Cancer in Peru 1

Cancer patterns, trends, and transitions in Peru: a regional perspective

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Peru, like several other South American countries, is experiencing remarkable population growth, ageing, and urbanisation, which has given rise to profound changes in its epidemiological profile. Prostate and breast cancer are the most frequent cancers in men and women, respectively, in Lima and Arequipa, the two areas with population-based cancer registries. However, infection-associated cancers (cervix and stomach) are also common, and rank highest in the national cancer mortality profile. Although a foundation of surveillance informs cancer-control initiatives in Peru, improvements in the vital statistics system, and the quality and use of incidence data for the planning and assessment of cancer prevention and control actions, are needed. Existing population-based cancer registries in Lima and Arequipa, and linkages to the established national mandatory cancer reporting system, are crucial for the collection of high-quality data on national cancer incidence. The delivery of effective cancer prevention and control measures requires sustained investment in the collection of high-quality data capable of informing policies and driving research programmes.

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This is the first in a Series of four papers about cancer in Peru

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Introduction

Latin America represents 10% of the world's population, and is currently experiencing rapid socioeconomic transition. Although the Human Development Index rankings (a comparative measure of social and economic development) of Latin American countries are high, profound inequalities exist within the constituent nations.[1] Peru is no exception, and the evolution of the country's social and epidemiological profile is reflected in national demographic trends: the country's population has more than doubled in the past half-century, from 13·2 million in 1961 to 31·2 million in 2015.[2] The country has seen progressive urbanisation, with a once-majority rural population (52·6% in 1961) now an urban one (>75% ca 2007).[2,3] A simultaneous decrease has been observed in the country's fertility rate, from 4·3 births per woman in 1986 to 2·5 births per woman in 2015,[4] accompanied by an increase in the median age of the population, with 6·7% of people older than 65 years in 2015 compared with 3·4% in 1961.[5] The ageing and growth of the population of Peru is expected to continue over the next few decades (figures 1 and 2).

In 2015, Peru was classified as an upper-middle-income country, with a slightly higher Human Development Index rank than the neighbouring countries of Colombia and Ecuador (table 1). Within a decade, total poverty in Peru fell from 48·7% in 2005 to 22·7% in 2014.[6] However, in 2014, inequalities within the country remained, with total poverty in rural settings three times that of urban settings (46% *vs* 15·3%).[6] Public health expenditure in Peru (5·3% of GDP) is lower than that of other countries in the region (eg, 10% in Chile and 9·7% in Brazil), and the USA (17·1%).[1]

Peru has three major geographical regions (coastal, Andean Highlands, and tropical rainforest) with distinctive climates, cultural, and socioeconomic characteristics. In 2007, 54·5% of the country's population lived in the coastal region, 32·0% in the Andean region, and 13·4% in the rainforest region.[3] Administratively, the country is divided into 24 departments and one constitutionally special province, Callao. The cities of Lima (the capital of Peru) and Callao, both in the coastal region, are home to almost 10 million people—a third of the country's population (figure 3).[7] Lima, despite having the greatest recorded in-migration within Peru, has a notably lower total poverty index (11·8%) relative to other departments within the coastal (14·3%), highlands (33·8%), and rainforest (30·4%) areas.

In 2012, Peru made an important and early achievement by reaching two of the UN's Millennium Development Goals: to reduce the infant mortality rate (deaths of children <5 years old per 1000 livebirths) and to reduce the maternal mortality rate (per 100 000 livebirths). The country's infant mortality rate decreased from 80 deaths per 1000 livebirths in 1990 to 17 deaths per 1000 livebirths in 2012, and the maternal mortality rate decreased from 250 to 89 deaths per 100 000 livebirths in the same period.[8] Although non-communicable diseases (NCDs) are the leading cause of death in Peru, communicable diseases still constitute a major part of the country's disease profile.[9,10] The epidemiological transition model of Peru has been categorised as non-western (ie, developing) and as being in the triple health burden stage, which implies the coexistence of communicable diseases and NCDs as major components of morbidity and mortality for the country, and suboptimal preparedness of the health system to deal with the volume of emerging chronic diseases.[11]

Cancer surveillance systems in Peru

Until 2016, Peru executed a national cancer control plan—the Plan Esperanza (discussed in the third paper

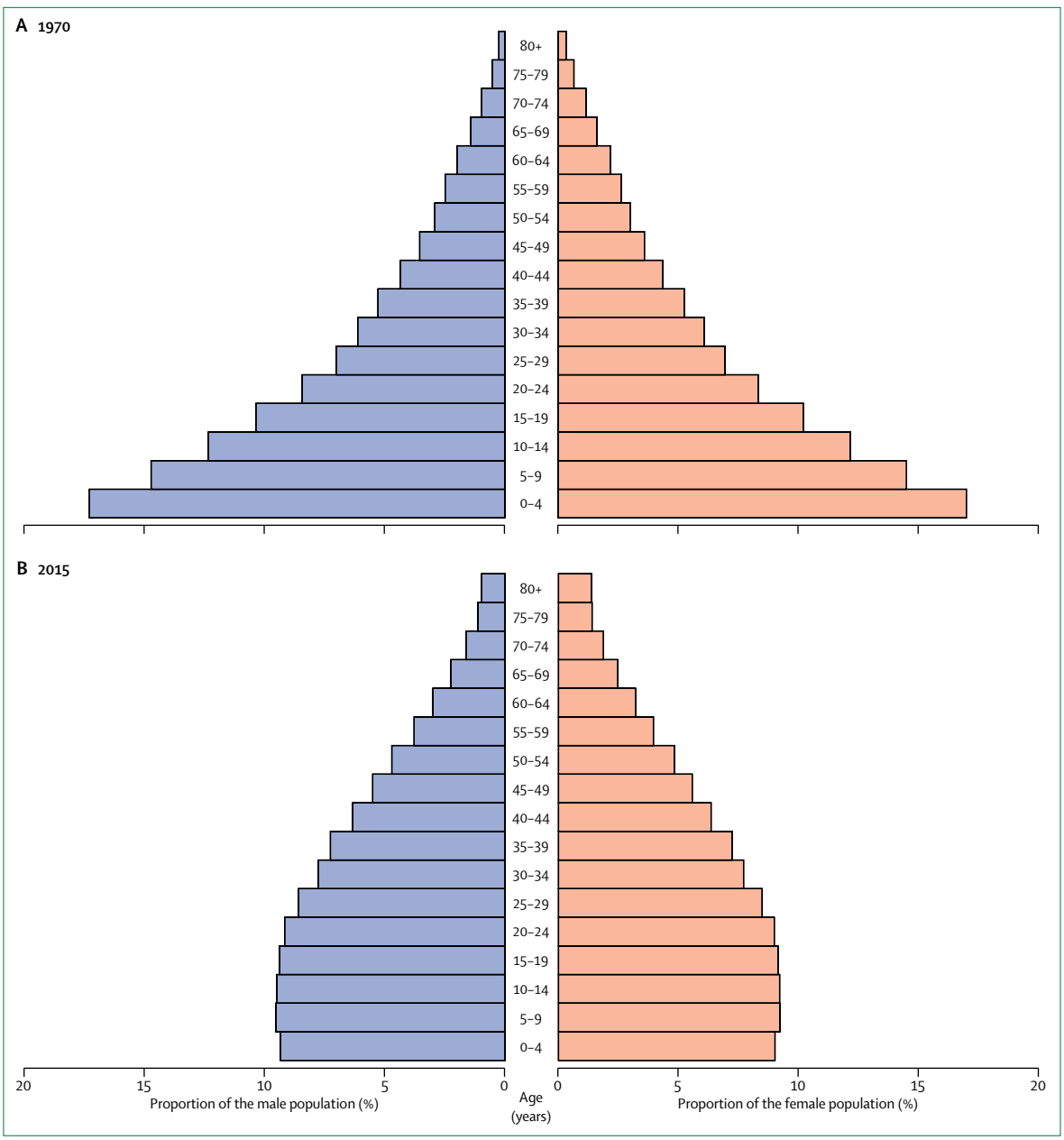

Figure 1: **Population structure of Peru in 1970 (A) and 2015 (B)**
Source: figure based on data from the National Statistics Institute.[2]

