Lost Productivity Attributed to Neoplasms in South America

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Perda de Produtividade Atribuída a Neoplasias na América do Sul

Pérdida de Productividad Atribuida a Neoplasias en América del Sur

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ABSTRACT

Introduction: The burden of the disease has been utilized in estimates of the impact of neoplasms, but lost productivity due to these diseases has not yet been explored. **Objective**: To estimate the years of productivity life lost (YPLL) and lost productivity due to premature cancer-related mortality in South American countries in 2019. **Method**: Mortality data available from Global Burden of Disease (GBD) Study 2019 was analyzed to estimate the burden attributable to neoplasms. The lost productivity in monetary terms was estimated using a proxy of the human capital approach (HCA). Calculations were performed by sex, in working age groups. **Results**: The total deaths and YPLL reached 192,240 and 2.463.155, respectively. The total permanent lost productivity was around US$ 4.4 billion and US$ 9.4 billion in purchasing power parity (PPP) – 0.13% of the continent's gross domestic product (GDP). Total cost per death was US$23,617. There were significant differences among countries, but the variation of scenarios shows robustness of the estimates. **Conclusion**: Cancer imposes a significant economic burden on South American countries., both in terms of health and productivity. Its characterization can help governments to allocate resources for policies planning and health interventions.

Key words: cost of illness; neoplasms; disability-adjusted life years; South America.

RESUMO

Introdução: A carga da doença tem sido empregada em estimativas do impacto das neoplasias, mas a perda de produtividade em razão dessas enfermidades ainda não foi tão explorada. **Objetivo**: Estimar os anos de vida produtiva perdidos (AVPP) e a perda de produtividade por conta da mortalidade prematura relacionada ao câncer em países da América do Sul em 2019. **Método**: Dados de mortalidade disponíveis no *Global Burden of Disease* (GBD) *Study 2019* foram usados para estimar a carga de doença atribuível a neoplasias. A perda de produtividade em termos monetários foi calculada usando um *proxy* da abordagem do capital humano (ACH). Os cálculos foram realizados por sexo, nas faixas etárias de trabalho. **Resultados**: O total de óbitos foi de 192.240 e o de AVPP, 2.463.155. A perda total de produtividade permanente foi de US$ 4,4 bilhões e US$ 9,4 bilhões em *purchasing power parity* (PPP) – 0,13% do produto interno bruto (PIB) da região. O custo total por morte foi de US$ 23.617. Houve diferenças significativas entre os países, mas a variação dos cenários mostra robustez das estimativas. **Conclusão**: O câncer impõe um ônus econômico significativo à América do Sul tanto em termos de saúde quanto de produtividade. Sua caracterização pode subsidiar os governos na alocação de recursos destinados ao planejamento de políticas e execução de intervenções de saúde.

Palavras-chave: efeitos psicossociais da doença; neoplasias; anos de vida ajustados pela incapacidade; América do Sul.

RESUMEN

Introducción: Se ha utilizado la carga de enfermedad en las estimaciones del impacto de las neoplasias, pero aún no se ha explorado la pérdida de productividad por estas enfermedades. **Objetivo**: Estimar los años de vida productiva perdidos (AVPP) y la pérdida de productividad debido a la mortalidad prematura relacionada con el cáncer en los países de la América del Sur en 2019. **Método**: Datos de mortalidad disponibles del *Global Burden of Disease* (GBD) *Study* 2019 fueron utilizado para estimar la carga de enfermedad atribuible a las neoplasias. La pérdida de productividad en términos monetarios se calculó utilizando un *proxy* de enfoque de capital humano (ACH). Los cálculos se realizaron por sexo, en los grupos de edad laboral. **Resultados**: El número total de muertes fue de 192.240 y de AVPP, 2.463.155. La pérdida total de productividad permanente fue del orden de US$ 4.400 millones y US$ 9.400 millones en *purchasing power parity* (PPP) – 0,13% del producto interior bruto (PIB) de la región. El costo total por muerte fue de $23,617. Hubo diferencias significativas entre países, pero la variación de escenarios muestra la robustez de las estimaciones. **Conclusión**: El cáncer impone una carga económica significativa a América del Sur, tanto en términos de salud como de productividad. Su caracterización puede apoyar a los gobiernos en la asignación de recursos para la planificación de políticas y ejecución de intervenciones en salud.

Palabras clave: costo de enfermedad; neoplasias; años de vida ajustados por discapacidad; América del Sur.

