

Social Burden and Economic Cost Estimation of Fatal Injuries in Workers Affiliated to Social Security in Ecuador: a Shared Challenge in Public and Occupational Health

Estimación de la carga social y el costo económico de las lesiones mortales en trabajadores afiliados a la seguridad social en Ecuador: un desafío compartido en salud pública y ocupacional



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Abstract

Introduction. Currently, there is limited knowledge on quantifying the labour and monetary losses due to work-related fatalities in developing countries.

Objective. To estimate the working years of potential life lost (WYPLLs) and economic losses (ELs) of workers affiliated to the social security system in Ecuador from 2014 to 2020.

Methodology. Administrative records of fatal injuries were provided by the General Insurance of Occupational Risks and data regarding workers and their wages were retrieved from the Statistical Employment Registry of Social Security. WYPLLs and ELs were calculated together to assess the impact on gross domestic product (%GDP) according to the place where the fatal accident occurred in men and women by age groups.

Results. During the study period, 123,121 accidents were recorded, of which 1,532 resulted in deaths (15-64 years). Consequently, 40,409 WYPLL were lost in the labor market, equivalent to 40.4 years per 1,000 workers. The ELs from premature worker deaths totaled 323.7 million USD, reducing GDP by -0.045%, with CFi exceeding WFi post-2016.

Conclusions. Policy adjustments should enhance occupational safety and address work-related travel fatalities, considering Ecuador's road safety challenges.

Keywords

Fatal injuries; workers affiliated; social burden; GDP.

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Declaration of interests

The authors have declared that there is no conflict of interest.

Data availability

All relevant data is in the article. For futher information, contact the corresponding author.

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Resumen

Introducción. En la actualidad, existe un conocimiento limitado sobre la cuantificación de las pérdidas laborales y económicas derivadas de las lesiones relacionadas con el trabajo en los países en desarrollo.

Objetivo. Estimar los años de trabajo de vida potencial perdidos (WYPLLs, por sus siglas en inglés) y las pérdidas económicas (ELs, por sus siglas en inglés) de los trabajadores afiliados al sistema de seguridad social en Ecuador entre 2014 y 2020.

Metodología. Los registros administrativos de lesiones mortales fueron proporcionados por la Dirección General de Riesgos Laborales, y los datos sobre los trabajadores y sus salarios se obtuvieron del Registro Estadístico de Empleo del Seguro Social. Los WYPLLs y ELs se calcularon conjuntamente para evaluar su impacto en el producto interno bruto (%PIB), según el lugar donde ocurrió el accidente mortal, desglosado por sexo y grupos de edad.

Resultados. Durante el período del estudio, se registraron 123.121 accidentes, de los cuales 1.532 resultaron en muertes (15 y 64 años). Como resultado, se perdieron 40.409 WYPLLs en el mercado laboral, lo que equivale a 40,4 años por cada 1.000 trabajadores. Las pérdidas económicas (ELs) debido a las muertes prematuras de los trabajadores sumaron 323,7 millones de USD, lo que representó una disminución del PIB de -0,045%, con el CFi superando al WFi a partir de 2016.

Conclusions. Los ajustes en las políticas deben enfocarse en mejorar la seguridad ocupacional y abordar las muertes relacionadas durante los desplazamientos por carretera, teniendo en cuenta los desafíos de seguridad vial en Ecuador.

Keywords

Lesiones mortales; trabajadores afiliados; carga social; PIB.

Introduction

Work-related injuries represent a significant social burden due to premature exit from the labor market as a result of disability and death. This burden is especially notable when deaths occur at a younger age [1]. Additionally, the loss of labor force result in a considerable economic impact, representing between 4% and 6% of the Gross Domestic Product (GDP) in most countries [2].