of this Series[12]). The aim of the Plan Esperanza was to improve access to cancer care services and reduce the burden and incidence of cancers of the cervix, breast, stomach, lung, and prostate.[13] The Ministry of Health is now preparing a new cancer control plan, which will focus on paediatric leukaemias, cervical cancer, and breast cancer. In 2013, the Peruvian Ministry of Health prepared a comprehensive situation analysis of the scale and profile of cancer in Peru, which has been a central component of both past and present cancer control plans.[14] The analysis included information from the mandatory cancer surveillance system (started in 1996), and detailed information on mortality (corrected for under-reporting; discussed later in this Series paper) and the prevalence of the main cancer risk factors (eg, tobacco smoking, alcohol consumption, and obesity). A report to strengthen cancer control in Peru was commissioned by the Ministry of Health. The assessment of global cancer control and readiness is discussed in the second paper of this Series,[15] and the results of and response to the review commissioned by the Peruvian Ministry of Health in the third paper of this Series.[12]

Population-based cancer registries

The analysis is supplemented by cancer incidence data obtained from the subnational population-based cancer registries in Peru. Population-based cancer registries systematically collect information on all reportable neoplasms that occur in a resident population of a geographically defined area from multiple sources, including pathology, clinical diagnosis, and death certificates. These registries are the only means to obtain cancer incidence and survival information on a population basis, and are thus a central element in the planning and assessment of cancer prevention and control actions in Peru.[16,17]

Peru belongs to a group of countries that have established, but not high-quality, population-based cancer registries.[18] The country's cancer incidence data are available from two subnational registries: the Arequipa and the Lima population-based cancer registries.

Arequipa is the second most populous city in Peru, with almost 1 million inhabitants, and is located in the southern part of the country, in the spurs of the Andean mountains, at 2328 m above sea level. The Population-based Cancer Registry of Arequipa was established in 2001 at the Oncology and Radiotherapy Department of the Goyeneche Hospital (belonging to the health-care system of the Ministry of Health) in Arequipa. The registry has been associated with the Southern Regional Institute of Neoplasms in Arequipa—one of the country's regional cancer institutes. Financial support for the registry is provided by the Ministry of Health (particularly since 2016, with the provision of a full-time registrar) and the Goyeneche Hospital (which covers fixed costs), although it mainly relies on the voluntary services of the director and the staff. The registry follows international recommendations, such as clear definitions of cancer cases, incidence data, multiple primaries, and coding,[19,20] for registration and reporting procedures. Data collection is both passive and active, with data first captured in Microsoft Excel and then migrated to CanReg5 (version 5.00.41b), the free software for population-based cancer registries developed by the International Agency for Research on Cancer. Data migration and software assistance is provided by the Global Initiative for Cancer Registry Development. The Arequipa cancer registry has made an effort to periodically disseminate multiple-year reports, with the most recent (covering 2004–07) publicly available in printed form.[21] The collection of accurate data is limited by a few factors; for example, the need to review almost every clinical record because electronic files are non-existent for some information sources, and restricted access to others (mainly private sources). Additionally, research activities focusing on the descriptive epidemiology of cancer incidence and resulting patterns are not routinely undertaken.

The Metropolitan Lima Cancer Registry dates back to 1968. After being active for 10 years, followed by a period of closure, the registry recommenced its activities in 1990. The population-based registry is housed at the Department of Epidemiology and Cancer Statistics at the National Institute of Neoplastic Diseases (INEN), which provides the registry with

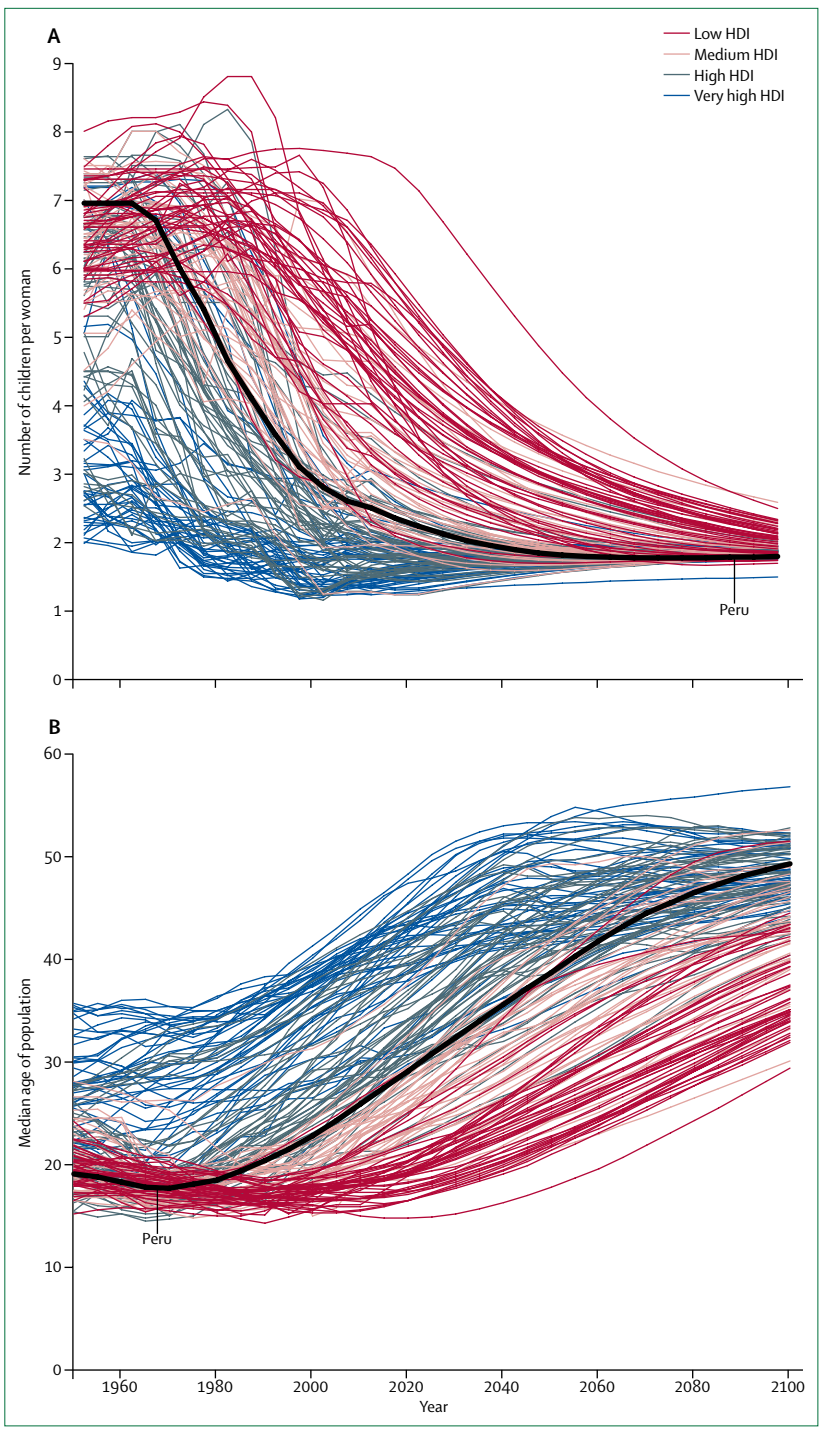

Figure 2: **Fertility rate (A) and ageing of population (B) in Peru and other countries worldwide**
HDI=Human Development Index. Source: figure based on data from the United Nations Human Development Reports.[1]

