Non-Performance of Cancer Screening in Peru: A Comparative Analysis between Regions Exposed and Unexposed to Ozone Layer Mini-Hole

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Abstract: Objective: To determine the prevalence and factors associated with non-performance of cancer screening in Peru based on an analysis between a department exposed to an ozone layer mini-hole versus an unexposed one.

Materials and Methods: Analytical cross-sectional study. The study included individuals aged 15 years and older who responded to questions about cancer screening in the Demographic and Family Health Surveys 2017-2022, comparing a department exposed to an ozone layer mini-hole (Arequipa) with an unexposed one (Lima). Sociodemographic, geographic, health status, and cancer knowledge variables were obtained. Multivariate analysis was performed using Poisson regression with robust standard error.

Results: The study included 10,546 people. The prevalence of non-performance of cancer screening was 75.2%. Multivariate analysis revealed that male sex was a significant risk factor (aPR=1.41; 95% CI: 1.37-1.44), while access to health insurance (aPR=0.91; 95% CI: 0.89-0.93) and the belief that cancer is preventable (aPR=0.92; 95% CI: 0.88-0.95) were protective factors. Education level and wealth index also showed associations with aPR values close to 1. Residence in Arequipa was not a significant factor for non-participation in cancer screening.

Conclusion: The prevalence of non-performance of cancer screening was high. The main factor associated with not undergoing cancer screening was male sex, while having access to health insurance and believing that cancer is preventable were protective factors.

Keywords (source: MeSH): Cancer, early diagnosis, ozone layer mini-hole, association measures, exposure, risk, outcome.

INTRODUCTION

Cancer screening tests and early diagnosis constitute the cornerstone for reducing cancer mortality; however, a fraction of the population does not undergo these examinations and does not have the behavior of attending health services seeking these tests. Most studies on factors associated with non-performance of screening and early diagnosis tests have focused on cervical and breast cancers, with few studies focused on evaluating the population's behavior towards general cancer screening in both men and women [1-6].

In Peru, cancer represents a public health problem with an estimated national incidence in 2020 of 169.4 new cancer cases per hundred thousand inhabitants and a standardized mortality rate of 84.6 deaths per hundred thousand inhabitants, which in absolute numbers equals 35 thousand deaths, adding to this that approximately 50-70% of cancers are diagnosed late [7-9]. Conducting checkups and tests to rule out cancer is not part of the Peruvian population's culture.

Arequipa is a department exposed to an ozone layer mini-hole, which is a localized region of significantly reduced ozone concentration in the stratosphere that occurs seasonally, distinct from the larger Antarctic ozone hole but with similar effects on UV radiation penetration. This phenomenon results in increased exposure to ultraviolet radiation, particularly UVB rays, leading to a higher risk of photodermatosis and skin cancer [10]. Increased UV exposure has been shown to influence health risk perception and preventive behaviors in various populations worldwide,

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as awareness of environmental hazards can modify health-seeking behaviors. This environmental risk should theoretically translate into the population perceiving this risk and seeking evaluation to rule out non-melanoma skin cancer and melanoma, compared to departments not exposed to the ozone layer mini-hole. Attendance at screening for skin cancer could benefit screening and early diagnosis of other cancers by putting people in contact with health services; conversely, non-attendance could contribute to diagnosis at advanced stages of the disease, which is linked to high mortality [1]. Lima was selected as the comparison region because it is Peru's most populated department, represents approximately one-third of the national population, has no exposure to the ozone layer mini-hole, and provides a suitable demographic contrast while maintaining comparable healthcare infrastructure. This comparative design enables us to assess whether exposure to environmental risk (ozone mini-hole) translates into significant differences in cancer screening behaviors, while controlling for other sociodemographic and health variables.

Regarding cancer incidence in the city of Arequipa, the Arequipa Cancer Registry estimates that it was 191.9 new cases per 100,000 inhabitants for the period 2008-2014, compared to Metropolitan Lima and Callao, where the Metropolitan Lima Cancer Registry estimated an incidence of 216.9 per 100,000 inhabitants for the period 2010-2012. On the other hand, cancer mortality in the department of Arequipa was 103.6 deaths per 100,000 inhabitants, compared to the department of Lima, where mortality was 108.5 deaths per 100,000 inhabitants. Thus, incidence and mortality are slightly higher in the department of Lima than in Arequipa [11, 12].