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INTRODUCTION

Annually, many premature sickening and deaths are associated with neoplasms[1,2]. In 2020, according to the International Agency for Research on Cancer (Iarc)[1], nearly 20 million new cases and ten million deaths by diseases occurred in the world, 714,314 in Latin America and Caribbean (LAC).

The cost of cancer is a function of the burden of disease and technological progress[3]. If the number of new patients increases health expenditures with diagnosis and treatment mostly, the decline of mortality for working-age population reduces the loss of productivity[3]. Its burden in LAC, especially in South America, is increasing in recent years due to population ageing, changes of lifestyle and epidemiological transition[4-8]. Low and middle-income regions with great population disparities have difficulty in precisely determining the health burden (incidence, prevalence and mortality by cancer), since reliable populational and epidemiological estimates are scarce[7].

The burden of the disease has been utilized to estimate the impact of neoplasms[9,10], but lost productivity was poorly investigated in LAC[4,6,11] so far. Further to the public health impact, cancer generates direct and indirect costs for individuals and society, the indirect include losses in labor productivity attributable to morbidity and mortality[12,13].

Estimates of lost productivity with social imputation to disease burden can be used to ensure additional understanding and identification of health priorities and management of decisions to prevent and treat neoplasms[14]. The human capital approach (HCA) is the most common method to value lost productivity as the amount of working-time reduced by the infirmity utilizing wages, the ratio of participation in the workforce (WF) and unemployment rate (UR)[14].

International comparative studies on cancer costs are rare and rarer in LAC[4,5,8]. The objective of the present study is to provide estimates of lost productivity in 2019 due to mortality by neoplasms in South American countries.

METHOD

Population-based, exploratory, quantitative, cross-sectional study estimating permanent lost productivity associated with deaths by neoplasms in working-age population in South America in 2019.

The Global Burden of Disease (GBD) Study 2019[9] estimates on the incidence, prevalence, mortality, years of lost life, years lived with disabilities and disability-adjusted life-years due to 369 diseases and injuries per sex for 204 countries and territories were utilized[9]. The metrics were obtained from the website of the Institute for Health Metrics and Evaluation (IHME)[15] where it is possible to access the Global Health Data Exchange (GHDx), catalog of researches, vital statistics and other health-related data. This tool summarizes several sources of data utilized to estimate mortality, causes of death and disease and risk factors of GBD 2019. The deaths in 2019 were collected by country, cause – Neoplasms (code B.1), age-range, sex, in absolute numbers, rates/100 thousand inhabitants and percentage[15,16].

The economic data about the participation in the WF, employment rate (ER) and minimum-wage per month for each country in US$ and purchasing power parity (PPP) were obtained from the site of the International Labor Organization (ILOSTAT)[17], like the working-age population per sex and age-range. The retirement ages in different countries were obtained from *Asociación Internacional de la Seguridad Social* (ISSA)[18], *Comisión Económica para América Latina e Caribe* (CEPAL)[19] *Banco Interamericano de Desarrollo* (BID) through *Organización para la Cooperación y el Desarrollo Económicos* (OCDE) and World Bank (WB)[20]. The Gross Domestic Product (GDP) per capita referred to 2019 and health expenditures are available at the WB database[21].

The economic burden or lost productivity is a relevant metric of the burden of disease evaluating not only clinical-epidemiological aspects but the social and economic burden of the infirmity[13].

A proxy of HCA[12-14] was utilized to estimate the permanent lost productivity associated with neoplasms in South America in working-age groups (15-69 years of age) per sex for 2019, the result of the multiplication of the time lost valued at market wage[13,14,22]. For each death by cancer of individuals in working-age, years of productive life lost (YPLL) were calculated as the difference between the retirement age and age of death by cancer (the mean point of the age-range)[23]. In Brazil, for instance, retirement age is 65 years for men and women. For the first age-range between 15 and 19 years, 48 years are necessary to reach the minimum age, result of 65 minus 17 years. This was done for all age-ranges (15-19; 20-24, ..., up to minimum age for retirement) and the value found was multiplied by the number of individuals who die within the age-range. This product was added to the 15-24 age-range and older than 25 years.

The number of individuals in the WF and off-workforce (OWF) per sex and country have been collected from the databases of the World Bank Group[21] and ILOSTAT[17]. Individuals OWF are those in working-age during the period investigated (unemployed or not employed). Working-age population is usually defined

as those aged 15 or more, varying for each country (in addition to the minimum threshold, some countries utilize maximum age). The values of WF and OWF were added and utilized as denominator of the indicator of proportion of WF where the numerator was the WF. ER (employment rate) was calculated by the UR.

