Air quality and incidence of osteoporotic hip fracture in Chile

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Summary

Objetive: Recent studies show an association between environmental pollution and the risk of suffering an osteoporotic fracture. This study aimed to determine if there is an association between environmental contamination with fine particulate matter ($PM_{2.5}$) and osteoporotic hip fracture.

Material and method: Retrospective incidence study. The Pearson correlation coefficient (r) was used to assess the correlation between the incidence rate of hospital discharges due to osteoporotic hip fracture in Chile and the annual average concentration of $PM_{2.5}$ in the Chilean Health Services in 2017.

Results: In 2017 there were 8,322 hip fractures in adults 65 years of age or older, with a rate per 100,000 inhabitants of 216 and 567 for men and women, respectively. No association was found between environmental contamination and hip fractures in women. Very weak direct association was found between the incidence rate of osteoporotic hip fracture in men and the annual concentration of $PM_{2.5}$ (r=0.074) by Health Services, being statistically not significant (p>0.05).

Conclusions: No statistically significant association was found between environmental pollution and the incidence rate of hospital discharges due to osteoporotic hip fractures in Chile.

Key words: environmental pollution, particulate matter, osteoporosis, hip.

INTRODUCTION

Environmental pollution has been associated with a variety of diseases. Among these conditions, cardiovascular[1] and respiratory[2] have been highlighted in the literature.

Air quality monitoring has preferably been oriented to particulate matter. These particles are mainly found in urban areas and come from thermal power plants, industrial processes, vehicle traffic, residential combustion of wood for heating, coal and industrial incinerators. Particulate matter (PM) is classified according to its diameter, depending on the intensity of its impact: particles of diameter less than 10 µg, known as PM_{10}, and diameters less than 2.5 µg, known as $PM_{2.5}$. The $PM_{2.5}$ particles, having a smaller diameter, penetrate into the pulmonary alveoli and enter directly into the bloodstream. This makes them the most harmful contaminant for health and the ones that generate higher levels of premature mortality in the population, ranking as the fifth mortality risk factor in 2015[3]. Exposure to higher concentrations of $PM_{2.5}$ caused 4.2 million deaths and 103 million lost healthy life years (AVISA) worldwide in 2015, representing 7, 6% of total deaths and 4.2% of AVISA[3]. Worldwide deaths attributable to $PM_{2.5}$ increased from 3.5 million in 1990 to 4.2 million in 2015[3].

Environmental pollution has been associated with a variety of diseases, especially those related to diseases of the skeletal muscle system, particulate matter is associated with oxidative damage and inflammation, which can accelerate bone loss and increase the risk of fractures in older adults Studies in Norway show a higher risk of developing osteoporosis and suffering an osteoporotic fracture in the population exposed to higher concentrations of $PM_{2.5}$[4,5]. Recent studies in the US show that for every 4.18 µg/m³ increase in $PM_{2.5}$ there is a 4.1% increase in hospital admissions for bone fractures in older adults. Low concentrations of parathyroid hormone in blood are associated with individuals who live in areas of higher $PM_{2.5}$ concentration[6].

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In Chile, $PM_{2.5}$ and other air quality variables are measured daily at air quality monitoring stations. In 2017, of the 31 monitoring stations with population representativeness (representing more than 10 million inhabitants of the 17.5 million inhabitants in Chile), 22 of them (69% of the total) presented concentrations above the value of the annual primary standard for $PM_{2.5}$ (20 µg/m³)[7]. That same year, more than 8 million inhabitants of Chile (figures close to 50% of the population) were exposed to average concentrations of $PM_{2.5}$ higher than the norm. In Chile's central zone, where there are more than 7 million inhabitants, the average concentrations of $PM_{2.5}$ reach 29 µg/m³. Toward southern Chile, the concentrations increase considerably. The city of Coyhaique, which has about 61 thousand inhabitants, is the most polluted city in Latin America, exposed to the highest average $PM_{2.5}$ concentrations (57 µg/m³)[7].

