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Prostate Cancer Mortality rates in Peru and its geographic regions

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ABSTRACT

Background

Prostate cancer is the fifth most prevalent cause of cancer death in men worldwide. A recent report described the mortality rates for prostate cancer in Peru, but a comprehensive evaluation of variations in prostate cancer epidemiology by geographic areas has not been performed, yet. Our aim is to evaluate the mortality rates of prostate cancer, according to geographical areas in Peru, between 2005 and 2014.

Methods

Information was extracted from the Deceased Registry of the Peruvian Ministry of Health. We analysed age-standardized mortality rates (world population) per 100,000 men. Spatial autocorrelation was determined according to the Moran Index. In addition, we used Cluster Map to explore relations between departments.

Results

Mortality rates increased from 20.9 (2005-2009) to 24.1 (2010-2014) per 100,000 men, an increase of 15.2%. According to regions, during the period 2010-2014, the coast had the highest mortality rate (28.9/100,000) while the rainforest had the lowest (7.43/100,000). In addition, there was an increase in mortality in the coast and a decline in the rainforest over the period 2005-2014. The departments with the highest mortality were Piura, Lambayeque, La Libertad, Callao, Lima, Ica, and Arequipa. Moreover, these departments (except Arequipa) showed increasing trends during the years under study. The departments with the lowest observed prostate cancer mortality rates were Loreto, Ucayali, and Madre de Dios. This study showed positive spatial autocorrelation (Moran's I: 0.30, p=0.01).

Conclusion

Mortality rates from prostate cancer in Peru continue to increase. These rates are higher in the coastal region compared to those from the highlands or rainforest.

Keywords: Prostatic neoplasms, Spatial clustering, Mortality, Peru.

BACKGROUND

Prostate cancer is the second most frequently diagnosed neoplasm in men and the fifth cause of cancer death worldwide [1-3]. In 2012, it represented 15% of all new cases of cancer diagnosed in men [1]; and in 2013, it caused 4.8 million disability-adjusted life-years (DALYs) worldwide, of which 43% were in low- and middle-income countries (LMICs) [4].

For most LMICs, data collection related to incidence and mortality of prostate cancer has limited validity [5]. In order to understand these patterns in Latin America, we conducted a literature search [6] regarding prostate cancer in the region. Between 2005 and 2009, mortality rates for Cuba were of 23.6 per 100,000 men and, between 2007 and 2009, Uruguay and Venezuela reported more than 18 deaths per 100,000 men. Overall, Latin America prostate cancer mortality at all ages has trended to increase [7].

In Peru, the incidence rates for prostate cancer were high in specific areas (Lima and Arequipa with 48.4 and 32.1 per 100,000 population, respectively) [8]. Moreover, for Metropolitan Lima, it was reported that the age-standardised mortality rate (ASMR) for prostate cancer increased from 11.4 (2004-2005) to 15.7 (2010-2012) per 100,000 population [9,10]. There are still no recent epidemiological studies focusing solely on prostate cancer in Peru and analysing it by regions.

The objective of this study is to provide the first epidemiological evidence regarding the mortality rates from prostate cancer in Peruvian men between 2005 to 2014, according to geographical location.

METHODS

Design and study setting

We conducted a secondary data analysis on the Peruvian Ministry of Health's database regarding prostate cancer deaths (code C61 according to the International Classification of Diseases, 10th revision) [11] between 2005–2014.

These registries are based on the reports from hospitals that are distributed throughout the country and most of which are part of the health network of the Ministry of Health. Although they do not include information from other sources (such as social security insurance or private insurances), they collect information on cancers in all departments from the main provider of healthcare service (70%) [12]. The cancer reporting system is limited by the scarcity of staff in public hospitals, high staff turnover, and the lack of supervision of data quality. These factors yield problems in data accuracy and completeness. For this reason, the calculation was made taking in consideration an underreporting of 40% estimated by the Peruvian Ministry of Health [13].