The product of the sum of potential years of life lost (PYLL), the proportion of the WF, ER, annual minimum wage and in PPP per sex for each country for the working-age population was calculated to obtain the total cost of the permanent lost productivity related to cancers in South America. The PPP is different for each country as it considers diverse wage purchasing power allowing better comparisons of income among them. An annual growth rate of 2% was considered for the minimum wages[12].

The analyzes were performed in Microsoft Excel® version 365 and presented as: (a) total cost of lost productivity; (b) cost of lost productivity by death (total cost divided by the number of deaths by neoplasms for working-age population; (c) rate between costs for men and women by death (cost of men's death divided by cost of women's death); and (d) total cost of lost productivity as proportion of GDP (total cost divided by GDP of 2019 for each country)[12,21].

A discount rate of 3% was applied[2,12], it estimates the cost incurred or result achieved at t1 compared with the current moment t0[12]. The results were converted to US$ dollars[24] of 2019 with exchange rates of PPP[12].

Because only secondary deidentified data were utilized in compliance with Directive 466 dated December 12, 2012[25] of the National Health Council, the Institutional Review Board (IRB) analysis and approval was waived.

Alternative scenarios to analyze the evolution of lost productivity for Latin American countries were designed, adding five years to the retirement age (individuals do not stop working when reach the retirement age due to their needs), changing the tendency of the epidemiological data by death (utilizing the values of the confidence interval of GHDx)[15] and modifying the discount rates (0 to 6%) (different ranges compared to the hypothesis of what the social cost is).

RESULTS

Latin America is large and diverse, accounting for 6% of the world population[21] and GDP of US$ 3,413,677,000,000. Approximately 550 thousand deaths were reported in 2019, (5.5% of the global deaths by cancer) for all ages with significant differences among countries, age-ranges and sex. Table 1 shows the inputs of socioeconomic, demographic and deaths by cancer for each country.

Table 2 portrays the deaths, YPLL, proportions of WF, ER and lost productivity utilizing nominal minimum wages in PPP and in American dollars for both sexes after the application of the discount rate, cost by death related to cancer, cost by death for men and women and total cost as percent of GDP. When official data on income or wages for Venezuela[17,19,20] were missing, the calculations of lost productivity by neoplasms for Latin America did not include these losses.

In 2019, Latin America reported 192,240 deaths in the working-age group and lost productivity in the subcontinent associated with neoplasms was approximately US$ 4.4 billion. In PPP, it reached more than US$ 9.3 billion.

Brazil has the highest PYLL (1,352,589 years), with the biggest total lost productivity (US$ 2,146,964,974) and Suriname, the lowest PYLL (2,708 years) and lowest loss (US$ 5,401,581). The 12 Latin American countries jointly reported 2,463,155 YPLL in 2019 and Brazil accounts for nearly 55%. In this same year, deaths by neoplasms of the working-age group reached 192,240, Brazil (108.081) and Argentine (27,499) accounted for 56% and 14% respectively, both countries with the largest subcontinent population (Table 1).

The total cost of lost productivity in Latin American countries in 2019 was US$ 4,399,112,929, and nearly US$ 9,4 billion in PPP. Brazil and Argentine revealed the highest lost productivity (US$ 2,146,964,974 and US$ 712,999,954 respectively) and in PPP (US$ 4,104,693,718 and U$ 1,856,905,191) and by sex. Brazil alone accounts for nearly 50% of the value referred to South America. The lower losses were in Guyana (US$ 5,739,833) and Suriname (US$ 5,401,581). In PPP, the lowest were recorded for these same countries, US$ 9,293,262 in Guyana and US$ 11,070,483 in Suriname, with the lower population of subcontinent.

The permanent lost productivity in 11 of 12 Latin American countries in 2019 represented 0.13% of the joint GDP. There are important variations among them, a larger portion of the GDP of Bolivia and Paraguay was assigned to cover costs related to lost productivity (0.26% and 0.27% each one) while Guyana and Chile spent 0.10% each and Brazil, 0.11%. The costs by death in Ecuador (US$ 41,785/death) and Uruguay (US$ 36,735/death) were 2-fold higher than Brazil and Guyana (US$ 19,864/death and US$ 16,168/death). For Latin America, the cost by death was US$ 23,616.