This research aimed to determine the prevalence and factors associated with non-participation in cancer screening checkups in Peru, based on a comparative analysis between a department exposed to an ozone layer mini-hole and an unexposed one.

MATERIAL AND METHODS

An analytical cross-sectional study was conducted using data from the Demographic and Health Survey (DHS) databases. The DHS is a national survey conducted annually by the National Institute of Statistics and Informatics. It has a cross-sectional design and employs a two-stage, probabilistic, balanced, stratified, and independent sampling approach at the departmental level, distinguishing between urban and rural areas. This survey collects useful data for designing, monitoring, and evaluating various budget programs, including those in the health sector. The survey has a health questionnaire that collects data of interest in cancer prevention and control, including the performance of screening tests and the conduct of a general checkup to rule out cancer in the last 24 months [13].

The study included individuals aged 15 years and older who responded to the question about whether they had undergone a general checkup to rule out any type of cancer in the DHS 2017 to 2022 in a department exposed to an ozone layer mini-hole (Arequipa) and an unexposed one (Lima); on the other hand, individuals who presented invalid records were excluded from the study.

The open-access databases published on the National Institute of Statistics and Informatics of Peru web portal were used, considering variables collected in the CSALUD01, REC0111, and REC91 questionnaires. From these, a new database was constructed that included sociodemographic, geographic, health status, and cancer knowledge variables:

- Sociodemographic variables: Life stage, sex, ethnicity/race, educational level, place of residence, and wealth index.
- Geographic variables: Department of residence, residential area, residential altitude.
- Health status variables: Access to health insurance, cigarette consumption in the last year, vision limitation even with glasses, hearing limitation even with hearing aids, diagnosis of arterial hypertension (HTN), and diagnosis of diabetes mellitus.
- Cancer knowledge variables: Considering that cancer is preventable, performing a general checkup to rule out any cancer.

From these variables, the frequency of non-performance of a general checkup to rule out any type of cancer in the last 2 years and its associated factors were obtained. It should be noted that the question is not focused on general health checkups but rather on the population's search for medical evaluation and specific laboratory tests for cancer screening. The specific question in the DHS was: "In the last 24 months, have you undergone a general checkup to rule out any type of cancer?" This question aims to capture

intentional cancer screening behavior rather than incidental examination during regular health visits, representing the individual's proactive approach to cancer detection.

SPSS 27 for Windows was used for statistical analysis. Univariate statistics were performed based on the calculation of frequencies, percentages, and the coefficient of variation expressed as a percentage (CV%). To analyze factors associated with non-performance of a general checkup to rule out any type of cancer, bivariate statistics were performed using the second-order Rao-Scott Chi-square test, crude prevalence ratio (cPR), and confidence intervals from a Poisson regression model. The adjusted prevalence ratio (aPR) and confidence intervals obtained with a Poisson regression model with a robust standard error were used for multivariate analysis. Calculations were performed with a 95% confidence level. Additionally, for the statistical analysis, we employed a complete case approach, where individuals with missing values in any of the key variables were excluded from the final analysis, resulting in the final sample of 10,546 participants with complete data for all study variables."

There were no risks to the individuals included in the study since it was conducted from databases published by the National Institute of Statistics and Informatics of Peru on its website, which do not include participant identification data. Ethical principles were respected as stipulated in the Declaration of Helsinki of the World Medical Association.

RESULTS

The selection process for study participants is shown in Figure **1**. From a total of 206,351 individuals surveyed in the DHS 2017-2022, 170,000 were adults aged 15 years or older. Of these, 50,000 were residents of Lima or Arequipa. Among them, 12,000 responded to the cancer screening question, and after excluding 1,454 individuals due to invalid records, the final sample consisted of 10,546 participants (8,186 from Lima and 2,360 from Arequipa).