Peru is composed by 25 departments, distributed in three geographical regions: coast, highlands, and rainforest [14,15]. The coast has experienced significant and unplanned population growth in urbanised areas in low-altitude settings; the highlands are a high-altitude area, with both urban and rural population; and the rainforest is located throughout the Peruvian Amazon [14,15] **(Figure 1).**

Figure 1: Peru geographical zones by department. The asterisk denotes the department of Callao.

Source: National Statistics Institute [16].

Statistical and spatial analysis

We used the number of prostate cancer deaths and population data to calculate the age-standardized rates mortality (ASMR).

We calculated region specific mortality rates for each 5-year age group and calendar period and derived ASMR by the direct method, using the world standard population [17]. We estimated mortality rates per 100,000 men. As the denominator, we used the population in five-year age groups, provided by the National Statistics Institute [16]. We used the software R 3.4.1 [18] for the statistical analysis.

We used the GeoDA software package for the spatial analysis [19]. We mapped the spatial distribution of prostate cancer mortality rates to determine if geographic groups were evident. The spatial analysis was performed using Moran's I statistic. The map results in a spatial typology consisting of five categories of health regions: (i) 'high–high' (positive autocorrelation), (ii) 'low–high' (negative autocorrelation), (iii) 'low–low' (positive autocorrelation), (iv) 'high–low' (negative spatial autocorrelation), and (v) 'not significant' indicated that there was no spatial autocorrelation. The value of the Moran index varies between -1 and $+1$, where negative values indicate a spatial conglomerate of territorial units with different values of analysis and positive values indicate a spatial conglomerate of territorial units with similar values of analysis. We used a reference distribution using 999 random permutations to indicate statistical significance.

RESULTS

The number of prostate cancer deaths in Peru during this period (2005-2014) was 13,522. Mortality rates from prostate cancer in Peru increased from 20.9 to 24.1 per 100,000 men between 2005-2009 and 2010-2014. This translates to a 15.2% increase (**Table 1**). Analysing by regions, the coastal region had the highest mortality with a range of 22.3-29.0/100,000 men when compared to the regions of the highlands (11.8-17.1/100,000 men)

and rainforest (4.0-11.6/100,000 men) (**Figure 2)**. Prostate cancer mortality rates increased by 16%, and 15.6%. in the coastal region and the highlands region respectively. In contrast, the mortality rates for the rainforest region decreased18.7%. (**Table 1).**

The departments with the highest mortality were Piura, Lambayeque, La Libertad, Callao, Lima, Ica, and Arequipa (**Figure 3)**. Of these, only Arequipa showed a decline of 22% in its mortality rate. Conversely, the other departments showed increasing trends: Piura (25.86 to 32.82/100,000 men with a percentage increase of 18.8%), Lambayeque (31.33 to 41.76/100,000 men with a percentage increase of 11.6%), La Libertad (27.71 to 34.07/100,000 men with a percentage increase of 18.3%), Callao (19.70 to 40.11/100,000 men with a percentage increase of 22.1%), Lima (22.62 to 28.82/100,000 men a with a percentage increase of 22.5%), and Ica (33.52 to 36.47/100,000 men with a percentage increase of 24.1%). The departments in the rainforest showed large increases in trends, mainly in Madre de Dios (2.18 to 17.74/100,000 men with a percentage increase of 182%) and Pasco (8.43 to 27.40/100,000 men with a percentage increase of 129.5%) **(Table 1 and Figure 4)**.

Concerning the spatial analysis and clustering, the mortality rates from 2005 to 2014 showed a positive spatial autocorrelation and significant clustering (Moran's I: 0.30, p=0.01). The departments with the lowest observed prostate cancer mortality rates were located in the Peruvian North-East (Loreto, Ucayali, and Madre de Dios) as shown in **Figure 5**.

Table 1. Age-standardized (world population) mortality rates per 100,000 men from prostate cancer at all ages in Peruvian geographic areas around 2005-2009 and 2010-2014, and corresponding change in rates.