The estimates by sex show important differences among the countries. Deaths of men in working-age (96,141) are slightly higher than women (96,099) in the subcontinent. In the most populous countries Brazil and Argentine, men die more than women, in less populous

Table 1. Demographic baseline, mortality by cancer and economic inputs for Latin America, 2019

Country	Total population[a]	Total deaths by cancer* (n)[b]	Life expectancy at birth (years)[a]	Monthly minimum wage in US$ (2019)[c]	Minimum wage in PPP US$ (2019)[c]	GDP (x million US$) [d]	Sex	Individuals off-WF x 1.000[a,c]	Individuals in the WF x 1.000[a,c]	Unemployment rate (%)[c]	Age of retirement (2019)[d,e]
Argentine	44,938,712	85,208.5	76.6	350	813	452,819	W	8,737	8,796	10.7	65
							M	4,671	11,561	9.2	65
Bolivia	11,513,102	14,034.8	71.5	307	786	40,895	W	1,573	2,435	4.4	60
							M	768	3,209	3.4	60
Brazil	211,049,519	266,014.4	75.8	253	443	1,873,288	W	39,871	45,756	14.5	65
							M	22,461	58,620	10.1	65
Chile	18,952,035	31,648.3	80.1	428	726	278,585	W	3,938	3,858	8	65
							M	2,229	5,232	6.7	65
Colombia	50,339,443	49,460.1	77.2	252	602	323,110	W	8,827	11,234	12.8	54
							M	3,840	15,050	7.9	59
Ecuador	17,373,657	17,626.6	77.0	394	755	108,108	W	2,887	3,442	4.6	65
							M	1,361	4,869	3.3	65
Guyana	782,775	780.4	69.9	212	437	5,174	W	163	120	15.1	60
							M	95	186	12.5	60
Paraguay	7,044,639	6,140.6	74.2	351	874	37,925	W	981	1,477	8.3	65
							M	396	2,134	5.4	65
Peru	32,510,462	33,395.2	76.7	279	534	228,326	W	3,678	8,600	3.7	65
							M	1,823	10,198	3.1	65
Suriname	581,363	715.6	71.6	234	634	4,221	W	117	97	11.1	60
							M	70	141	5.7	60
Uruguay	3,461,731	10,083.7	77.9	444	616	61,231	W	636	807	10.5	70
							M	373	937	7.2	70
Venezuela	28,515,829	34,771.2	72.0	NA	NA	NA	W	6,794	3,849	NA	55
							M	2,986	7,071	NA	60
South America	427,063,267	549,879.2	75.1			3,413,682					

Sources: [a]World Bank Group[21]; [b]GHDx[15] 2019; [c]ILOSTAT[17]; [d]*Banco Interamericano de Desarrollo*[20] , [c]CEPAL[19].
Captions: PPP = purchasing power parity; GDP = Gross Domestic Product; WF = workforce, W = women; M = men; NA = non-available.
(*) all age-ranges, except 0 to 1 year.
Note: Venezuela was not included in the calculation of total GDP.

as Guyana and Suriname, women in working-age die more. More than half of women's deaths in working age occurs in Guyana, whose death ratio men/women is 0.48, a quite expressive result.

The variations of lost productivity in PPP and nominally were relevant in Colombia and Uruguay, where lost productivity in men is 70% higher than women. In Colombia, for instance, the values in PPP for men were US$ 454,679,931 and for women, US$ 315,283,095. In Uruguay, these values were US$ 132,255,934 and US$ 83,941,992 for men and women, respectively. Peru and Paraguay had little difference of lost productivity in PPP for men and women, 1.03 and 1.05 respectively and Bolivia, a ratio of 0.76 indicating high loss for women. Nominal losses were lower in Peru (US$ 185,814,563 for men and US$ 181,323,126 for women) and Paraguay (US$ 52,919,493 for men and US$ 50,192,908 for women), and the highest losses by sex were in Colombia (US$ 130,184,528 for men and US$ 76,587,410 for women) and Uruguay (US$ 88,046,681 for men and US$ 55,365,450 for women).

The cost by death in the 11 countries analyzed was higher for men than women. The death ratio men/women were higher in Guyana and Colombia (2 and 1.72), while in Paraguay (1.07) and Uruguay (1.17) were the lowest.