The only study in Latin America that evaluates the association between air pollution and osteoporosis was carried out in Chile, analyzing the association between hospital discharges from 2005 to 2011 and the particulate matter. No statistically significant association was found between air pollution and the average annual incidence of osteoporotic hip fracture in Chile. However, data from some cities were used and not data corresponding to the Chilean Health Services, so a large number of hospital discharges were left out of the study[8].

The aim of this study was to determine if there is an association between air pollution and osteoporotic hip fracture in the Chilean population.

MATERIAL AND METHOD

A retrospective incidence study was conducted.

The National Health Services System (NHSS) of Chile has 29 territorial Health Services (HS) that encoPMass defined geographical territories.

The Ministry of Health's Department of Health Statistics and Information (DHSI) 2017 records were used, from which the amount of osteoporotic hip fractures was obtained for each Chilean HS. The hip fractures correspond to the S72 code of the ICD-10 (tenth edition of the International Classification of Diseases), and hip fractures corresponding to adults 65 years of age or older were used, as these are attributed to osteoporosis.

From the records of the National Institute of Statistics (NIS), the data of the population of 65 years and over by HS were obtained in 2017. The HS data of the number of inhabitants of 65 years or more were used and the number of hip fractures in adults 65 years of age or older by HS to calculate the incidence of osteoporotic hip fracture in each HS.

Data from the National Air Quality Information System (SINCA) were used to obtain the annual average concentration of $PM_{2.5}$ (in µg/m³) in each SS. Because not all health services have $PM_{2.5}$ monitoring stations or do not have validated records for 2017, 8 of the 29 HS of Chile were excluded, which means approximately 3 million of the country's inhabitants (17% of the total Chilean population).

With the statistical package SPSS 21.0, Pearson's correlation coefficient was measured (test used to measure the degree of relationship of two linearly related quantitative variables) to assess the association between the annual incidence of osteoporotic hip fracture by HS and the annual average of concentration of $PM_{2.5}$ per HS in 21 of the 29 Chilean HS (representing approximately 14.5 of the 17.5 million inhabitants of the country, 83% of this). A 95% confidence level was used, so the results with $p<0.05$ are considered significant. When interpreting the level of correlation, a value $r=1$, a very strong correlation $1>r>0.8$, a strong correlation with $0.8>r>0.6$, a moderate correlation with 0, is considered a perfect correlation. $6>r>0.4$, a weak correlation with r $0.4>r>0.2$, a very weak correlation with $0.2>r>0$, and a null correlation with $r=0$.

The study has its limitations. It is retrospective and does not assess the health habits of the population evaluated. However, by including most of the HS in Chile, it uses a large part of the population and by including only the 2017 data, it does not present the bias of including population that changed direction in the evaluated years.

RESULTS

In 2017, 8,322 osteoporotic hip fractures occurred in Chile for an estimated population of 17.5 million, according to the 2017 Census. The national incidence rate of osteoporotic hip fractures was 415.4 per 100,000 adults of 65 or older, being lower for men (215.9 per 100,000 men 65 or older) and higher for women (566.8 per 100,000 women 65 or older). The HS with the highest incidence of osteoporotic hip fractures is the HS of Iquique and Tarapacá, while the HS with the lowest incidence is the Eastern Metropolitan Area (Table 1).

In terms of air quality, this was evaluated with annual concentrations of $PM_{2.5}$ in each HS. The annual primary standard for $PM_{2.5}$ is 20 µg/m³. Of the 21 HS evaluated, 12 were exposed to average annual concentrations above the norm. The Aysén HS, with approximately 110,000 inhabitants, is the HS exposed to the highest annual average concentrations of $PM_{2.5}$ (48.3 µg/m³); while the Magallanes HS, with approximately 161,000 inhabitants, is the HS with the lowest annual average concentrations of $PM_{2.5}$ (5.4 µg/m³) (Figure 1).