For more on **Global Initiative for Cancer Registry Development** see http://gicr.iarc.fr/

	Life expectancy of both sexes (years)	Population >65 years old (%)	Urban population (%)	Gross national income per capita (USD)	Public health expenditure (wDP)	Human Development Index (number [rank])	Population in multidimensional poverty (%)
Peru	74·6	6·5%	178·3%	11 015	5·3%	0·734 (84)	10·4%
Brazil	74·5	7·8%	85·4%	15 175	9·7%	0·755 (75)	2·9%
Colombia	74·0	6·3%	76·1%	12 040	6·8%	0·72 (97)	7·6%
Chile	81·7	10·1%	89·8%	21 290	7·7%	0·832 (42)	NA
Ecuador	75·9	6·9%	69·1%	10 604	6·4%	0·732 (88)	3·7%
USA	79·1	14·3%	83·1%	52 946	17·1%	0·915 (8)	NA

Source: United Nations Human Development Reports.[1] NA=not available.

Table 1: **Socioeconomic indicators 2014 in Peru, neighbouring countries, and the USA in 2014.**

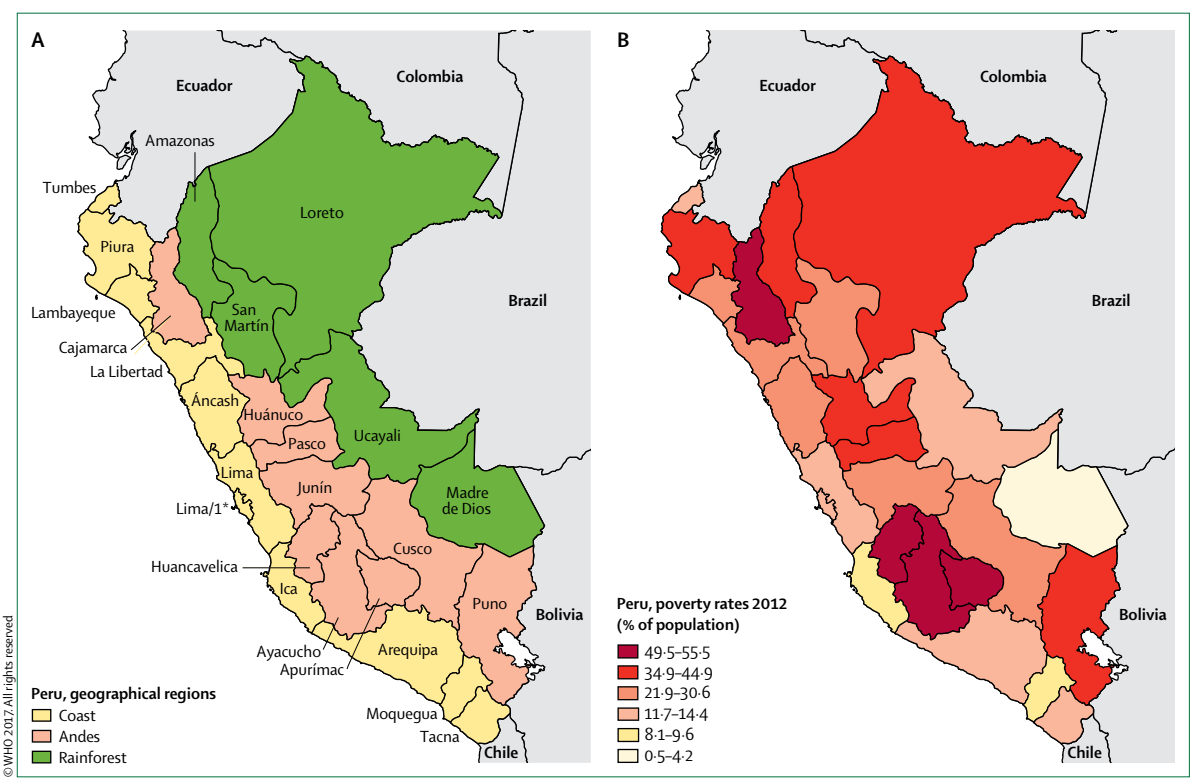

Figure 3: **Peru's geographical zones (A) and poverty rates (B) by department**
The asterisk denotes Lima and Callao province. The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement. Source: figure based on data from the National Statistics Institute.[6]

financial and technical assistance. Since its inception, the registry's target population has been Lima and the neighbouring province of Callao, which have a combined population of 9·3 million.[22] In the Metropolitan Lima Cancer Registry, incidence data are captured via active means, involving a staff of 30 people. The major challenges to active data collection include: high workload; accessing data from sources within the private sector (eg, hospitals and laboratories); and, problems with existing infrastructure (eg, space limitations and the need for IT enhancements). Data from the registry were published in the serial publication Cancer Incidence in Five Continents, from the International Agency for Research on Cancer for 1990–91.[23] The registry has also periodically produced local incidence reports, with the most recent publication including data from 2010 to 2012.[22]

The Arequipa and Lima cancer registries are active members of the International Association of Cancer Registries, and the challenges of sustainability and

For more on the **International Association of Cancer Registries** see http://www.iacr.com.fr

	Peru (GLOBOCAN 2012)					Lima (PBCR, 2010–12)					Arequipa (PBCR, 2010–13)				
	Cancer site	N	%	ASR	Cum risk	Cancer site	N	%	ASR	Cum risk	Cancer site	N	%	ASR	Cum risk
Males															
1	Prostate	3909	21·2%	30·4	3·4	Prostate	5884	24·6%	48·4	2·9	Prostate	596	24·8%	32·1	2·2
2	Stomach	2136	11·6%	16·6	1·9	Stomach	2730	11·4%	21·8	1·4	Stomach	213	8·9%	11·6	1·0
3	Lung	1447	7·9%	11·3	1·3	Colorectal	1929	8·1%	15·5	1·1	Colorectal	204	8·5%	10·6	0·8
4	Colorectal	1318	7·2%	10·2	1·2	Lung	1661	6·9%	13·4	0·9	Non-Hodgkin lymphoma	205	8·5%	10·6	0·8
5	Non-Hodgkin lymphoma	833	4·5%	6·3	0·7	Non-Hodgkin lymphoma	1499	6·3%	11·8	0·9	Lung	128	5·3%	6·8	0·5
	All sites but skin	18 410	100·0%	140·9	14·6	All sites but skin	23 918	100·0%	191·2	13·5	All sites but skin	2400	100·0%	128·3	9·2
Females															
1	Cervix	4636	19·0%	32·7	3·4	Breast	6079	21·0%	41·5	3·8	Breast	703	20·2%	38·0	3·5
2	Breast	3952	16·2%	28·0	2·9	Cervix	3331	11·5%	22·2	2·0	Cervix	586	16·8%	31·2	2·9
3	Stomach	2205	9·0%	15·0	1·7	Colorectal	2205	7·6%	14·3	1·0	Thyroid	258	7·4%	13·3	1·2
4	Colorectal	1735	7·1%	11·9	1·4	Stomach	2206	7·6%	14·2	1·0	Colorectal	214	6·1%	11·4	1·0
5	Lung	1332	5·5%	9·1	1·0	Thyroid	1652	5·7%	11·0	1·0	Stomach	199	5·7%	10·3	0·8
	All sites but skin	24 436	100·0%	169·8	16·8	All sites but skin	28 889	100·0%	193·4	14·7	All sites but skin	3486	100·0%	186·3	15·1

ASR=age standardised rate per 100 000. PBCR=population-based cancer registry. N=annual number of new cancer cases. Cum risk=cumulative risk, up to 70 years old.