Different scenarios were constructed from the results shown in Table 2: (a) values of the discount rate, (b)

Table 2. Estimate of PYLL due to neoplasms, deaths, proportion of WF and ER of Latin American countries per sex, age-range and working age, 2019

Countries and working age population	PYLL (years)		Deaths (n)		Proportion of the WF		ER	
	W	M	W	M	W	M	W	M
Argentine			13,372	14,127				
15-24	10,366.55	14,416.03	230	319	0.32	0.46	0.71	0.76
25+	158,165.43	141,863.60	13,142	13,808	0.55	0.78	0.92	0.93
Bolivia			2,308	1,328				
15-24	2,900.20	3,661.19	72	91	0.42	0.57	0.9	0.92
25+	25,581.89	13,433.84	2,236	1,237	0.68	0.9	0.97	0.98
Brazil			52,793	55,288				
15-24	43,394.87	60,281.90	963	1,333	0.5	0.62	0.68	0.77
25+	657,030.12	591,882.46	51,830	53,955	0.54	0.75	0.89	0.93
Chile			4,539	4,430				
15-24	2,824.01	4,595.76	63	102	0.29	0.34	0.8	0.81
25+	49,216.48	43,455.60	4,476	4,328	0.54	0.78	0.93	0.94
Colombia			5,218	5,158				
15-24	10,461.83	14,264.70	260	355	0.43	0.58	0.75	0.84
25+	75,837.85	69,260.80	4,958	4,803	0.59	0.86	0.9	0.94
Ecuador			3,640	2,660				
15-24	5,746.02	8,560.60	127	189	0.34	0.53	0.88	0.93
25+	47,814.60	32,273.18	3,513	2,471	0.61	0.87	0.97	0.98
Guyana			239	116				
15-24	248.76	237.15	6	6	0.4	0.57	0.67	0.77
25+	2,144.05	1,196.95	233	110	0.43	0.7	0.91	0.91
Paraguay			1,313	1,290				
15-24	1.627,79	2.393,76	36	53	0.58	0.66	0.8	0.88
25+	17.874,76	14.246,84	1277	1,237	0.73	0.9	0.95	0.97
Peru			6,840	4,949				
15-24	8.650,80	12.447,42	191	276	0.47	0.71	0.92	0.93
25+	88.613,20	61.485,52	6,649	4,673	0.65	0.89	0.97	0.98
Suriname			126	91				
15-24	151,89	156,49	4	4	0.28	0.47	0.6	0.81
25+	1.408,28	991,49	122	87	0.51	0.73	0.93	0.97
Uruguay			1,651	2,253				
15-24	744,13	1.170,27	15	23	0.42	0.52	0.68	0.76
25+	20.308,48	23.888,81	1,636	2,230	0.59	0.76	0.93	0.96
Venezuela			4,060	4,451				
15-24	8.564,05	6.379,69	214	157	0.19	0.51	0.83	0.88
25+	60.404,45	40.530,89	3,846	4,294	0.41	0.76	0.93	0.93
South America	1,300,080.49	1,163,074.92	96,099	96,141				

Source: GHDx[15].
Captions: PYLL = potential years of life lost; WF = workforce; ER = employment rate; W = women; M = men.

retirement age and (c) number of deaths with upper and lower confidence intervals from GHDx[15].

Work-related losses caused by premature deaths were estimated with different discount rates. Taking Argentine as example: at baseline, lost productivity is US$ 712,999,955 (Table 3). Without discount in nominal values, it would be US$ 958,382,376. The absolute difference is US$ 245,382,421, corresponding to an increase of 34%. Lost productivity was higher without discount and with discount of 6%, losses reduced for all countries.

Change of retirement age was tested. The variations were positive, the costs with permanent lost productivity increased because time of payment of social security by the WF was longer. Epidemiologic alterations were simulated utilizing mortality. Lost productivity increases with upper confidence interval of the number of deaths from GHDx[15], and if lower confidence interval is utilized, lost productivity declines for the entire Latin America.

DISCUSSION

The main results indicate a total cost of lost productivity related to cancer of nearly US$ 4.4 billion for Latin American economies (US$ 9.4 billion in PPP), accounting for 0.13% of the combined GDP of these countries (ranging between 0.06% and 0.27%). The costs by death reached US$ 23,617 in 2019. With different labor markets in terms of job offer, hours worked and wages, the comparison between GDP and lost productivity demonstrate the effect of these premature deaths: the potential impact on the economy and social losses arising from it[12,13]. More sensitive regions or with low socioeconomic indexes have high mortality rates[26]. A decline of lost productivity by premature death would be the consequence of the reduction of deaths for working-age population and a shift of the deaths to advanced ages due to increased survival.

Population and economic differences are deep in Latin American countries (GDP, WF, UR, retirement age)[17,20,21,27] able to impact the diversity of PYLL calculated and on the estimates of lost productivity. This heterogeneity is found also in many articles analyzing the distinct regions and countries[9,12]. Different settings indicate that local factors as change of WF, retirement age and deaths associated with these diseases are important to interpret the outcomes. As informal economy is a characteristic of countries in development[17,19,20,28], it is possible that the results of the present study underestimated total lost productivity.