In the field of occupational health, various epidemiological indicators are used to analyze work-related fatal injuries [3]. While most of these indicators focus on the relative frequency of deaths from different causes in relation to the exposed working population over a given period, a recently noted alternative is the use of working years of potential life lost (WYPLLs) [4,5]. For example, if the age limit of 65 years (retirement) is taken as a reference, WYPLLs is obtained by subtracting the age at the time of death from this limit. Thus, if a worker dies at the age of 20, they would lose 45 years of potential labor market contribution (Example 1). Similarly, if a worker dies at 42, the loss would be 23 years (Example 2), and in the case of a worker who dies at 64, the lost contribution would be 1 year (Example 3). In total, the sum of WYPLLs for these three cases would be 69 years. However, as observed, the burden is greater for deaths occurring at younger ages (Example 1). Quantifying WYPLLs provides



a much broader perspective in terms of relevance for societal sustainability and economic development. On the one hand, it represents the loss of human capital in terms of years of working life due to a specific cause of death, reflecting the time a worker would have contributed to society had they not died before reaching life expectancy or retirement age. On the other hand, WYPLLs translate into monetary costs that negatively impact national productivity and GDP growth by reducing the years in which workers could have contributed to a country's economy [6].

Most studies have focused on estimating WYPLLs associated with various work-related causes [7,8]. However, few investigations have analyzed a breakdown by the place of occurrence. According to estimates from the International Labour Organization, there are 350,000 workplace deaths and 158,000 deaths during work-related road commutes each year [9]. Work-related road commutes have become a major unresolved occupational road safety issue, particularly affecting low- and middle-income countries [10]. A disaggregated analysis by place of occurrence, distinguishing between deaths occurring in the workplace and those during work-related road commutes, would enable the design of more targeted interventions to reduce the social burden of premature deaths and, consequently, their economic impact [8,11].

In the Republic of Ecuador, the minimum age for formal employment is 18 years. However, under exceptional circumstances, employment is permitted from the age of 15, provided specific requirements are met and the necessary authorization is obtained. Retirement is possible at the age of 65, contingent upon meeting the minimum required contributions. Regardless of age, occupational injuries, both fatal and non-fatal, are acknowledged by the social security system for compensation purposes. This includes accidents occurring while commuting to and from work, on secondments, as well as travelling for work-related purposes. As in other countries across Latin America, road accidents are among the leading causes of death in the working-age population [12]. It is plausible that the number of work-related commuting fatalities may surpass those occurring directly in the workplace due to increased exposure to road hazards, with significant differences likely across gender and age groups [13]. Despite the decreasing trend in the number of occupational accidents in the country, to our knowledge, there is no research quantifying WYPLLs by place of death in the working population affiliated with the social security system.

In this context, the objective of this study was to estimate the social burden and assess the economic impact of deaths by place of occurrence among workers covered by social security using administrative records available in the Republic of Ecuador. Specifically, the aim is to quantify WYPLLs and economic losses (ELs), as well as to estimate their impact on GDP. Based on the demographic distribution of workers affiliated with the social security system in the country (Supplement, S1), we hypothesize that there are significant differences in the location of occurrence by sex, with deaths occurring at the workplace representing the greatest economic burden and impact.

Methodology

Design and data

This study adopts a retrospective quantitative approach based on the analysis of secondary data. Since the administrative records of occupational accidents were not publicly accessible, the Observatorio Ecuatoriano de Seguridad y Salud en el Trabajo at the Universidad Espíritu Santo formally requested these records from the General Occupational Risk Insurance of the Ecuadorian Social Security Institute (IESS) and obtained them electronically. This source of



information has been used in previous studies on other occupational health issues in the country [14,15]. The nationally provided microdata included detailed information on the age and sex of the victims, as well as the place of death, covering the period from January 1, 2014, to December 24, 2020. Ethics committee approval was not required, as the records were anonymous. This study has formal authorization to use data from the General Occupational Risk Insurance for research purposes (No. IESS-DSGRT-2020-0151-OF).

Variables

Age threshold

In the absence of a consensus on the age limit for estimating WYPLLs [16], 64 years of age was established as the threshold for active working life, working capacity, and the standard retirement age [6]. Recent research on the mortality of working-age populations in Latin American countries used this age limit [17]. For the analysis, age was grouped into ten-year categories (15-24, 25-34, 35-44, and 45-64). Workers aged 65 years and older constituted 1.9% of the total fatalities, even though they made up 4.8% of the employed population, averaging 156,906 affiliated workers throughout the study period (Supplement, S2).