	2005-2009	2010-2014	% change (2014-2010/2005-2009)
Peru	20.89	24.07	15.2
Coast	24.96	28.94	16.0
Highlands	13.73	15.87	15.6
Rainforest	9.14	7.43	-18.7
Amazonas	6.18	6.45	4.42
Ancash	13.13	17.47	33.1
Apurimac	10.40	13.36	28.5
Arequipa	29.49	23.01	-22.0
Ayacucho	11.97	14.39	20.3
Cajamarca	14.68	15.42	5.0
Callao	29.31	35.77	22.1
Cusco	10.42	6.83	-34.5
Huancavelica	11.78	21.53	82.8
Huanuco	20.50	27.27	33.0
Ica	26.95	33.46	24.1
Junin	15.89	19.06	19.9
La Libertad	25.82	30.53	18.3
Lambayeque	30.48	34.02	11.6
Lima	23.92	29.29	22.5
Loreto	7.30	3.42	-53.1
Madre de Dios	7.97	22.47	182.0
Moquegua	22.13	16.57	-25.1
Pasco	8.85	20.31	129.5
Piura	27.56	32.75	18.8
Puno	13.56	15.08	11.3
San Martin	10.10	8.97	-11.3
Tacna	16.72	21.67	29.7
Tumbes	26.52	17.05	-35.7
Ucayali	14.20	10.28	-27.7

Figure 2. Age-standardised mortality rates (per 100 000 men) for prostate cancer in Peru and its regions from 2005 to 2014.

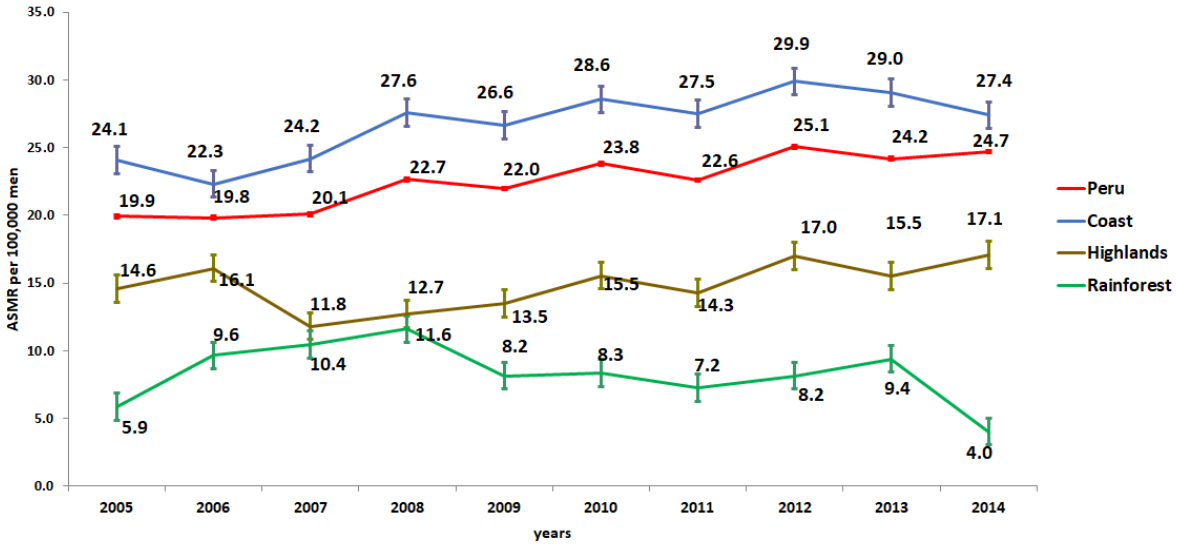


Figure 3. Age-standardised mortality rates (per 100 000 men) for prostate cancer by departments in Peru from 2005 to 2014.