Few studies addressing lost productivity related to neoplasms in Latin America and even in LAC were found[8,11,29]. Pearce et al.[12] estimated the lost productivity related to deaths in Brazil, Russia, India, China and South Africa (BRICS) and concluded that for the eight thousand deaths in Brazil in 2012, the total cost was US$ 4,647,822,021 (0.2% of the GDP), different from the present study regarding incidence and lethality of these diseases[1,26]. The authors utilized higher income *per capita* in the calculations and did not include melanomas and other skin cancers. Even though, the results are close in relation to proportionality and proximity.

There are distinct estimates than the ones presented. Khorasani et al.[2] estimated the PYLL and cost of cancer-related lost productivity by premature death in Iran in 2012 based on data found in Global Cancer Observatory (Globocan) and a discount rate of 3% with a total cost of US$ 1.93 billion of lost productivity. Hanly and Sharp[10] estimated PYLL and economic burden related to premature death by cancer in Ireland in 2009 reaching 509.5 million Euros or 0.3% of the GDP. A study conducted by Siqueira et al.[11] analyzed the economic burden of cancer on the Brazilian health system and societal between 2010 and 2015, calculating the costs of lost productivity related to morbidity, impairment and premature death with HCA (discount of 5%) without annual wage corrections. The total economic cost of cancer was US$ 59.7 billion in 2015 accounting for 1.7% of the GDP in the period and the indirect costs of mortality were of US$ 37,200,903,018 for the same year. The present study estimated for 2019 a total cost of US$ 2,146,964,974 of lost productivity. This asymmetry of the studies' results can be attributed to databases, methodologies, discount rates and utilization of other costs.

Comparing the present study with Hofmarcher et al.[3] which estimated the utilization of funds and main components of cancer costs in 31 countries of Europe in 2018, these authors revealed higher lost productivity in richer countries as they tend to register lower values of PYLL. The highest PYLL for Latin America were found in the four largest GDP (Argentine, Brazil, Colombia and Peru).

The comparisons among costs of lost productivity were more homogeneous when expressed in PPP (Table 3). This tool can be utilized as conversion of reported expenses in local currency into a common artificial currency (purchasing power parity), eliminating the effect of differences of price levels among the countries[30]. No study addressing lost productivity in PPP in Latin America in addition to the analysis already mentioned for BRICS was found[12].

The mean cost by death for the subcontinent was US$ 23,616 (US$ 20,709 for women and US$ 26,535 for men), equivalent to 0.13% of the GDP. The cost of deaths has important differences among countries and sex.

Table 3. Estimate of lost productivity due to neoplasms, costs by death and percent of GDP, Latin American countries, per sex and working-age population, 2019