Table 2: **Five most common cancers ranked by age-standardised rates among males and females in Peru, Lima, and Arequipa**

financing of personnel, among others, are common to the maintenance of both. The registries collectively cover 33% of the total population of Peru, and provide valuable information on the magnitude and distribution of cancer in two geographically representative regions of the country. The sustained collection of high-quality data from these registries is urgently needed for the assessment of, and decision-making processes related to, cancer control actions.

A third population-based cancer registry was intermittently functional in Trujillo—a city on the northern coast of Peru with a population of almost 700 000. The Trujillo Cancer Registry published high-quality data from 1984 to 1990,[23,24] and from 1998 to 2002.[25] However, the registry closed in 2002.

Mandatory cancer reporting system

In 2006, the Peruvian Ministry of Health set up a mandatory cancer reporting system, in accordance with the Plan Esperanza and aiming to cover expenses of cancer treatment in underserved populations.[12,14,26] This web-based surveillance system relies on 59 reporting hospitals that are distributed throughout the country and most of which are part of the health network of the Ministry of Health. The information on new cancer cases (coded in the International Classification of Diseases for Oncology, third edition)[27] is reported on a monthly basis, and has been useful for the quantification of patients with cancer and the cost of cancer treatment among poor citizens. Although it does not include information from private sources, it collects information on cancers diagnosed in many departments (including those located in the tropical rainforest), and has proven to be a valuable information source for the population-based cancer registries, particularly the Arequipa cancer registry, which relies more heavily on passive data collection than the Metropolitan Lima Cancer Registry. The mandatory cancer reporting system is mainly limited by the scarcity of staff in public hospitals, high staff turnover, and the scarcity of supervision of data quality. All of these factors yield problems in data accuracy and completeness.

The civil registration and vital statistics system

In Peru, civil registration is the responsibility of the National Identification and Civil Registration Registry (RENIEC), and vital statistics are the responsibility of the National Statistics Institute (INEI). The data from these databases are, in turn, provided to the Ministry of Health. Peru's civil registration and vital statistics system received a medium vital statistics performance index score of 0·50–0·69 in a global assessment of 148 countries or territories between 1980 and 2012. This score indicates that, although the system is functional, the quality of the mortality data limits its use in support of public policy.[28] Under-registration of deaths was estimated at 41% in 2012, with particularly low coverage and quality of data before 2006.[14] WHO estimated the registry coverage of cause of death from 2010 to 2012 at 69%.[29] Accordingly, since 2001, the Ministry of Health have corrected the mortality data using a methodological approach previously validated for the Americas.[30] Caution is therefore needed in the interpretation of epidemiological studies that use mortality data from Peru because they might or might not incorporate these adjustments. As an example, the Ministry of Health reports 30 832 cancer deaths in both sexes

Panel: **Data sources and methods**

Cancer data

The GLOBOCAN 2012 estimates provided overall cancer incidence and mortality information for Peru;[32] observed cancer incidence data were obtained from the Metropolitan Lima Cancer Registry (1990–91 and 2010–12), and the Population-based Cancer Registry of Arequipa (2002–03 and 2010–13). Data provided by the population-based cancer registries (Lima 2010–12 and Arequipa 2010–13) were checked for overall consistency and completeness; however, their use does not imply that the data necessarily comply with the highest international quality standards for population-based cancer registries. Newly reported cancers from the Cancer Surveillance System of the Peruvian Ministry of Health were provided by the National Centre of Epidemiology, Prevention and Disease Control at the Ministry of Health for 2010–12. National mortality data by region for 2010–12 were obtained, with cause of death coded with ICD-10 from the vital statistics system, from the Peruvian Ministry of Health. Registered mortality data were corrected by the Ministry of Health for under-registration, following the method suggested by the Pan American Health Organization.[30] The WHO Mortality Database provided corresponding mortality data for the trend analyses for Peru, its neighbouring countries (Brazil, Colombia, Chile, and Ecuador), and the USA for comparative purposes.

Population data and estimation of rates

Population figures were obtained from the National Institute of Neoplastic Diseases.[2] To adjust for the effects of age in comparative analyses of incidence and mortality rates by country and over time, the age-standardised rate in terms of the world standard population[33] were used, both at a national level and for the populations of Lima and Arequipa, covered by the population-based cancer registry. In presenting the time trends in mortality age-standardised rate, random fluctuations were evened out by country, sex, and cancer site by LOESS regression.

in 2011,[14] whereas WHO reports almost half that number (16 330 deaths).[31] Such discrepancies yield difficulties reconciling comparability and a precise assessment of the national cancer mortality burden in Peru.

The cancer landscape and related factors

Cancer incidence in Peru

Based on data from GLOBOCAN,[32] the annual number of new cancer cases (except non-melanoma skin cancer) in Peru in 2012 was 42 846. The age-standardised incidence rate (per 100 000) was 140·9 among males and 169·8 among females (table 2), and annual cancer deaths were estimated to be 26 165 in both sexes.[32] By 2030, the annual number of new cancer cases is expected to be 73 846—a 72% increase compared with 2012.[32] The GLOBOCAN incidence rates for all ages were based on estimated national mortality data and modelled survival for 2012; the rates were partitioned by age-specific proportions from the cancer registries of Lima and Trujillo for 1998–2002 (panel).

Cancer incidence in Lima

In Lima, the mean annual number of new cancer cases was 17 710 (all sites except non-melanoma skin) for the 2010–12 period, most of which (54%) were in females. In the same period, the age-standardised rate (per 100 000) for all cancers combined was 191·2 for males and 193·4 for females (table 2): an increase of 50% and 28%, respectively, compared with 1990–91.[23] The most prevalent cancers for both sexes are shown in table 2 and figure 4A.

Cancer incidence in Arequipa

In Arequipa, the mean annual number of diagnosed cancers was 1682 (58·9% female) for the 2010–13 period. The age-standardised rate (per 100 000) for all cancers was 128·3 for males and 186·3 for females (table 2). In the same period, incidence rates in Arequipa were consistently higher among females than males. The age-standardised rate (per 100 000) for all cancers combined increased by 12% in males and 1% in females, compared with the 2002–03 period. The most prevalent cancers for both sexes are shown in table 2 and figure 4B.[34]

Changing incidence profiles in Peru: interpretation

The age-standardised incidence rates for all cancers combined (except non-melanoma skin cancers) were much higher among males in Lima than those in Arequipa; among females, the rates were similar (table 2). In both Lima and Arequipa, prostate cancer was the most common cancer in males and breast cancer was the most common cancer in females; in terms of frequency, these cancers were followed by infection-associated cancers of the stomach in males and cervix in females (table 2; figure 4). For both sexes, the incidence rates (age-standardised rate per 100 000) of stomach cancer were markedly higher in Lima than in Arequipa (21·8 *vs* 11·6 in males; 14·2 *vs* 10·3 in females). Neither these results nor the mortality rates for stomach cancer (figure 5) follow the high-altitude, high-risk pattern that suggests a positive correlation between altitude and gastric cancer as observed in other parts of the region and in the whole of Peru.[35,36] In this context, altitude has been suggested to be a surrogate for factors that might cluster in mountainous regions; for example, host genetic, bacterial, dietary, and environmental factors.[35] Local studies in Lima reported a positive association between ethnic ancestry and stomach cancer, and a predominant role for ethnic-associated socioeconomic factors and disparities in access to health services.[37] No such studies have been done in Arequipa.