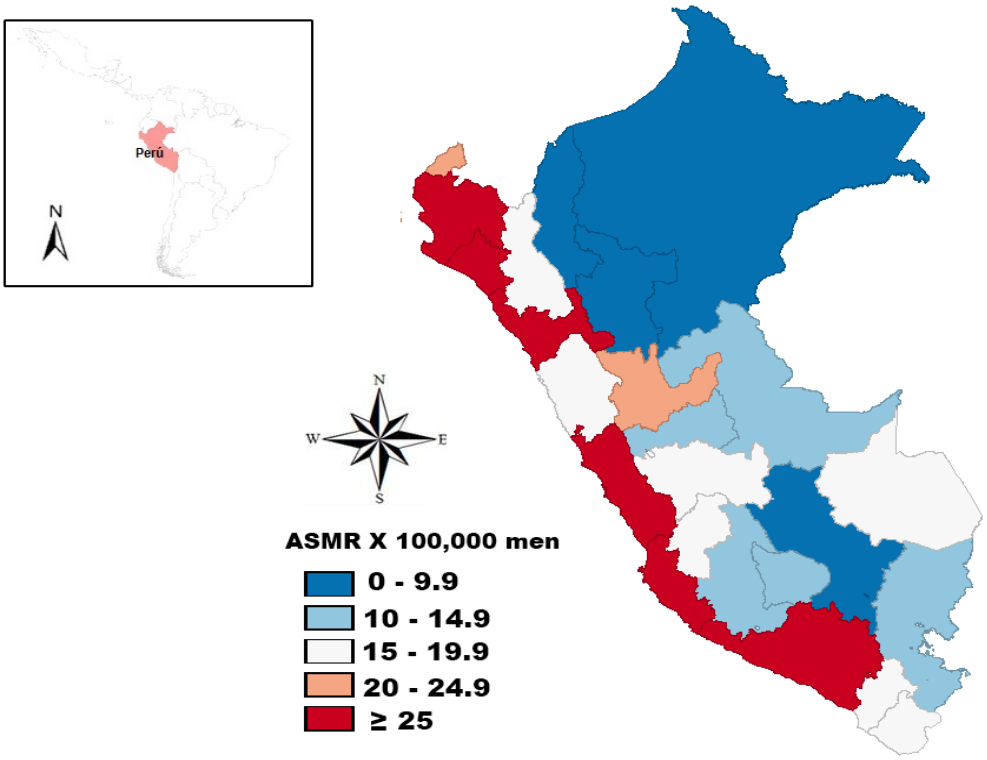


Figure 4. Trends of age-standardized (world population) mortality rates per 100,000 men from prostate cancer in all departments of Peru.