Countries and working age population	Productivity lost in PPP minimum wage 2019 (US$)			Productivity lost in nominal minimum wage 2019 (US$)			Cost by death (US$ 2019)			Costs by death (rate M/W)	Total cost as % of GDP
	W	M	Total	W	M	Total	W	M	Total		
Argentine	803,767,461.48	1,053,137,729.56	1,856,905,191.04	311,086,620.16	401,913,334.68	712,999,954.84	23,264.03	28,450.01	25,928.21		
15-24	22,978,119.18	49,168,705.13	72,146,824.31	8,037,464.84	11,525,748.40	19,563,213.23	34,945.50	36,130.87	35,634.27	1.22	0.16
25+	780,789,342.30	1,003,969,024.44	1,784,758,366.73	303,049,155.33	390,387,586.28	693,436,741.61	23,059.59	28,272.57	25,730.49		
Bolivia	169,493,893.50	129,865,202.83	299,359,096.33	60,925,970.40	46,205,580.07	107,131,550.47	26,397.73	34,793.36	29,464.12		
15-24	10,340,073.58	18,108,761.26	28,448,834.84	3,355,615.79	5,870,665.94	9,226,281.73	46,605.77	64,512.81	56,602.96	1.32	0.26
25+	159,153,819.92	111,756,441.57	270,910,261.49	57,570,354.61	40,334,914.13	97,905,268.73	25,747.03	32,607.04	28,190.40		
Brazil	1,757,059,904.63	2,347,633,813.85	4,104,693,718.48	916,234,061.02	1,230,730,913.18	2,146,964,974.20	17,355.22	22,260.36	19,864.41		
15-24	78,433,624.31	152,986,929.03	231,420,553.34	36,402,812.33	70,955,642.86	107,358,455.18	37,801.47	53,230.04	46,758.91	1.28	0.11
25+	1,678,626,280.32	2,194,646,884.83	3,873,273,165.14	879,831,248.70	1,159,775,270.32	2,039,606,519.02	16,975.33	21,495.23	19,280.68		
Chile	221,038,108.19	288,605,199.13	509,643,307.31	120,227,166.01	156,971,374.39	277,198,540.40	26,487.59	35,433.72	30,906.29		
15-24	5,707,839.15	11,026,537.83	16,734,376.98	2,733,633.95	5,281,981.93	8,015,615.88	43,391.02	51,784.14	48,579.49	1.34	0.10
25+	215,330,269.03	277,578,661.30	492,908,930.33	117,493,532.06	151,689,392.47	269,182,924.52	26,249.67	35,048.38	30,575.07		
Colombia	315,283,095.38	454,679,931.11	769,963,026.49	76,587,410.67	130,184,528.24	206,771,938.91	14,677.54	25,239.34	19,927.90		
15-24	24,373,347.28	50,205,079.64	74,578,426.92	7,410,947.86	17,106,870.80	24,517,818.67	28,503.65	48,188.37	39,866.37	1.72	0.06
25+	290,909,748.10	404,474,851.48	695,384,599.57	69,176,462.81	113,077,657.44	182,254,120.24	13,952.49	23,543.13	18,671.66		
Ecuador	271,900,659.20	287,524,820.76	559,425,479.96	128,708,071.33	134,534,260.95	263,242,332.28	35,359.36	50,576.79	41,784.50		
15-24	15,576,048.07	38,228,832.29	53,804,880.35	6,601,739.65	16,195,808.34	22,797,547.99	51,982.20	85,692.11	72,144.14	1.43	0.24
25+	256,324,611.14	249,295,988.47	505,620,599.61	122,106,331.68	118,338,452.61	240,444,784.28	34,758.42	47,890.92	40,181.28		
Guyana	4,749,135.47	4,544,126.47	9,293,261.94	2,911,170.58	2,828,662.39	5,739,832.97	12,180.63	24,385.02	16,168.54		
15-24	349,598.84	545,817.45	895,416.29	155,448.89	242,272.09	397,720.98	25,908.15	40,378.68	33,143.42	2.00	0.1
25+	4,399,536.63	3,998,309.02	8,397,845.65	2,755,721.69	2,586,390.30	5,342,111.99	11,827.13	23,512.64	15,574.67		
Paraguay	137,932,329.91	145,025,851.47	282,958,181.37	50,192,908.65	52,919,493.42	103,112,402.07	38,227.65	41,022.86	39,612.91		
15-24	7,921,516.13	14,581,419.86	22,502,935.99	2,582,800.01	4,755,754.08	7,338,554.09	71,744.44	89,731.21	82,455.66	1.07	0.27
25+	130,010,813.77	130,444,431.61	260,455,245.38	47,610,108.64	48,163,739.35	95,773,847.98	37,282.78	38,935.93	38,096.20		
Peru	381,988,754.70	396,313,641.15	778,302,395.84	181,323,126.60	185,814,563.83	367,137,690.43	26,509.23	37,545.88	31,142.39		
15-24	23,969,793.16	52,667,541.43	76,637,334.59	10,170,543.22	22,351,992.63	32,522,535.85	53,248.92	80,985.48	69,641.40	1.42	0.16
25+	358,018,961.54	343,646,099.72	701,665,061.26	171,152,583.38	163,462,571.20	334,615,154.58	25,741.10	34,980.22	29,554.42		
Suriname	5,275,875.02	5,794,608.80	11,070,483.83	2,514,445.40	2,887,135.61	5,401,581.01	19,955.92	31,726.76	24,892.08		
15-24	194,133.35	453,241.28	647,374.63	65,359.52	152,494.05	217,853.56	16,339.88	38,123.51	27,231.70	1.59	0.13
25+	5,081,741.67	5,341,367.52	10,423,109.19	2,449,085.88	2,734,641.56	5,183,727.44	20,074.47	31,432.66	24,802.52		
Uruguay	83,941,992.45	132,255,934.52	216,197,926.98	55,365,450.85	88,046,681.31	143,412,132.16	33,534.49	39,079.75	36,734.67		
15-24	1,570,982.05	3,418,741.34	4,989,723.39	899,931.18	1,958,457.61	2,858,388.80	59,995.41	85,150.33	75,220.76	1.17	0.23
25+	82,371,010.40	128,837,193.18	211,208,203.58	54,465,519.67	86,088,223.70	140,553,743.37	33,291.88	38,604.58	36,356.37		
Venezuela											
15-24	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
25+	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South America	4,152,431,209.93	5,245,380,859.65	9,397,812,069.58	1,906,076,401.67	2,433,036,528.07	4,339,112,929.74	20,709.44	26,535.46	23,616.92	1.28	0.13