Age-standardised rate per 100 000 of cervical cancer and thyroid cancer were higher among females in Arequipa than those in Lima (31·2 *vs* 22·2 for cervical cancer; 13·3 *vs* 11·0 for thyroid cancer; table 2). The higher cervical cancer incidence and mortality rates in Arequipa compared with Lima could be related to the lower socioeconomic and living conditions,[6] or accessibility to health services in Arequipa. Much like other parts of the world, the high incidence of thyroid cancer in Arequipa is most probably related to the increased coverage of health services, improvement in cancer surveillance programmes, and development of and increased access to diagnostic imaging services.[38] In Arequipa, gallbladder cancer ranked seventh among females with an age-standardised rate

of 10·5 per 100 000 (figure 4). Within Latin America, Peru ranks second after Chile for having one of the highest rates of gallbladder cancer.[39] A high frequency of gallstones and the resulting chronic irritation, which is a major determinant for gallbladder cancer,[40,41] has been reported among Peruvians living in the highlands, and has been attributed to ethnic ancestry.[42] In an area of northern Chile that is geographically closer to Arequipa than to Lima, genetic factors and poor living conditions have been associated with elevated gallbladder cancer incidence and mortality rates.[43] These factors could also contribute to the high gallbladder cancer rates in Arequipa. Aflatoxin contamination, and its presence in red peppers in Peru, Chile, and Bolivia, has also been associated with gallbladder cancer.[44–46] Furthermore, the high incidence of gallbladder cancer in Arequipa is consistent with the high gallbladder mortality rates in the southern departments of the country that neighbour Chile (discussed later; figure 5).

Cancer cases reported by the National Cancer Surveillance System

From 2010 to 2012, the number of new cancer cases reported by the mandatory reporting system was 36 617, of which 23 571 (64·4%) were in females (table 3). The five most common cancers reported through this hospital-based system were cancers of the cervix, breast, stomach, non-melanoma skin, and prostate, which coincides with the common cancers reported by the registries (except non-melanoma skin, which is not collected by the population-based cancer registry), and the priorities of the Plan Esperanza.

For the 2010–12 period, although the total number of cancer cases reported nationally via the National Cancer Surveillance System was far lower than the number reported in Lima via the population-based cancer registry (36 617 *vs* 52 807, respectively; tables 2 and 3), the number of cervical cancer cases reported nationally was almost double the number reported in Lima (6104 [16·7% of all cases] *vs* 3331 [6·3% of all cases]). Given that the mandatory system prioritises public institutions with diagnostic and treatment capacities, and excludes most private and social security health institutions, the number of cancer cases yielded by this system has restricted coverage. The high number of cervical cancer cases reported nationally, compared with the number reported by the Lima registry, might be because public institutions tend to treat women who are poorer than those treated privately and who are at high risk of cervical cancer, such as those from high-risk cervical cancer areas (eg, tropical rainforest). It would therefore appear that the mandatory system better captures data relating to one of the cancers targeted by the Plan Esperanza (ie, cervical cancer), when compared with those data captured by population-based cancer registries. The low percentage (<2%) of unknown primary sites in the mandatory reporting system (table 3) is driven by a system that prioritises institutions with the capacity to perform a histopathological diagnosis of cancer; additionally, a reporting bias toward cancers targeted in the Plan Esperanza cannot be ruled out.

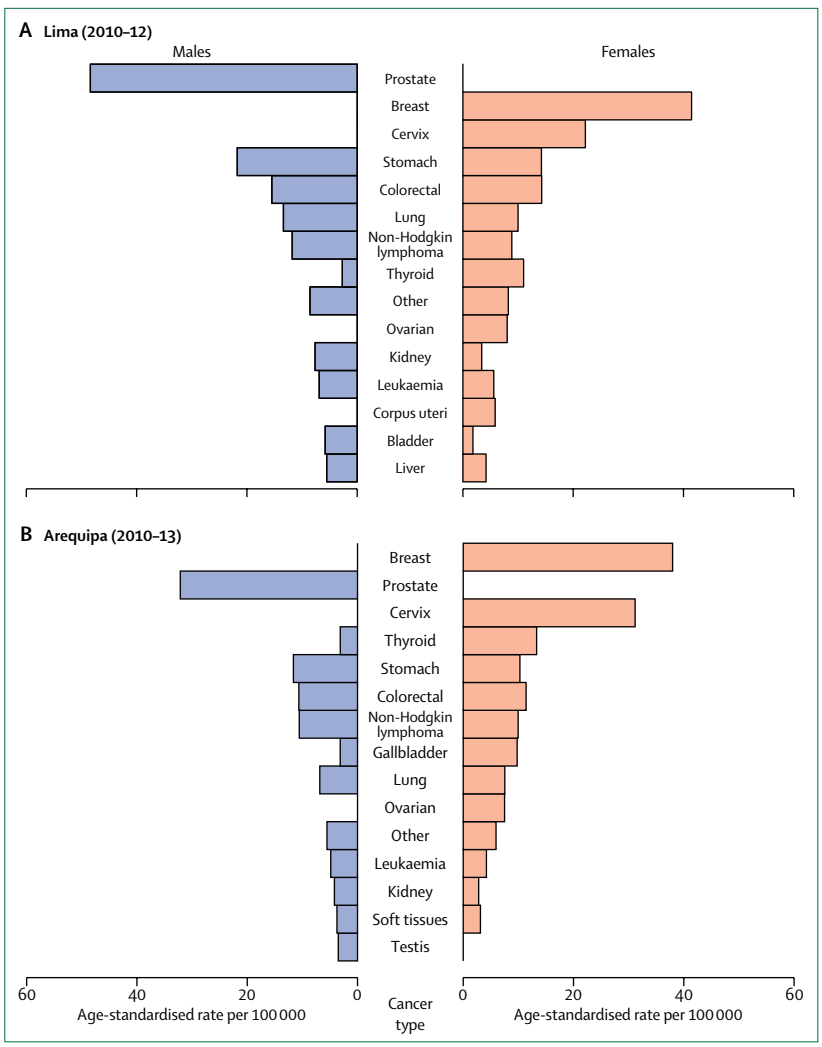

Figure 4: **Leading causes of cancer incidence (age-standardised rates per 100 000) in Lima between 2010 and 2012 (A) and in Arequipa between 2010 and 2013 (B)**
Source: figure based on data from the Metropolitan Lima Cancer Registry, and the Population-based Cancer Registry of Arequipa.