Regarding the association between the annual average concentration of $PM_{2.5}$ and annual incidence rate of osteoporotic hip fractures by HS, analyzing in men, women and in both sexes, no association was found between the variables, since the coefficient Pearson's correlation (r) is very weak $0.2>r>0$ (Table 2). In the dispersion diagram for the incidence of osteoporotic hip fracture due to HS based on the average annual concentration of $PM_{2.5}$, the low attributable relationship between both variables can be seen, since both the HS with the lowest annual concentration $PM_{2.5}$ (Magallanes HS: 5.4 µg/m³) as the HS with the highest concentration of $PM_{2.5}$ (Aisen HS: 48 µg/m³) had similar osteoporotic fracture incidence rates, 325 per 100,000 inhabitants aged 65 or over in Magallanes HS compared to 398 of Aysén HS (Figure 2).
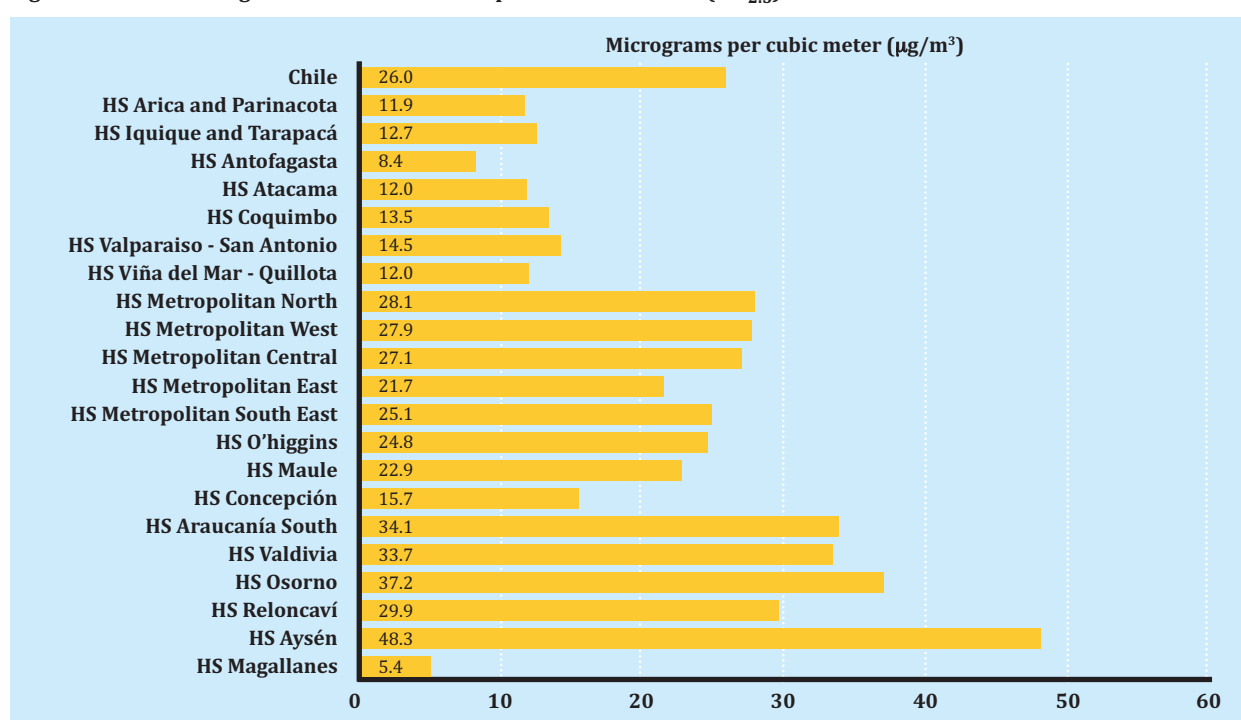
DISCUSSION

This is the first study that evaluates the link between air pollution and incidence of osteoporotic hip fracture in the Chilean HS, since it could cover most of the country's population, unlike a previous study in which only environmental pollution was evaluated in the main cities of Chile[8].