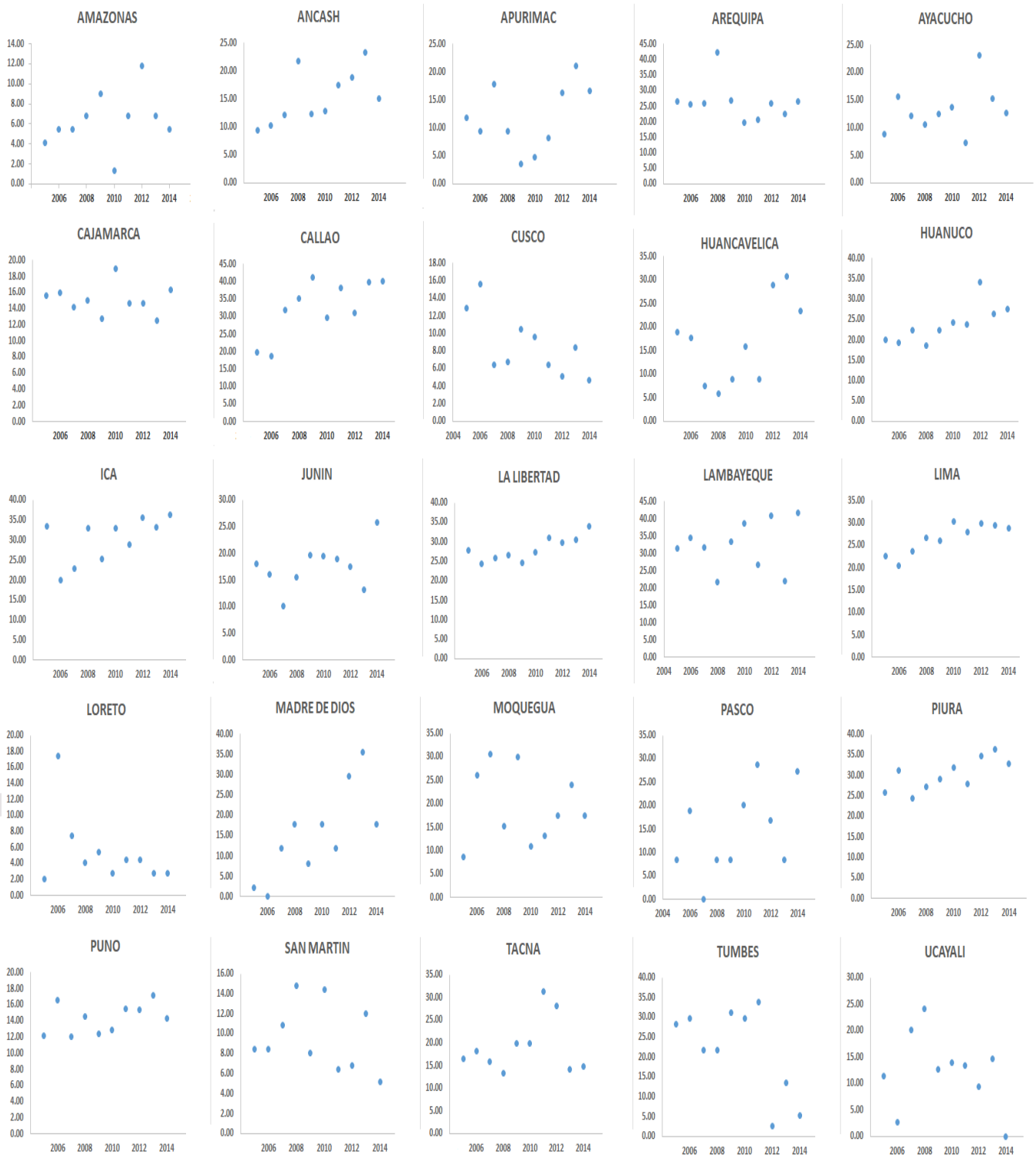
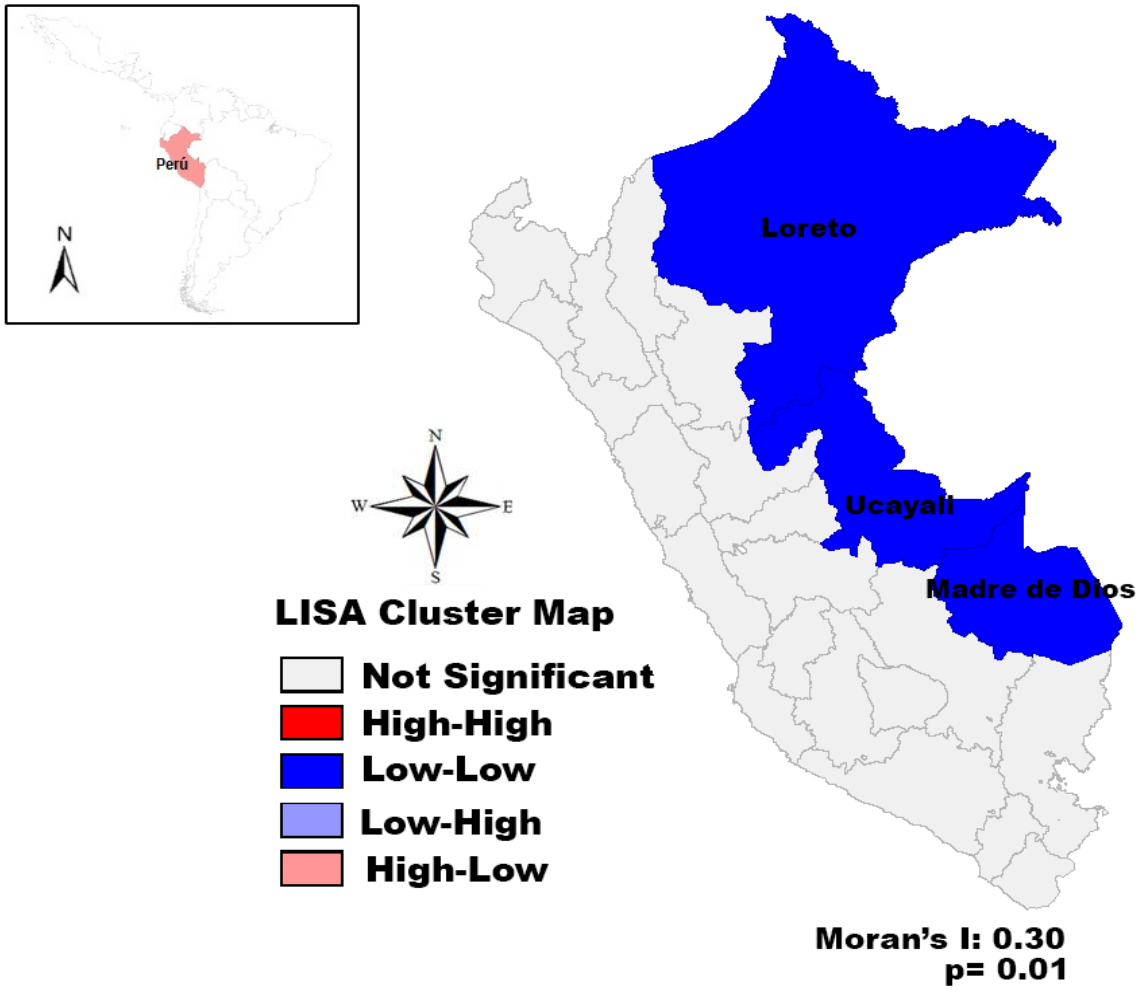