Cancer mortality

According to GLOBOCAN 2012,[32] the annual number of cancer deaths (all cancers, excluding non-melanoma cancer) in both sexes in Peru was 26 165, with an age-standardised rate of 92·1 per 100 000. The most common causes of cancer mortality among males were prostate, stomach, and lung cancer, with age-standardised rate of 14·9, 13·9, and 10·0 per 100 000, respectively. Among females, stomach, cervix, and breast cancer were associated with the highest mortality rates, with age-standardised rates of 12·4, 12·0, and 8·5 per 100 000, respectively. Calculations from the Ministry of Health for 2008–12 (which have been corrected for under-reporting) indicated NCDs represented 63·0% of all causes of death in Peru,

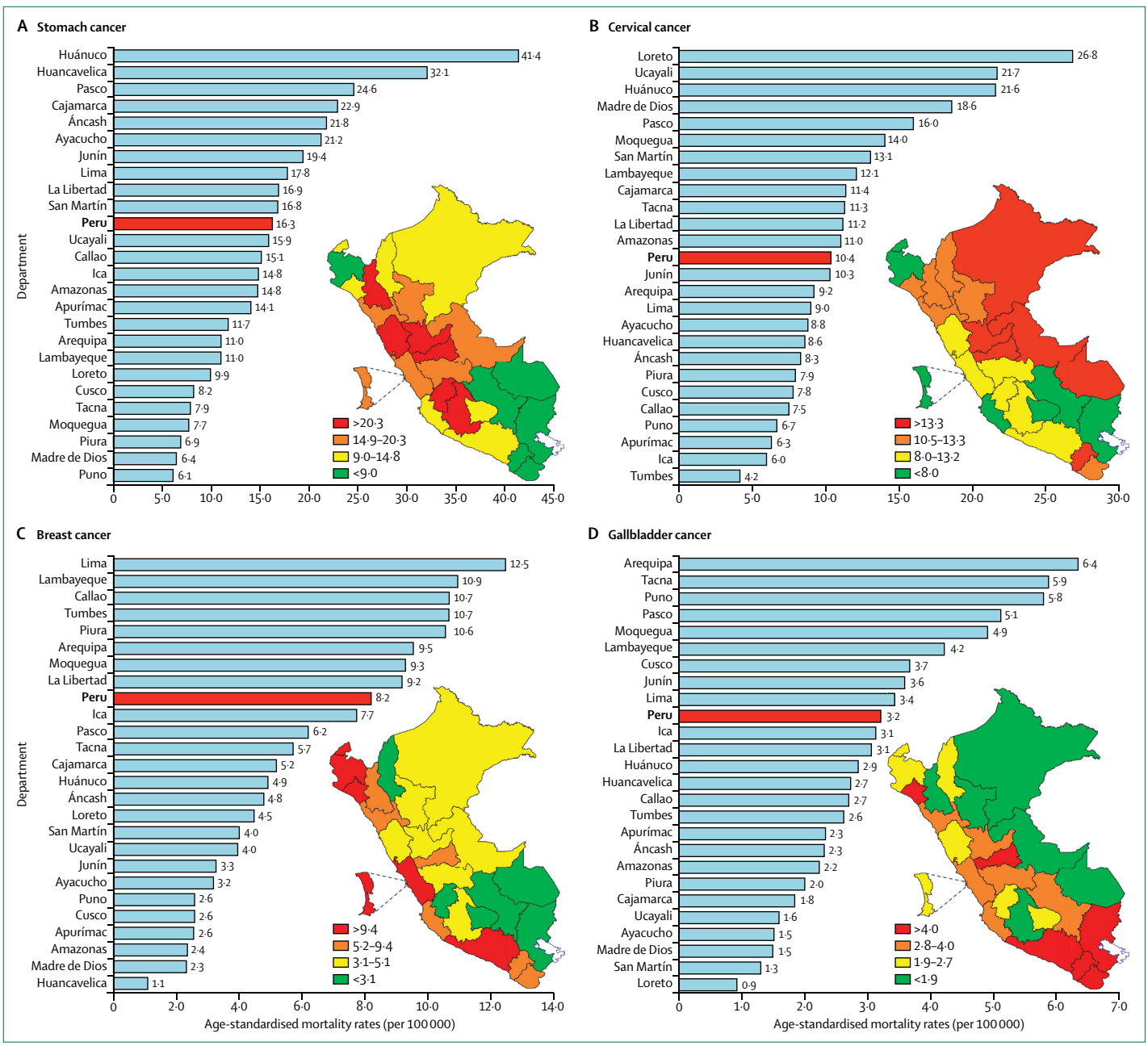

Figure 5: **Age-standardised mortality rates (per 100 000) for stomach cancer (A), cervical cancer (B), breast cancer (C), and gallbladder cancer (D) by departments in Peru (blue bars) and overall (red bar) from 2008 to 2012**
Source: figure based on data from the Ministry of Health, Peru.

See Online for appendix

followed by infectious diseases (21·4%), and accidents and lesions (11·5%; unpublished data). The Ministry of Health also concluded that the estimated mean annual number of deaths due to cancer was 29 418 for the same period, with an age-standardised mortality rate of 113·2 per 100 000 for both sexes combined (unpublished data).

The cancer mortality distribution by department for stomach, cervical, breast, and gallbladder cancer for the 2008–12 period were reviewed (figure 5), and the age-standardised rates, standard error, and 95% CI for each of the four cancers were calculated (see appendix).

Stomach cancer mortality rates (both sexes combined) show a six-times to seven-times variation between departments, with significantly higher rates recorded in the country's poorer districts and departments within the high mountains (eg, Huánuco, Huancavelica, and Pasco; figure 5; appendix). This finding is consistent with reports of an increased risk of gastric cancer among low

socioeconomic groups and populations who reside at high altitudes.[35]

Departments within the rainforest (eg, Loreto), and some Andean and poorer districts (eg, Huánuco), exhibit some of the highest cervical cancer mortality rates in the country (figure 5; appendix). This pattern reflects reports of increased risk of dying in poorer departments with less-developed health infrastructure.[6,14] The high cervical cancer mortality rates in Peru and in the Latin American region have fostered landmark studies in cervical cancer prevention and early detection, including the human papillomavirus (HPV) vaccine acceptability studies,[47–49] and feasibility and pilot implementation studies that reported a high HPV vaccine uptake.[50–52] Although the HPV vaccine was shown to be cost-effective for Peru in a 2012 report,[53] the vaccination had not been fully integrated into the national immunisation programme in 2015.[54] In 2016, the Peruvian Ministry of Health began a school-based programme to allow girls to receive the HPV vaccine for free, with parental consent. Projects to identify the most appropriate cervical cancer screening test were undertaken in various settings in Peru, and screening with a single visual inspection with acetic acid test was shown to reduce the incidence rates of cervical cancer, particularly in remote areas like the Peruvian Amazon.[55–57] Nevertheless, there is no formal early detection programme for cervical cancer in Peru, despite the availability of financial resources for activities related to the early detection and treatment of cervical cancer in the Plan Esperanza.

Age-standardised female breast cancer mortality rates are significantly higher in the coastal departments of Peru, especially in the northern part of the country (Lambayeque), and in Lima and Callao (figure 5; appendix). In the coastal region, not only are the living conditions better (ie, less poverty) than elsewhere in the country,[6] but also 72% of clinical oncologists, 85% of radio-oncologists, and most oncological care are concentrated in this region.[14] These factors probably contribute to a higher diagnostic capacity that, together with a better death certification, might underlie the observed higher breast cancer mortality rates in Lima. No formal programme for the early detection of breast cancer exists in Peru.

Gallbladder cancer mortality rates (both sexes combined) are significantly higher in some of the southern districts of Peru, nearest Chile (eg, Tacna, Puno, and Arequipa), than the rest of Peru (figure 5; appendix), consistent with the previously described findings of high incidence rates of this cancer in the Population-based Cancer Registry of Arequipa.

