proton pump inhibitors	-1,957,727	1,159,316.9	-1.689	450	0.092	-4,236,074.2	320,620.2

*significant at 5%
**significant at 1%

Discussion

This study provides a better understanding of the cost of fragility-related fractures and the factors that can lead to increased fracture costs in Colombia. It is important to note that the costs generated are those normally covered by the health insurance agencies (EPSs in Spanish), but fractures generate other costs for patients and their families (out-of-pocket expenses) like transportation, care and food, which are not covered in this study. It is also highly probable that the patients who were referred may have had other expenses in other healthcare institutions (15).

The most significant contributions of this study were the identification of the care costs for fragility-related fractures, and the finding that age and passive or active smoking lead to a significant increase in these costs (16). In 50% of the cases, the total fragility fracture care cost was more than six million Colombian pesos. This is a considerable expense for the healthcare system (17), considering that in just six months, 452 patients were admitted to the Hospital Alma Máter de Antioquia with fragility fractures, not counting people with a history of cancer or those who suffered fractures after admission. This reinforces the need to study fracture risk factors to provide the conceptual basis for developing prevention programs (18).

Regarding fragility risk factors, greater total costs were found in smokers, those with advanced age, overweight and obesity (19), and those with a history of fractures. Costs were found to increase significantly with age and active or passive smoking. Increased cost means that more fracture care services were required or, in other words, that older people required more time and care to recover from a fracture. This is consistent with the physiological mechanisms, since bone fragility and comorbidities increase with age because there is a longer exposure to agents which, in excess, may be harmful to health, like tobacco, sugary beverages, and medications, among others (20). Although a significant positive relationship was expected between age and more services for fracture recovery, to date no study has shown these characteristics. This study contributes to the evidence and supports the need to strengthen programs aimed at older patients and reduce their risk of fractures.

Smoking was also identified as another factor which significantly increases the total fragility fracture care costs. Tobacco increases bone resorption, decreases bone mineralization and may lead to more serious fractures. This means that active or passive smokers need more time and care to recover from a fragility fracture. Unlike age, smoking is a preventable behavior. This study provides evidence that a person does not need to be an active smoker to have more health problems than non-smokers; it is enough to be exposed to tobacco smoke at home. We recommend evaluating passive as well as active smoking and informing patients and their relatives of the health problems which may become more complicated if measures are not taken to decrease the use of tobacco in the home (21).

On the other hand, this study has several limitations, beginning with the lack of a comparison group without fragility to evaluate the risk of fragility produced by each factor. Another significant limitation is the lack of bone density tests to diagnose osteoporosis. It is highly probable that bone fragility is due to osteoporosis, but this could not be measured. Bone fragility was diagnosed through clinical assessment when patients were found to have a more severe fracture than expected for the triggering event. The inability to control for osteoporosis may have generated overestimates or underestimates of the associations between the fragility risk factors and total costs.

Finally, there are limitations in not measuring cardiovascular disease or hypertension, which may lead to longer hospital stays. However, as there is sufficient evidence that cardiovascular disease and hypertension are associated with age (22, 23), some of the effect of these problems on increased healthcare costs is included in the consideration of age. We recommend that future studies include the variables which may affect this association.

Despite these limitations, this study is a pioneer in the bone fragility field in Colombia, characterized by scant information on care costs and the factors which may complicate fracture recovery. The study findings propose new objectives and serve as a conceptual basis for fracture prevention and care programs already in place. A very important strength of this study is its sample size (452 people), which decreased the probability of random error.

We hope that future studies will be able to explore the costs in other sub-regions of the country or related to contexts like post-COVID-19. In this regard, this study was performed before the COVID-19 pandemic, and our data may serve as a basis for studies evaluating the effects that COVID-19 may have on the cost and complications of bone fragility fractures.

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