In our analysis of more than 8,000 hospital discharges during 2017 due to osteoporotic hip fractures in Chile, we found a very weak direct association between the incidence rate of HS in men with air pollution by fine particulate matter and that did not present statistical significance.

Table 1. Annual average of concentrations of fine particulate material PM$_{2.5}$ and incidence of hip fractures in adults 65 years of age or older in each Health Service (HS) during 2017

|	Annual average of concentrations of (MP$_{2,5}$) in µg/m³	Incidence of fractures per 100,000 inhabitants aged ≥65 years	Incidence of fractures per 100,000 men aged ≥65 years	Incidence of fractures per 100,000 women aged ≥65 years
Chile	26.0	415.4	215.9	566.8
HS Arica and Parinacota	11.9	349.9	182.5	484.7
HS Iquique and Tarapacá	12.7	608.7	306.4	863.7
HS Antofagasta	8.4	374.1	202.6	505.8
HS Atacama	12.0	430.5	224.1	606.5
HS Coquimbo	13.5	559.5	258.0	802.0
HS Valparaíso - San Antonio	14.5	399.4	235.9	520.9
HS Viña Del Mar - Quillota	12.0	375.7	168.3	525.5
HS Metropolitan North	28.1	399.7	220.6	528.0
HS Metropolitan West	27.9	406.7	210.3	556.1
HS Metropolitan Central	27.1	339.5	155.3	462.7
HS Metropolitan East	21.7	201.6	94.3	269.4
HS Metropolitan South East	25.1	348.4	194.9	458.6
HS O'higgins	24.8	371.8	199.7	521.0
HS Maule	22.9	410.7	157.9	483.7
HS Concepción	15.7	373.3	200.7	488.9
HS Araucanía South	34.1	423.3	253.0	557.9
HS Valdivia	33.7	431.6	245.7	580.9
HS Osorno	37.2	368.2	183.7	511.6
HS Reloncaví	29.9	310.6	173.6	425.9
HS Aysén	48.3	398.3	244.1	543.5
HS Magallanes	5.4	325.1	171.0	452.5

Figure 1. Annual average concentrations of fine particulate material (PM$_{2.5}$) in the Health Services of Chile in 2017

Microgramos per cubic meter (µg/m³)

Chile	26.0
HS Arica and Parinacota	11.9
HS Iquique and Tarapacá	12.7
HS Antofagasta	8.4
HS Atacama	12.0
HS Coquimbo	13.5
HS Valparaiso - San Antonio	14.5
HS Viña del Mar - Quillota	12.0
HS Metropolitan North	28.1
HS Metropolitan West	27.9
HS Metropolitan Central	27.1
HS Metropolitan East	21.7
HS Metropolitan South East	25.1
HS O'higgins	24.8
HS Maule	22.9
HS Concepción	15.7
HS Araucanía South	34.1
HS Valdivia	33.7
HS Osorno	37.2
HS Reloncaví	29.9
HS Aysén	48.3
HS Magallanes	5.4

Table 2. Pearson correlation coefficient (r) between the incidence of osteoporotic hip fracture and annual concentration of PM$_{2.5}$ by Health Service, according to gender

	Both genders	Mens	Women
Annual average of concentrations of MP$_{2,5}$	-0.114 (p>0.05)	0.074 (p>0.05)	-0.148 (p>0.05)