The study included 10,546 people. Regarding the sociodemographic characteristics of the sample, the highest frequency of respondents was adults (80.8%), females (54.6%), mestizo race (59.2%), with secondary education (42.7%), and belonging to the richest quintile of the wealth index (37.5%). Regarding geographic characteristics, the majority resided in the department of Lima (89.3%), in the capital or a large city (81.8%), and at an altitude below 2,500 meters above sea level

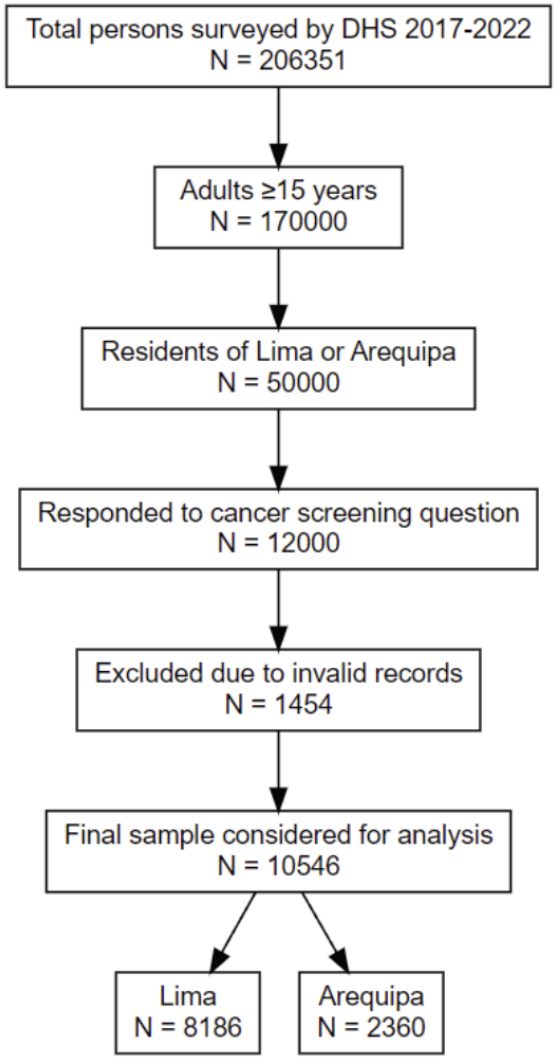

Figure 1: Flowchart of participant selection process from the Demographic and Family Health Surveys (DHS) 2017-2022 for cancer screening analysis in Lima and Arequipa, Peru.

(96.6%). Regarding health status characteristics, 73.7% had access to health insurance, 19.9% had consumed alcohol at least 12 days in the last year, 22.7% had consumed cigarettes in the previous year, 0.9% had some limitation in vision or hearing, 8.2% had a diagnosis of HTN, and 4.6% had a diagnosis of diabetes mellitus. Regarding knowledge and practices about cancer, 78.8% considered that cancer was preventable. This is shown in Table **1**.

Regarding the comparative characteristics of the surveyed samples from Lima and Arequipa, statistically significant differences were observed in several sociodemographic and health variables. The detailed comparison between these populations is presented in Supplementary Table **S1**. Key differences included distribution according to life stage, ethnicity/race, educational level, place of residence, altitude, wealth

Table 1: Sociodemographic and Health Status Characteristics of the Sample Included in the Study

Characteristic	Unweighted frequency	Weighted %	CV (%)
Sociodemographic			
Life Stage			
Older adult	473	6.1	6.2
Adult	8200	80.5	0.7
Young adult	1873	13.3	3.6
Sex			
Male	5139	46.2	1.7
Female	5407	53.8	1.4
Ethnicity/Race			
Quechua	2527	21.1	3
Black, dark-skinned, mixed Black, Afro-Peruvian	710	6.2	6
White	643	6.8	6
Mestizo	5870	58.9	1.4
Other	323	2.9	8.8
Don't know, no response	473	4.1	7.3
Educational Level			
No education	50	0.4	20.4
Primary	798	7.1	6.3
Secondary	4707	43	2.1
Higher education	4991	49.5	1.9
Wealth Index			
Poorest	414	1.8	10
Poor	1701	12.4	4.4
Middle	2479	21.2	3.2
Rich	2824	27.7	2.7
Richest	3128	36.9	2.7
Geographic			
Department of Residence			
Arequipa	2360	11	3.9
Lima	8186	89	0.5
Place of residence			
Capital, a large city	5906	81	0.8
Small city	1639	7.4	4.7
Town	2160	8.9	5.1
Rural area	841	2.7	7.7
Altitude			
Equal to or above 2500 masl	895	3.6	9.4
Below 2500 masl	9651	96.4	0.3
Health Status			
Access to health insurance			
Yes	7704	73.3	1
No	2842	26.7	2.7

(Table 1). Continued.