Figure 5. Spatial cluster map of prostate cancer mortality rates for the period 2005-2014.

Bottom graphs show the results of local cluster analysis: p-values and the corresponding set of significant outliers and clusters for a <0.05 significance level.



DISCUSSION

Mortality rates from prostate cancer in Peru continue to increase. We calculated, between 2005-2014, an average rate of 22.5/100,000 men and a percent increase of 15.2%. A study by Sierra *et al*. [3], indicated that the mortality rate of prostate cancer was one of the two leading causes of cancer deaths in males in Central and South America, except in Chile, Argentina, Colombia, and El Salvador where it ranked third. In Belize (between 2003-2007), the highest rate reached 28.9 per 100,000 men; in Uruguay (between 2005-2007) it was of 21.8; and in Cuba (between 2004-2007) it was 24.1 per 100,000 men. The lowest rates were in Peru (between 2001-2005), Nicaragua (between 2003-2007), and El Salvador (between 1999-2003) with a range of 6.8-9.7 deaths per 100,000 men.

According to the National Household Survey, approximately 30% of the Peruvian population still does not have ~~a~~ health insurance [20,21]. The Peruvian health system is poorly organized with many disparities existing between healthcare providers' system [12], Preventive health policies have not been properly adopted by the Ministry of Health (there is no national screening program digital rectal examination and prostate-specific antigen levels for prostate cancer) [22].