Figure 2. Scatter plot of incidence of total osteoporotic hip fractures by Health Service and annual average concentration of PM$_{2.5}$ in each of them
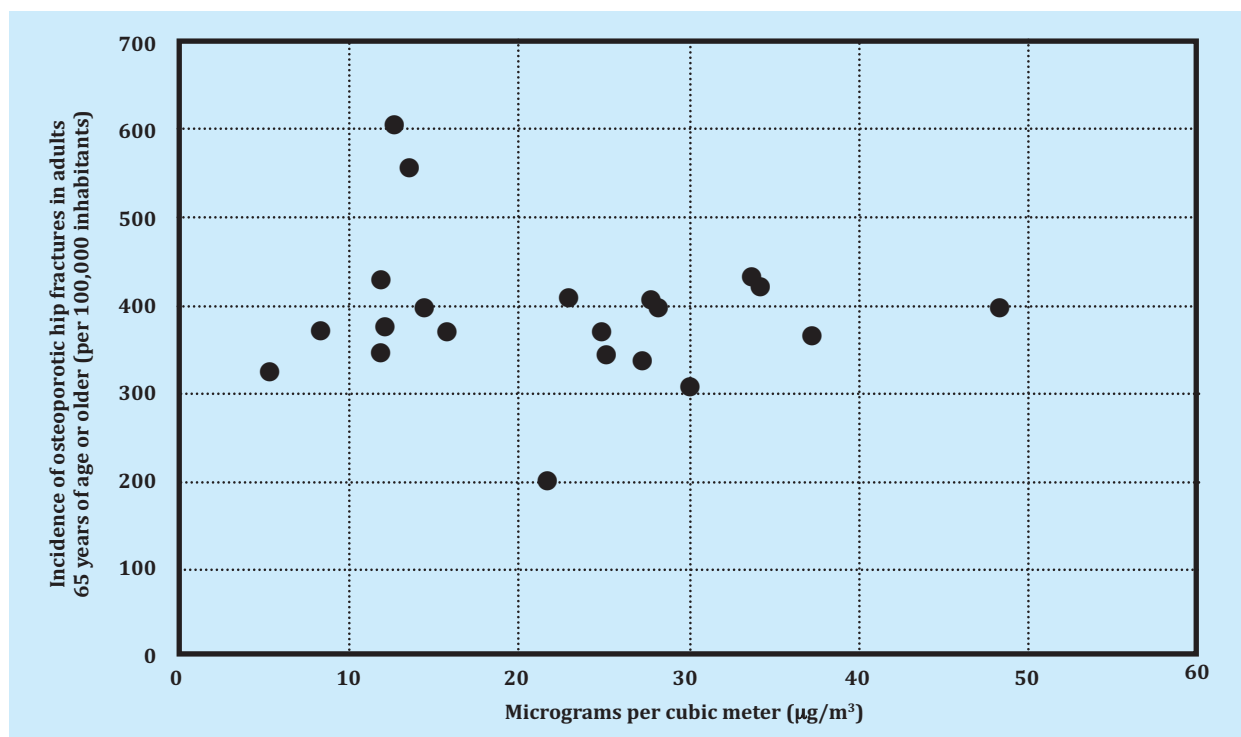
Diddier Prada et al. found an association between prolonged exposure to PM$_{2.5}$ and excessive loss of longitudinal bone. They also found that the population of areas with a higher concentration of PM$_{2.5}$ have a higher risk of suffering an osteoporotic fracture[6].

In 2 studies conducted in Oslo (Norway), a direct and statistically significant association was found between environmental contamination, total bone mineral density (BMD)[4] and forearm fracture[5]. However, given that the part of the population that suffers osteoporotic hip fractures may have a normal BMD or in the range of osteopenia, for our study we decided to evaluate the osteoporotic hip fracture instead of BMD.

A study in Taiwan found lower BMD values at higher concentrations of environmental pollutants[9], with a low relative risk, but which is important given that a large part of the world's population is exposed to polluted air. In this work, the lower BMD was associated with the impact of environmental pollutants at bone level, since bone is a lifetime reserve for heavy metals. Lead and other toxic metals such as cadmium, mercury and aluminum form bonds with the calcium of hydroxyapatite, resulting in a biological waste for life, since more than 90% of the lead in the human body is found in the bones and on the teeth[10].

In conclusion, in our retrospective analysis of more than 8,000 hospital discharges of 2017 due to osteoporotic hip fractures in Chile, we found no association between the incidence rate of HS with air pollution, represented by the annual average concentration of PM$_{2.5}$.

▶▶ **Conflict of interests:** The authors declare no conflict of interest.

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