Characteristic	Unweighted frequency	Weighted %	CV (%)
Alcohol consumption in the last year, 12 or more days			
Yes	2017	19.6	3.4
No	8529	80.4	0.8
Cigarette consumption in the last year			
Yes	2443	22.6	3.1
No	8103	77.4	0.9
Limitation in vision or hearing, even with glasses or hearing aids			
Yes	85	1	15.5
No	10000	99	0.2
HTN diagnosis			
Yes	702	8.2	5.4
No	9844	91.8	0.5
Diabetes mellitus diagnosis			
Yes	416	4.8	7.2
No	10130	95.2	0.4
Knowledge and practices about cancer			
Considers that cancer is preventable			
Yes	8503	91.2	0.5
No	724	8.8	5.6
Had a general checkup to rule out cancer			
Yes	8158	25.5	2.8
No	2388	74.5	1

index, access to health insurance, alcohol consumption, and limitations in vision or hearing (all $p < 0.05$). These differences highlight the importance of controlling for these factors in the multivariate analysis to isolate the effect of residence in an area exposed to the ozone layer mini-hole.

Between 2017 and 2022, 75.2% of respondents had not undergone a general checkup to rule out cancer in the preceding 2 years. In the bivariate analysis using the second-order Rao-Scott Chi-square test, it was observed that life stage, sex, educational level, residential area, place of residence, altitude, wealth index, access to health insurance, cigarette consumption in the last year, diagnosis of HTN, and knowledge that cancer was preventable were associated with non-performance of a general checkup to rule out any type of cancer (Supplementary Table **S2**).

The multivariate analysis using Poisson regression with robust standard errors found that male sex was an associated factor for non-performance of a general checkup to rule out any type of cancer. In contrast, access to health insurance, HTN diagnosis, and the consideration that cancer was preventable were protective factors. Primary and secondary education, categorized from poorest to richest in the wealth index, were associated with a non-performance of a general checkup to rule out any type of cancer in the studied sample; however, they presented a very close to 1 adjusted prevalence ratio (aPR), so their impact as associated or protective factors is negligible. This is shown in Table **2**.

DISCUSSION

This research reveals that three out of four individuals in the studied sample had not undergone a general checkup to rule out cancer in the past two years. The associated factors were male sex, primary and secondary education, and wealth index categories from poorest to richest. Protective factors such as access to health insurance and the consideration that cancer is preventable were also identified. On the other hand, the population residing in Arequipa did not

Table 2: Multivariate Analysis of Factors Associated with Non-Performance of a General Checkup to Rule out any Type of Cancer

Possible associated factors	Crude model			Adjusted model		
	cPR	95% CI	p-value	aPR	95% CI	p-value (Wald)
Residence						
Arequipa	0.99	0.96 – 1.02	0.44	0.99	0.94– 1.03	0.542
Lima (Ref)	1			1		
Life Stage						
Older adult	0.9	0.85 – 0.97	0.002	0.93	0.87 – 1.00	0.059
Adult	0.99	0.96 – 1.02	0.377	0.97	0.95 – 1.00	0.056
Young adult (Ref)	1			1		
Sex						
Male	1.4	1.37 – 1.43	<0.001	1.41	1.37 – 1.44	<0.001
Female (Ref)	1			1		
Ethnicity/Race						
Quechua	1.05	1.03 – 1.08	<0.001	1.01	0.98 – 1.03	0.674
Black, dark-skinned, mixed Black, Afro-Peruvian	1.06	1.01 – 1.10	0.009	1.01	0.97 – 1.05	0.725
White	0.99	0.95 – 1.04	0.811	0.96	0.91 – 1.00	0.071
Other	1.09	1.03 – 1.15	0.003	1.03	0.97 – 1.09	0.305
Don't know, no response	1.04	0.98 – 1.09	0.192	1	0.95 – 1.05	0.882
Mestizo (Ref)	1			1		
Educational Level						
No education	1.12	0.97 – 1.29	0.138	1.28	1.10 – 1.50	0.002
Primary	1.09	1.04 – 1.13	<0.001	1.08	1.03 – 1.14	0.001
Secondary	1.12	1.01 – 1.14	<0.001	1.07	1.04 – 1.09	<0.001
Higher education (Ref)	1			1		
Place of residence						
Capital, a large city	0.94	0.90 – 0.97	<0.001	1.01	0.97 – 1.06	0.604
Small city	0.92	0.88 – 0.96	<0.001	1.01	0.95 – 1.07	0.744
Town	0.95	0.91 – 0.99	0.01	1	0.95 – 1.05	0.956
Rural area (Ref)	1			1		
Altitude						
Equal to or above 2500 masl	1.04	1.00 – 1.07	0.06	1.01	0.97 – 1.05	0.717
Below 2500 masl (Ref)	1			1		
Wealth Index						
Poorest	1.22	1.16 – 1.28	<0.001	1.14	1.07 – 1.21	<0.001
Poor	1.19	1.15 – 1.23	<0.001	1.13	1.09 – 1.18	<0.001
Middle	1.17	1.13 – 1.21	<0.001	1.11	1.07 – 1.15	<0.001
Rich	1.13	1.09 – 1.16	<0.001	1.09	1.05 – 1.15	<0.001
Richest (Ref)	1			1		
Cigarette consumption in the last year						
Yes	1.12	1.10 – 1.15	<0.001	1	0.98 – 1.03	0.804
No (Ref)	1			1		