Categorization of place (death)

As variables resulting from work accidents, fatal injuries in the workplace (WFi) versus fatal injuries in commuting accidents (CFi) were considered, as established in the legal regulations in the country. This disaggregated analysis, according to the place of occurrence, allows us to more precisely identify the social burden that deaths represent. Workplace accidents are linked to occupation-specific activities and working conditions, whereas accidents during work-related commutes are influenced by external factors such as traffic, road infrastructure, and journey duration [11,18]. Given the limitations of the available information, the explanatory variables analyzed focused on sociodemographic characteristics, specifically sex and age. Despite these restrictions, these variables are suitable for comparing the social and economic burdens of WFi and CFi.

Indicators

The following outlines the indicators utilized to estimation the social burden in terms of WYPLLs and the economic impact expressed as a percentage of GDP. The calculation of WYPLLs is based on the classical approach proposed by Romeder & McWhinnie (1977) [7], adapted to assess workforce losses due to premature mortality. It involves summing the number of deaths in each age group, multiplied by the years remaining until the reference age:

WYPLLs =
$$\sum d_i \mathbf{x} (\mathbf{R} - \mathbf{W}) + \sum d_i \mathbf{x} (\mathbf{R} - i)$$

where:

- *d*_i represents the number of deaths at age *i*,
- R is the upper limit of working age, set at 64 years (retirement age), and
- W is the lower limit of working age, set at 15 years.



To identify the population groups with the highest social burden, WYPLLs rates were calculated using the following formula:

WYPLLs rate =
$$\left(\frac{\sum WYPLLs}{N}\right) \times 100,000$$

where:

• N represents the total study population within the 15–64 years age group (Supplement, S1).

Subsequently, the analysis aimed to determine the economic impact (ELs) that the country would forgo in terms of GDP (%) due to YWPLLs. This assessment considered two key elements: the average annual salary of workers affiliated with social security (Supplement, S3) and the annual GDP per capita in US dollars (Supplement, S4). The following formula provides a simplified estimate of the impact on GDP:

$$\% \mathbf{GDP} = \left(\frac{\mathrm{ELs}}{\mathrm{GDP}}\right) \mathrm{x} \ 100$$

where:

- ELs are calculated by multiplying WYPLLs by the average annual salary of socially insured workers aged 15–64 years. The annual salary serves as a measure to evaluate the purchasing power and income levels of workers, as well as to estimate the economic impact of productivity loss due to premature deaths resulting from work-related accidents [19].
- The annual GDP represents the market value of the final goods and services produced over a specific period, expressed in millions of USD. The loss of contribution from deceased individuals adversely affects consumption and investment, ultimately hindering economic growth.

By quantifying these losses, policymakers can better understand the long-term consequences of work-related fatalities and design targeted interventions to mitigate their impact.

Analysis

In addition to the previous estimates [9,10], the statistical analysis included trend analysis through the calculation of the slope value (S) to describe temporal changes (both downward and upward) and the statistical significance at the 95% level (p < 0.05). For data processing and statistical analysis, we used Microsoft Excel for Mac (version 16.78).

Results

The results of this study are presented in two sections. The first section focuses on estimating the social burden broken down by sex. This analysis highlights gender disparities in WYPLLs. The second section quantifies the economic impact of this social burden. This approach provides a comprehensive view of the socioeconomic cost of premature mortality.



Social burden

In total, the WYPLLs amounted to 40,409 between 2014 and 2020, of which 52.5% were attributed to CFi. Men accounted for 93% of the total WYPLLs. The temporal evolution of the study period is shown in Figure 1. Between 2014 and 2019, the WYPLLs exhibited a significant downward trend, with a more pronounced decrease in WFi (slope = -434.8; p = 0.004) compared to CFi (slope = -245.9; p = 0.003). In 2020, a notable reduction was observed compared to the previous year. Starting in 2016, the number of WYPLLs due to CFi exceeded that of WFi and remained high for the remainder of the period.





Notes. CFi = fatal injuries in commuting accidents; WFi = fatal injuries in the workplace.

The age group of 25–34 years showed the highest number of WYPLLs for both locations of occurrence, with 9,971 in CFi and 8,418 in WFi (Figure 2.1). However, the highest WYPLL rates were concentrated in the 15 to 24 age group (Figure 2.2).