According to regions, the highest mortality rates were observed in the coastal region (mainly in the departments of Piura, Lambayeque, La Libertad, Callao, Lima, Ica, and Arequipa) when compared to the highlands and the rainforest. This could be related to deficient reporting systems in the highlands and rainforest, as these areas are less developed with less accessible healthcare in these areas; However, the rates for both regions follow an ascending (highlands) and descending (rainforest) pattern over the years. Another explanation could be ethnic and racial differences, age, and overweight/obesity status in the coastal region. Regarding race, black men show a higher prostate cancer mortality rate [23] even adjusting with other cofactors like education and income levels [24,25]. Even though Peru has a high degree of racial mixing, the coastal region has a strong African influence

[26] that may explain those high rates. In addition, the risk of prostate cancer also increases with age [27,28], and more than 70% of men have histologic evidence of prostate cancer by the time they are 80 years old [17]. Currently, elderly adults represent 10% of the Peruvian population [18] and there is a larger proportion of men above 65 years of age in the coastal region (9%) compared to the other two regions (the highlands and the rainforest with around 7%) [10]. Another risk factor is overweight/obesity [27,29], which is associated with an increased risk of mortality and recurrence from prostate cancer [30]. Since the coastal region shows the highest obesity rates in adults [31] and children [15], this could also explain their higher mortality rate.

The coastal region has the main centres in oncology and the largest number of oncology-trained professionals, mainly in the department of Lima [8], including new cancer centres in the departments of La Libertad and Arequipa, which aim to help in the decentralization of cancer care [32]. However, this is not sufficient as most patients are diagnosed with advanced stages, leading to a poor prognosis [22,23]. Moreover, this region is considered the most densely populated with more than a third of the Peruvian population [34] and with the highest national Human Development Index (HDI) [35]. The latter demonstrates a directly proportional relationship with the burden of prostate cancer [36].

Regarding spatial analysis and clustering, the departments in north-eastern Peru (Loreto, Ucayali, and Madre de Dios) showed significantly lower mortality rates compared to their neighbouring departments. However, some departments, as Madre de Dios, have increased their mortality in the last years.

Due to the lack of adequate services for the diagnosis and treatment of cancer, Peru is currently in the process of creating new cancer centres in the coast region and rainforest [32,37], in addition to establishing oncology units in general hospitals. The goal is to decrease the mortality from prostate cancer and other neoplasms among Peruvians in the future. However, we would like to recommend the addition of more professionals trained in

oncology, especially in the regions of the highlands and rainforest. Additionally, a comprehensive approach is needed to reduce the disparities in access to cancer care as well as the modification of the risk factors related to mortality for prostate cancer.

This study has limitations related to the use of secondary sources of information, including the possibility of having incorrect or incomplete data. Likewise, the data obtained and analysed in the present study did not allow us to compare by ethnicity or socioeconomic status, which would have provided a clearer overview about the risk from prostate cancer in Peruvian men. Nevertheless, this is the first effort to contribute to the literature on geographical differences in prostate cancer mortality in Peru. This information should help in the creation of health policies aimed at the population at risk and in the improvement of data collection systems.

In conclusion, mortality rates from prostate cancer in Peru are still increasing. The mortality rates were higher in the coastal region. Conversely, they were lower in the highlands and rainforest. These related geographical differences in mortality could be a reflection of race/genetics and other well-established and modifiable risk factors, including obesity, the lack of a decentralized health system and disparities in access to cancer care and incomplete reporting between regions. They may also reflect different validity of diagnosis and registration, which are difficult to evaluate, but are unlikely to totally explain the observed large variation in mortality rates.

List of abbreviations

DALYs: disability-adjusted life-years

LMICs: Low- and middle-income countries

HDI: Human Development Index

ASMR: Age-standardized mortality rate

Declarations

Ethics approval and consent to participate

Ethical approval and consent of the participant were not necessary since this study involved the use of a previously published secondary database.

Consent for publication

Not applicable

Competing interests

The author(s) declare that they have no competing interests.

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Authors' contributions

JST, JSG conceived the research idea and collected the data. JST, JFM, EFR, LT perform the first version of the manuscript. All authors designed the study. JST, SFM performed the statistical and spatial analyses. MRP, JMP, and CLV provided the critical review of the manuscript. All authors drafted the manuscript and approved the final version.

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