(Table 2). Continued.

Possible associated factors	Crude model			Adjusted model		
	cPR	95% CI	p-value	aPR	95% CI	p-value (Wald)
Alcohol consumption in the last year, 12 or more days						
Yes	1.07	1.04 – 1.09	<0.001	0.99	0.97 – 1.02	0.46
No (Ref)	1			1		
Limitation in vision or hearing, even with glasses or hearing aids						
Yes	1.01	0.90 – 1.13	0.885	0.99	0.87 – 1.13	0.869
No (Ref)	1			1		
HTN diagnosis						
Yes	0.92	0.88 – 0.97	0.002	0.96	0.69 – 0.69	0.148
No (Ref)	1			1		
Diabetes mellitus diagnosis						
Yes	0.91	0.86 – 0.98	0.008	0.94	0.88 – 1.01	0.094
No (Ref)	1			1		
Access to health insurance						
Yes	0.87	0.85 – 0.89	<0.001	0.91	0.89 – 0.93	<0.001
No (Ref)	1			1		
Considers that cancer is preventable						
Yes	0.97	0.94 – 1.02	0.209	0.92	0.88 – 0.95	<0.001
No (Ref)	1			1		

participate significantly more than the Lima population in checkups to rule out any cancer.

This study found that the prevalence of non-participation in a general checkup to rule out any type of cancer in the last 2 years was 75.2% in the populations of Arequipa and Lima. This value is similar to that obtained in the 2014-2017 study based on data from the Tottori prefecture cancer registry (Japan) in which only 72.3% of a retrospective cohort of 72 171 people underwent a cancer screening [1]. The prevalence of non-participation is higher than that reported in another study conducted in the cities of Matsuura, Hasami, and Minamishimabara in Japan, where non-participation rates in health checkups (which included cancer and other non-communicable diseases) were 63.3%, 45.7%, and 56.9% respectively [14], and also higher than that reported in the cities of Chengdu, Zigong, Nanchong, and Mianyang in China where 60% of the population between 20 and 75 years old underwent regular health checkups [6]. On the other hand, the prevalence is lower than that reported in Thailand and South Korea, where non-participation in health checkups was 95.1% and 30.3%, respectively. Notably, in Thailand, annual health checkups are free [15].

This investigation found that originating from Arequipa was not a significant factor in the non-performance of a general checkup to rule out any type of cancer in the last 2 years. Although Arequipa is exposed to an ozone layer mini-hole [10] and its population would present a higher risk of developing non-melanoma skin cancers and melanoma, there is no statistically significant difference in the prevalence of non-performance of a general cancer screening checkup compared to the Lima population. This unexpected finding warrants deeper analysis. Several factors may explain this lack of association. First, the Arequipa population may not perceive having a higher risk of skin cancer or other cancers compared to the Lima population, as evidenced by the insufficient level of knowledge and practices regarding photoprotection documented in local studies [16-19]. This gap between objective environmental risk and risk perception may be exacerbated by insufficient health literacy regarding the connection between UV radiation and cancer risk, consistent with findings that health literacy plays a crucial role in adherence to cancer screening programs [20]. Second, even when risk awareness exists, it may not translate into preventive behaviors due to structural barriers to healthcare access, including geographic obstacles in certain areas of Arequipa, limited