Below are the estimated calculations of WYPLLs based on the place of death and stratified by age groups for both men and women separately. Among men (Table 1), there were general trends towards a decrease in WYPLLs, from 3,334 to 1,888 Cfi and from 4,615 to 1,844 CFi for WFi between 2014 and 2019. However, these reductions were not significant for certain age groups in men. The decrease in WYPLLs was not significant for the 45-64 age group for Cfi (p = 0.141) and for the 25-34 and 35-44 age groups for WFi (p = 0.184 and p = 0.055, respectively). In 2020, compared with 2019, the lowest reductions in WYPLLs were in the 45-64 age group for workplace deaths and in the 15-24 and 25-34 age groups during CFi. As for women (Table 2), WYPLLs for CFi showed a general trend of decrease, except for the age group 45-64, where there was a slight increase, but no significant change. WFi among women accounted for only 0.7% of WYPLLs, with a total of 12 deceased.

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Figure 2. Distribution of WYPLLs (2.1) and rate (2.2) by place of occurrence and age groups among workers affiliated with the social security system, Republic of Ecuador: 2014-2020.



Table 1. Trends in WYPLLs of men by place of occurrence and age groups workersaffiliated with the social security system by place of death and age groups, Republic ofEcuador: 2014-2020.											
Place	Year	2014	2015	2016	2017	2018	2019	Slopeª	P trend	2020	Pv⁵
CFi	15-24	668	979	801	534	623	445	-78.9	0.011	356	-20.0
	25-34	1656	1070	1311	1518	1587	828	-123.8	0.043	587	-29.2
	35-44	735	809	686	564	735	368	-43.9	0.024	98	-73.3
	45-64	276	428	285	266	124	247	-15.4	0.141	86	-65.4
	Total	3334	3285	3083	2882	3069	1888	-245.9	0.003	1126	-40.3
WFi	15-24	1024	1113	668	534	312	223	-83.8	0.006	134	-40.0
	25-34	2036	1484	1449	897	1380	828	-104.9	0.184	242	-70.8
	35-44	1005	980	490	466	686	613	-43.9	0.055	245	-60.0
	45-64	551	390	314	304	209	181	-43.8	0.002	171	-5.3
	Total	4615	3966	2920	2201	2587	1844	-354.8	0.001	791	-57.1

Notes. CFi =fatal injuries in commuting accidents; WFi = fatal injuries in the workplace; ^a Slope (2014-2019); ^b Percentage variation (2019-2020).



Table 2. Trends in WYPLLs of women by place of occurrence and age groupsworkers affiliated with the social security system by place of death and age groups,Republic of Ecuador: 2014-2020.

Place	Year	2014	2015	2016	2017	2018	2019	Slopeª	P trend	2020	Pv⁵
	15-24	134	89	0	89	45	45	-14.5	0.004	0	-100
	25-34	483	242	173	207	207	104	-34.8	0.002	0	-100
CFi	35-44	98	98	49	74	98	74	-2.9	0.041	25	-66.7
	45-64	19	57	29	29	38	29	1.4	0.453	10	-66.7
	Total	734	486	250	398	388	250	-48.5	0.012	34	-86.4
	15-24	0	0	45	0	0	0	-		0	-
	25-34	35	0	0	35	35	0	0.0	0.966	0	-
WFi	35-44	25	49	25	0	0	0	-		0	-
	45-64	19	0	0	10	0	0	-		9	-
	Total	78	49	69	44	35	0	-9.4	0.114	9	-

Notes. CFi =fatal injuries in commuting accidents; WFi = fatal injuries in the workplace; ^a Slope (2014-2019); ^b Percentage variation (2019-2020).

Economic impact

The ELs associated with premature deaths among workers affiliated with the social security system amounted to 323.7 million USD during the study period, representing an average reduction of -0.045% in the national GDP due to all WYPLLs. The ELs for CFi totaled 170.3 million USD (-0.024% of GDP), while WFi accounted for 153.4 million USD (-0.022% of GDP).

As shown in Figure 3, the ELs exhibited a downward trend between 2014 and 2019, with a more significant continuous decline for WFi (slope = -3.2; p = 0.002) compared to CFi (slope = -2.6; p = 0.016). However, starting in 2016, the ELs and associated GDP percentage for premature deaths from CFi surpassed and remained above those for WFi.