Source: GHDx[15].
Captions: PPP = purchasing power parity; GDP = Gross Domestic Product; M = men; W = women; NA = Not available.

Table 4. Percent of lost productivity in relation to the baseline scenario based in the variation of the discount rates, retirement age and number of deaths

Countries	With discount	Discount 6%	Actual retirement after five years of retirement age	Absolute number of deaths (upper CI)	Absolute number of deaths (lower CI)
	(%)	(%)	(%)	(%)	(%)
Argentine	34	-17	46	12	-6
Bolivia	33	-20	40	40	-37
Brazil	34	-20	39	6	-6
Chile	30	-19	45	10	-10
Colombia	34	-20	44	32	-27
Ecuador	41	-23	33	33	-25
Guyana	39	-23	27	35	-28
Paraguay	38	-22	36	35	-28
Peru	40	-23	32	37	-29
Suriname	36	-22	29	26	-21
Uruguay	31	-19	42	9	-9

Caption: CI = confidence interval.
Note: Venezuela did not submit data of lost productivity.

The results appear lower than the observed in other sites and regions. Khorasani et al.[2] found higher costs for men *versus* women (US$ 1.209 billion *vs*. US$ 722 million). The mean cost of premature death by cancer was US$ 40,946 for men and US$ 31,720 for women[2,3,10].

An Irish study referred to 2009[10] found higher costs of premature mortality by neoplasms in men (total cost of 332 million Euros, cost/death of 290,172 Euros, cost PYLL of 30,588 Euros) *versus* women (total cost of 117 million Euro, cost/death equal to 159,959 Euros and cost/PYLL of 14,628 Euros). Comparisons should be made cautiously due to methodological, populational and economic heterogeneity.

The first limitation of the study refers to the utilization of global health, economic and demographic data[15,19,20]. National registers tend to be more consistent but subnotification or missing data as occurred with Venezuela blocked its use. Difficulties related to the identification of information were reported by Hofmarcher et al.[3] to conduct multinational studies.

The present evaluation was focused to lost productivity with a quantitative description of the burden of neoplasms. Health direct costs and temporary lost productivity were not considered.

The utilization of minimum wages instead of mean income in the calculation is another limitation. For that region, the mean wages and minimum wages do not express well how wages and incomes are divided into different groups given that informal jobs are part of the reality[17] and the mean retirement age is different from the government-approved age. It is common the individual continues to work after retiring to complement its earning, therefore, the value calculated may be underestimated because productive life is longer than the official retirement age[13,28].

Critiques of HCA suggest that the values generated by lost productivity can be biased regarding standards of income. The lost productivity of economically disadvantaged groups, youngsters and women who receive low wages tend to be less valued with this approach. Even though, HCA is the most utilized method to calculate lost productivity[14,31].

This is the first study addressing estimates of lost productivity due to mortality by neoplasms for all Latin American countries which offer a complementary approach about the impact of the mortality. A rising number of countries has screening programs and national guidelines of treatment for many neoplasms[7,26,32], but information about the economic burden of these diseases are limited [4,5,8,33]. As opposed to developed countries, many neoplasms generating high lost productivity in South America can be prevented, early detected and/or treated.

The permanent lost productivity related to neoplasms is relevant with expressive individual or social impact with mean loss *per capita* of US$ 23,617 in working-age population and social loss of nearly US$ 4.4 billion for Latin America (US$ 9.4 billion in PPP).

CONCLUSION

Neoplasms bring an important economic and health burden and the characterization of the burden of lost

productivity can help governments to allocate funds to elaborate prevention policies and interventions.

To evaluate lost productivity favors international comparisons about the consequences of the disease and allows to find approaches to deal with them. The diversity of the estimates of lost productivity for Latin America can encourage social and economic discussions about gender inequalities, access to health services, screening and treatment programs in that region.

CONTRIBUTIONS

All the authors contributed substantially for the study design, analysis and/or interpretation of the data, wording and or critical review. They approved the final version to be published.

DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

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