	ICD-O-3	Males	Females	Total	%
Cervix uteri	C53	··	6104	6104	16·7%
Breast	C50	18	4088	4106	11·2%
Stomach	C16	1936	1768	3704	10·1%
Skin	C44	1410	1789	3199	8·7%
Prostate	C61	2071	··	2071	5·7%
Colon, rectosigmoid junction, and rectum	C18–C20	938	1123	2061	5·6%
Haemapoietic and reticuloendothelial systems	C42	739	601	1340	3·7%
Bronchus and lung	C34	670	655	1325	3·6%
Thyroid	C73	204	1036	1240	3·4%
Lips, oral cavity, and pharynx	C00–C14	578	509	1087	3·0%
Lymph nodes	C77	493	481	974	2·7%
Ovary	C56	··	793	793	2·2%
Unknown primary site	C80	275	417	692	1·9%
Gallbladder	C23	158	531	689	1·9%
Liver and intrahepatic bile ducts	C22	322	339	661	1·8%
Connective, subcutaneous, and other soft tissues	C49	314	271	585	1·6%
Pancreas	C25	254	317	571	1·6%
Brain and central nervous system	C70–C72	260	280	540	1·5%
Kidney	C64	326	205	531	1·5%
Corpus uteri	C54	··	513	513	1·4%
Others	··	2080	1751	3831	10·5%
TOTAL	C00–C80	13 046	23 571	36 617	100%

ICD-O-3=International classification of diseases for oncology, third edition.

Table 3: **New cancer cases by cancer site, reported by the National Cancer Surveillance System, Peru 2010–12**

Cancer mortality trends 1968–2014: an Americas context

Data from the WHO mortality database were used to compare mortality trends of the main cancers in Peru with those of neighbouring countries (ie, Chile, Brazil, Colombia, and Ecuador), and the USA (figure 6).[31] Data from 1968 to 2014 were compared for all countries, except Brazil (1979–2014) and Colombia (1968–2013). Peru had the lowest prostate cancer mortality rate compared with its neighbours; however, the rate has continuously increased, similar to prostate mortality rates of Ecuador (figure 6). A similar pattern was seen for breast cancer in Peru with Ecuador. From 2006 onwards, the USA displayed the lowest prostate cancer mortality rates and the highest breast cancer mortality rates among the countries. The notable reduction in breast cancer mortality in the USA, compared to other countries, is likely to be due to better treatment, and early diagnosis and screening.

Among males, a decline in stomach cancer mortality rates was observed in all countries (figure 6), consistent with global findings;[58] however, the decline was less marked in Peru. The stomach cancer mortality rate of Peru was double that of the USA, higher than that of Brazil, but lower than that of Chile, Colombia, and Ecuador.

Cervical cancer mortality trends (based on all ages) in Peru were stable, in contrast with the reductions seen in other countries (figure 6). These trends are difficult to interpret (particularly for deaths due to cervical cancer),

because of the high proportion of unspecified uterine cancer deaths. Nonetheless, when the population was restricted to women younger than 50 years old (data not shown), although the magnitude of the rates diminished, the trend patterns were similar; thus, non-specified uterus deaths were probably true cervical cancers. The observed increase in mortality rates since 2006 could also be related to an improvement in reporting of cervical cancer deaths, secondary to the implementation of the Plan Esperanza.

Lung cancer mortality trends for males in Peru were stable over time (figure 6).[59,60] Among females, lung cancer mortality trends increased in Peru and in neighbouring countries, consistent with the pattern of females starting to smoke later than males in several low-to-middle income countries.[61] Although the described trends might follow expected patterns (eg, prostate and breast cancer), the low magnitude of the rates can probably be attributed to the low coverage of the Vital Statistics System. Future trends will be influenced by improved coverage of the system and by improved reporting and cancer control actions that will probably result from the Plan Esperanza.

Cancer-related research: information for action

In 2015, to align with the Plan Esperanza, INEN adopted a 5-year National Plan of Oncological Research, which sought to improve and promote cancer-related research, build cancer research capacity, and establish a national cancer research network in Peru.[62] This plan mentions

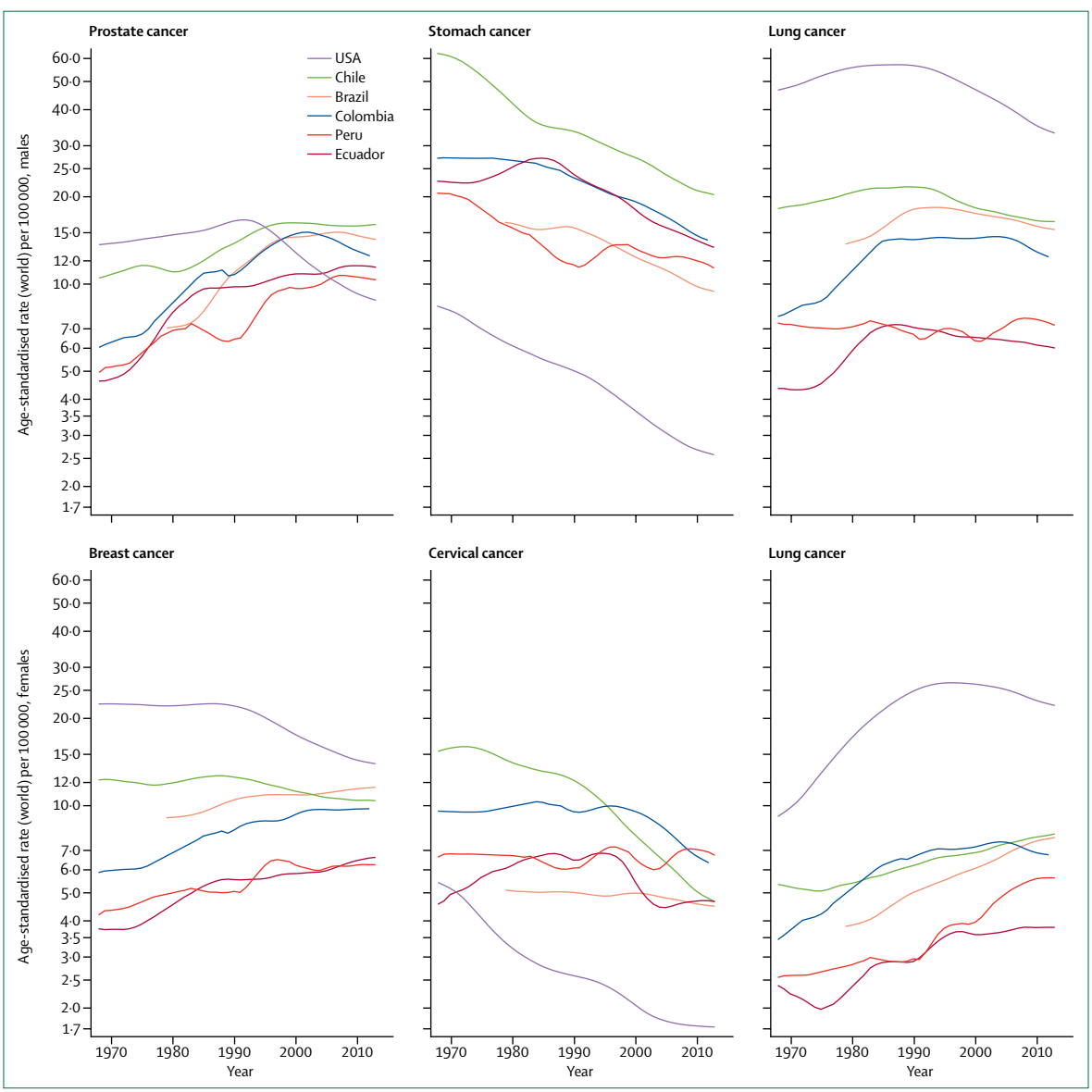

Figure 6: **Mortality trends of the most common cancers in Peru, neighbouring countries, and the USA (age-standardised rate per 100 000), 1968–2014**
Source: figure based on data from the International Agency for Research on Cancer (Cancer Mortality Database).[31]