Figure 3. Temporal evolution of ELs and %GDP by place of occurrence, Republic of Ecuador: 2014-2020.

Notes. CFi = fatal injuries in commuting accidents; WFi = fatal injuries in the workplace.



Discussion

The objective of this study was to estimate the social burden and analyze the economic impact of premature mortality among workers affiliated with social security in Ecuador, differentiating by sex and place of occurrence. The findings highlight a significant burden in terms of working years of potential life lost (WYPLLs) and economic losses (ELs), with men accounting for the largest proportion of WYPLLs and a decreasing trend observed between 2014 and 2019. Additionally, a reduction in ELs associated with these deaths was noted, although significant differences were found depending on the place of occurrence.

Our results are consistent with those of other studies reporting on the social burden of workrelated premature mortality and the economic impact on national GDP. A study conducted in a state in Brazil estimated a total of 64,791.5 WYPLLs for the 2,137 deaths caused by workrelated injuries between 2000 and 2019 [20]. In Colombia, a total of 229,573 WYPLLs were quantified for the 7,968 deaths recorded due to work-related accidents between 2009 and 2021, representing an approximate economic loss of 2,236.34 million USD, equivalent to 0.112% of GDP in 2009 and 0.011% in 2021 [21]. A study conducted in Hungary revealed that among nearly 4.8 million people aged 30 to 64 in the workforce, the costs associated with the loss of working years due to premature death amounted to approximately 7.119 billion USD, representing 7.21% of the country's GDP [22].

The analysis reveals differentiated patterns in the place of occurrence based on sex and age groups. Men bear the greatest social burden of premature deaths, particularly those occurring in the workplace. This suggests greater occupational risk exposure compared to women, a phenomenon widely documented in the literature [2]. This pattern is primarily attributed to their higher presence in high-risk economic sectors such as construction, manufacturing, and transportation. In contrast, female mortality was higher during commuting than in the workplace. In many cases, their reliance on public transportation increases their exposure to additional road hazards, such as pedestrian accidents while traveling to work, reflecting greater vulnerability as road users [13].

Young workers showed the highest number of WYPLLs, which reinforces the indications of the International Labour Organization [3], empowering young people to act to protect themselves and their peers at work should be at the heart of strategies to improve the safety and health of these workers. On the other hand, the decrease in WYPLLs was not significant for the older workers, which may be an effect of higher levels of experience and the phenomena of the aging of the working population [23].

The economic costs associated with illness, disability, and premature death continue to play a pivotal role in health sector resource allocation decisions. This decline in productivity highlights the substantial social and economic costs tied to premature mortality. The reduction in the economic impact of this burden is linked to fewer WYPLLs and a corresponding decrease in GDP percentage, as noted in the ILO's World Employment and Social Outlook [3] report. The significant economic repercussions of premature workforce mortality underscore the urgent need for comprehensive occupational health and safety measures, emphasizing the value of preventive strategies and robust labor policies to alleviate this burden and potentially save billions in healthcare costs and productivity losses.

Despite the relevant findings obtained in this study, it is important to acknowledge certain limitations that may influence the interpretation of the results. The study relies on administrative records, restricting the analysis to the variables available in official databases. Incorporating additional variables would allow for a more detailed analysis. Moreover, in this context,



the actual number of fatalities may be significantly higher than reported in official records. Additionally, the study is limited to workers affiliated with social security, excluding a considerable portion of the Ecuadorian workforce, particularly those employed in the informal sector. This exclusion may affect the validity of the estimates regarding working years lost and the associated economic losses [12,15]. Future research could incorporate complementary data sources, such as statistical death records, to provide a more comprehensive understanding of the issue of fatal occupational accidents in the country.

Conclusions

The metrics used reveal the economic impact of WYPLL in percentage terms of GDP, allowing us to assess the magnitude of the effect of premature mortality on the country's economy. The differences observed according to place of occurrence by sex and age suggest the need for a new approach to public policies. Regarding future projects, it is essential to continue strengthening the improvement of safe and healthy work environments, and priority must be given to implementing more effective prevention programs to reduce deaths associated with work-related travel, which reflect road insecurity in Ecuador.