availability of specialized services, or financial constraints despite nominal coverage, similar to challenges documented in other regions [22-25]. Finally, competing daily priorities or cultural factors may diminish the perceived urgency of preventive health behaviors, a phenomenon observed in studies of health checkup participation in diverse populations [14,15]. Together, these factors likely contribute to the disconnect between environmental exposure and preventive health behaviors observed in our study.

Low level of education, defined in this study as the absence of instruction, primary or secondary education, constituted an associated factor for non-performance of a general checkup to rule out any type of cancer in the last 2 years. This phenomenon does not seem to be unique to Lima or Arequipa. Still, various worldwide surveys find a gradient between education level categories and non-performance of checkups [6,14,15], which could be linked to understanding the importance of checkups, the importance of testing for diseases such as cancer, as well as understanding health personnel recommendations [6,20]. This situation seems to have improved during the COVID-19 pandemic as some studies have reported that educational level did not play a significant role in performing checkups as it did before the pandemic [21].

The present investigation found a weak association between the wealth index and non-performance of a general checkup to rule out any type of cancer in the last 2 years, which coincides with other studies showing inequity in access to cancer diagnosis in populations in poverty situations, which translates into a higher proportion of late diagnoses and high mortality [22-25]. In Peru, evaluations by health personnel as well as tests for screening of prioritized cancers are free both in Ministry of Health facilities, regional governments as well as in social security (EsSalud), which are the main health providers of the Peruvian state, so the problem would not be linked to the direct cost of care and examinations but with geographical, cultural barriers, myths, and false ideas about cancer, which impacts access to health services [26-28].

Protective factors for non-performance of cancer screening checkups were access to health insurance, and considering that cancer is preventable. Insurance was a protective factor against the non-performance of cancer screening checkups, which implies a positive impact of the insurance mechanisms offered by the Peruvian state. This coincides with various studies showing that insurance coverage is associated with performing checkups, screening tests, early diagnosis, and greater survival, observing negative effects on these parameters when insurance is unavailable or interrupted [29-34]. Considering that cancer is preventable also constitutes a protective factor and shows that populations with more information about the disease have better participation in checkups and screening tests [20].

PUBLIC HEALTH IMPLICATIONS

Based on our findings, several evidence-based public health interventions could be implemented to improve cancer screening rates in Peru. Given that male sex was the strongest factor associated with non-performance of cancer screening, targeted awareness campaigns specifically designed for men should be prioritized. These could include messages that address masculine norms and beliefs that may discourage preventive care-seeking behaviors, delivered through channels that effectively reach men, such as workplaces, sports venues, or male-oriented media. Additionally, gender-sensitive training for healthcare providers could help create more welcoming environments for men seeking preventive services.

Our finding that health insurance access is a protective factor suggests that continued efforts to expand insurance coverage through Peru's Universal Health Insurance (Seguro Integral de Salud) are warranted. Special attention should be given to removing administrative barriers that may limit effective utilization of covered preventive services. Policy efforts should focus not only on expanding nominal coverage but also on ensuring that coverage translates to actual access to quality cancer screening services, particularly for vulnerable populations.

Educational interventions that reinforce the message that cancer is preventable could be integrated into primary healthcare settings, as our results show that this belief is associated with higher screening rates. Community-based interventions in areas exposed to environmental risk factors, such as Arequipa, should focus on strengthening the connection between environmental awareness (e.g., UV radiation exposure) and personal preventive behaviors, addressing the apparent disconnect we observed in this study. These educational efforts should be culturally appropriate and address specific misconceptions or knowledge gaps identified in the target populations.

Considering the significant association between education level and screening behavior, interventions should be tailored to different educational levels, with simplified messaging and navigation assistance for less educated populations. Mobile screening units could help overcome geographic barriers in both urban and rural areas, particularly in regions where healthcare facilities are not easily accessible. Finally, integrating cancer screening promotion with other public health programs could create synergies and maximize limited resources. These practical interventions, based on our findings, could significantly improve cancer screening rates and contribute to earlier detection and reduced cancer mortality in Peru.