some of the bibliometric studies that describe scientific research output in the fields of health and cancer in Peru. In a comparative study of 12 South American countries, Peru's scientific research output increased between 2001 and 2009, although it still lagged behind other countries on the continent.[63] This study also highlighted scientific collaboration between countries: Peruvian scientists predominately collaborated with US-based researchers, with only 8% of Peruvian researchers reported to have collaborations with South American countries. In 2010, only one Peruvian national biomedical journal was reportedly indexed in MEDLINE, despite an increasing number of Peruvian biomedical journals.[63,64] In a cancer-specific bibliometric study that covered scientific research output and collaboration in Peru from 2000 to 2011, from which 358 articles were published in health journals and indexed in Scopus or Science Citation Index Expanded, cervical cancer was by far the most studied cancer, followed by breast and stomach cancer.[65] INEN was the most productive institution, with 121 articles reporting authors affiliated with the institution.

Our search, which included articles both in English and in Spanish, and indexed in MEDLINE, LILACS, and SciElo between 2011 and 2015, identified 295 articles. Scientific research output increased each year from 52 articles in 2011 to 79 in 2015. Overall, the most commonly studied cancers were cervical (including HPV studies; 18·0%) and breast cancer (13·9%), followed by stomach (10·5%) and colorectal cancer (6·1%). In 2011, stomach cancer was the most studied cancer, while in 2012 it was cervical cancer. By 2015, breast cancer was the most commonly studied cancer. The most common studies were narrative reviews (24·1%), followed by cross-sectional studies (13·9%), and case reports (12·5%). Randomised trials represented 3·4% of the scientific output, with most published in 2015. INEN was affiliated, either alone or in collaboration, with 24·4% of the articles, and was the most productive institution, followed by the Universidad Peruana Cayetano Heredia (12·5%) and the Ministry of Health (9·8%). The Universidad Peruana Cayetano Heredia houses CRONICAS—a centre of excellence for NCD research.

Improving data for cancer control

This Series paper provides a foundation of useful information (both from surveillance systems and research activity perspective), which can be used to inform cancer control initiatives in Peru. However, intensified efforts are needed to improve coverage, data quality, and the use of these sources for planning purposes. To ensure international data quality standards are met and that data are used for the assessment and revision of the national cancer control plan, the provision of support for the existing population-based cancer registries in Peru is crucial. Such registries are the only means by which to obtain cancer incidence, yet sustainability of population-based cancer registry in terms of quality and existence remains one of the major challenges in low-income and middle-income countries.[66,67]

As discussed earlier, the Trujillo Cancer Registry was closed in 2002, despite having collected 10 years of high-quality data. A funding model in which registries are supported by different institutions, including universities, should be considered, and has been shown to be sustainable in Colombia.[66] The provision of high-quality information by population-based cancer registries provides invaluable benefits in the assessment of the effect of cancer control interventions for the resources expended.[16] In this context, the feasibility of reviving the Trujillo Cancer Registry should be discussed by relevant stakeholders. The International Agency for Research on Cancer-led Global Initiative for Cancer Registry Development can provide support to registries, mainly in the form of technical support and training through the Latin American hub.[18]

The mandatory cancer data reporting system provides useful information for the characterisation of the cancer cases and patient flow in the public health system in Peru—a required element of the Plan Esperanza. Nonetheless, the mandatory system needs to be integrated with the existing population-based cancer registries to ensure regular data delivery. Caution would need to be exercised if data from the mandatory reporting system were to be used for the estimations of national cancer incidence rates, because the system relies exclusively on passive data reporting and only captures data from public hospitals and, therefore, does not comply with the requirements of the multiple-source population-based cancer registries.[17] National incidence estimates derived from the mandatory reporting system would not truly be population-based and, when presented alone, could be misleading. A similar mandatory cancer reporting system exists in Colombia, the purpose of which is to evaluate the distribution of high-cost diseases among the different health insurance companies within the health system to reduce associated financial risks, rather than to obtain cancer incidence.[68]

For more on **CRONICAS** see https://www.cronicas-upch.pe/

Cancer mortality and incidence constitute major components of cancer surveillance. Peru needs to address the improvement of vital statistics as a matter of urgency,[28,69,70] and mortality data should be provided to the population-based cancer registries. The integration of cancer registries into the existing surveillance systems, which has been suggested to be a key element for the improvement of cancer registration,[18] is particularly feasible in Peru, given the already implemented sub-systems by the Ministry of Health. Finally, a substantial amount of local research, particularly in infection-related cancers (eg, stomach and cervical cancer) has been done in Peru, and has provided the cancer control programme and activities with important information.

Search strategy and selection criteria

We searched MEDLINE, LILACS, and SciELO for studies of Peru of the most common cancers using the terms "Peru", "cancer", stomach cancer", "cervix cancer", "breast cancer", "lung cancer", and "gallbladder cancer". Articles published between Jan 1, 2011, and Dec 31, 2015, and written in English or Spanish, were included. Initially, 510 articles were identified: 183 with LILACS, 220 with MEDLINE, and 97 with SciELO. After duplicates were removed, 295 articles remained and were included for review in this Series paper.

Conclusion

The striking demographic transition in Peru over the past five decades has resulted in cancer playing a major role in the overall burden of disease for the country, where both communicable diseases and NCDs are prominent. With prostate and breast cancer now the most common cancer types, closely followed by stomach and cervical cancer, Peru is faced with the double burden of infection and western lifestyle-associated cancers. The most frequent cancers show clear geographical variations, which is consistent with existing research evidence; however, the higher gallbladder cancer mortality rates observed in the southern part of Peru deserve further study.

Despite local research efforts in cervical cancer prevention, the cervical cancer mortality trends indicate that more attention is needed. Early detection activities need to be revisited and reshaped into a formal detection programme. Besides a strong hospital-based cancer reporting system in public institutions, Peru has valuable surveillance strategies that serve to inform cancer control actions across disease domains. These include household surveys, subnational population-based cancer registries, and national vital statistics.[70] Nevertheless, efforts to ensure their sustainability, complementarity, and the attainment of high-quality international standards are needed,[71,72] and should be accompanied by extended dissemination and use.

We hope that the findings presented in this Series paper, alongside the fourth paper in this Series[73] on oncological services, capture the most relevant elements of cancer in Peru and invite the necessary players to set new cancer prevention, research, and control priorities for the country.

Contributors

All authors contributed information, interpreted findings, and reviewed and approved the final version of the Series paper. MP and FB were responsible for the conceptualisation of the article. MP, FB, and GA did the literature search. LEM and EP provided and helped in the interpretation of data from the population-based cancer registries of Arequipa and Lima, respectively. WR provided, analysed, and helped in the interpretation of mortality data by department. MP, SA, and WR were responsible for the figures and tables. MP, SA, GA, LEM, JJM, EP, WR, and FB were responsible for writing the Series paper.

Declaration of interests

We declare no competing interests.

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