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Supplements

According to the Statistical Employment Register of Social Security (REESS), in the Republic of Ecuador, the Services sector accounts for 52.4% of workers affiliated with the social security system, followed by commerce with 18.3%, and manufacturing with 13.3%. Large companies (with more than 200 workers) employed 44.8% of the active workforce, while medium-sized companies represented 16.2%. Between 2014 and 2020, the number of affiliated workers decreased by an average of 38,467 annually, dropping from 3.29 million to 3.06 million. Workers aged 15–34 years remain predominant. However, since 2016, there has been a significant increase in the number of workers over 35, especially in the 45–64 age group. In terms of sex distribution, 57.4% were men and 42.6% were women.

S1 . Average number of workers affiliated to the social security system by sex and age groups (2014-2020).							
Sex	Age group	Average	95% CI				
	15-24	201504	145454 - 257556				
	25-34	543609	468953 - 618264				
Men	35-44	465276	413262 - 517290				
	45-64	561325	503198 - 619451				
	65+	99742	84559 - 114925				
	15-24	130245	112510 - 147980				
Women	25-34	415587	379433 - 451741				
women	35-44	357177	311189 - 403166				
	45-64	430550	369960 - 491139				
	65+	57163	39607 - 74719				

Note. Source: Statistical Employment Registry in Social Security (REESS), 2014-2020.

Of the 123,121 work-related injuries recorded by social security between 2014 and 2020, 99.1% occurred among workers aged 15–64 years. Of these injuries, 1.3% resulted in death, with 783 cases occurring during work-related commutes and 749 occurring in the workplace. Men recorded the highest number of deaths in both settings, with the age group of 25–34 years being the most affected. A chi-square test p-value of 0.520 indicated that there was no statistically significant evidence. This suggests that there are no significant differences in the distribution of accidents between work-related commutes and the workplace based on sex and age group.



S2 . Cumulative number of deaths by place of occurrence, sex, and age groups (2014-2020).						
Sex	Age group	WFi	CFi	Total		
	15-24	99	90	189		
	25-34	248	241	489		
Men	35-44	163	183	346		
	45-64	180	223	403		
	65+	16	13	29		
	15-24	9	1	10		
Women	25-34	41	3	44		
wonnen	35-44	21	4	25		
	45-64	22	4	26		
	65+	1	0	1		

Notes. Source: Data provided by the Seguro General de Riesgos del Trabajo of the Instituto Ecuatoriano de Seguridad Social. WFi = fatal injuries in the workplace. CFi = fatal injuries in commuting accidents

The distribution of the average annual salary in US dollars (USD) reveals gender disparities. While women earn more than men in the 15–34 age group, men surpass women starting at age 35, with the largest difference occurring in the 65 and older age group, where men earn an average of 9,023 USD, compared to 6,424 USD for women. Student's t-test revealed significant differences in means for the age groups 25-34 (p = 0.020), 45-64, and 65 years and older (p < 0.0001), with no significant differences observed in the 15-24 (p = 0.431) and 35-44 (p = 0.608) age groups.

S3 . Average annual salary in USD (2014-2020).							
Sex	Age group	Average	95% CI				
	15-24	5300	5162 - 5438				
	25-34	7937	7741 - 8133				
Men	35-44	9681	9365 - 9997				
	45-64	10122	9921 - 10323				
	65+	9023	8898 - 9148				
	15-24	5359	5218 - 5499				
Women	25-34	8343	8005 - 8681				
women	35-44	9160	8613 - 9707				
	45-64	8796	8491 - 9101				
	65+	6424	6326 - 6522				

Note. Source: Statistical Employment Registry in Social Security (REESS), 2014-2020.



According to estimates from the Economic Commission for Latin America and the Caribbean, Ecuador's GDP declined between 2014 and 2015, indicating an economic contraction. Beginning in 2017, the country began to show signs of recovery. However, in 2020, the economy faced a significant drop in GDP, declining by 10.9% compared with 2019, primarily owing to the impacts of the COVID-19 pandemic.

S4 . Annual GDP of Ecuador in millions of USD (2014-2020).						
Year	GDP					
2014	102.718					
2015	97.210					
2016	97.671					
2017	104.467					
2018	107.479					
2019	107.596					
2020	95.865					

Note. Source: Own estimates based on official sources from the Economic Commission for Latin America and the Caribbean.