STRENGTHS AND LIMITATIONS

This study has several notable strengths. First, it utilizes data from a nationally representative survey with a rigorous sampling methodology, which enhances the generalizability of our findings to the wider Peruvian population. Second, the large sample size (10,546 participants) provides adequate statistical power to detect associations and allows for comprehensive multivariate analysis controlling for multiple potential confounders. Third, the comparative design between a region exposed to an ozone layer mini-hole and an unexposed region offers a unique opportunity to examine the relationship between environmental risk factors and preventive health behaviors. Fourth, the inclusion of both sociodemographic factors and cancer knowledge variables provides a more comprehensive understanding of the determinants of cancer screening behavior. Finally, the use of robust statistical methods, including Poisson regression with robust standard errors, strengthens the validity of our findings.

This study has several limitations that should be acknowledged. First, its cross-sectional nature prevents the establishment of causal relationships between the identified factors and non-performance of cancer screening. Longitudinal studies would be necessary to determine causality and track changes in screening behaviors over time. Second, the reliance on self-reported data may introduce recall and social desirability biases, potentially leading to over-reporting of cancer screening behaviors. Third, the DHS question about cancer screening is general and does not differentiate between types of cancer screenings or their appropriateness for different demographic groups, which may mask important differences in screening patterns for specific cancers. Fourth, while we controlled for several potential confounders, unmeasured factors such as family history of cancer, specific knowledge about cancer types, or healthcare provider recommendations could influence screening behaviors. Fifth, our analysis focused only on two departments in Peru, which limits the generalizability of our findings to other regions with different socioeconomic, cultural, and environmental characteristics. Finally, the study did not capture qualitative aspects of decision-making regarding cancer screening, such as specific barriers, motivations, or cultural factors that might influence the decision to undergo screening, which would require complementary qualitative research approaches.

CONCLUSIONS

In conclusion, the prevalence of non-performance of any cancer screening checkup was high. The main factor associated with non-performance of a cancer screening checkup was male sex, while having access to health insurance and considering that cancer is preventable were protective factors. Coming from Arequipa, a department exposed to an ozone layer mini-hole, was not a factor associated with performing a checkup.

These findings have significant practical relevance for public health policy and clinical practice in Peru. They highlight the urgent need for targeted interventions to increase cancer screening rates, particularly among men and those without health insurance, who represent vulnerable populations with reduced access to preventive care. Healthcare providers should emphasize the preventable nature of many cancers during patient education, as this belief was associated with higher screening rates.

Future research directions should include: 1) longitudinal studies to establish causal relationships between the identified factors and cancer screening behaviors; 2) qualitative research to better understand the barriers and facilitators to cancer screening, particularly among men; 3) intervention studies testing targeted strategies to improve screening uptake among high-risk groups, especially men and uninsured individuals, irrespective of regional UV exposure; 4) investigations into the effectiveness of health literacy programs in bridging the gap between environmental risk awareness and preventive behaviors; and 5) implementation research to identify the most cost-effective approaches to integrate cancer screening promotion into existing healthcare services in Peru. Such research would provide valuable evidence to guide the development of effective cancer control

programs that could ultimately reduce the burden of late-stage cancer diagnosis and associated mortality in the country.

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FINANCIAL DISCLOSURE

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

INFORMED CONSENT

Since this is a secondary data analysis, informed consent was not required.

DATA AVAILABILITY

The data supporting the findings of this study can be accessed by the original research paper at the following link: https://proyectos.inei.gob.pe/microdatos/

AUTHORS' CONTRIBUTION

WR: Study conceptualization, data curation, formal analysis, investigation, methodology, writing–original draft, manuscript review, and editing. **VJVP**: Data curation, investigation, methodology, manuscript review and editing. **RE**: Data curation, methodology, manuscript review and editing. **NG**: Investigation, methodology, writing–original draft. **ZMG**: Investigation, methodology, writing–original draft. **FEZM**: Supervision, Funding acquisition, Writing - Review & Editing. **EG**: Investigation, methodology, writing–original draft.

SUPPLEMENTAL MATERIALS

The supplemental materials can be downloaded from the journal website along with the article.

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