Case Fatality Rate of COVID-19 and Association With Sociodemographic Characteristics of Populations in Ecuador, 2020

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Research Article

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Abstract

Background

COVID-19 has caused deaths worldwide affecting the most vulnerable population with different case fatality rates. Socioeconomic conditions have demonstrated a role regarding the spread of infections and mortality. Socioeconomic characteristics of Ecuador related to poverty, ethnicity and demographic characteristics increase the impact of COVID-19 in certain populations.

Methods

Objective

To analyze the influence of demographic factors on the COVID-19 case fatality rate (CFR) in Ecuador. **Design**: cross sectional study. **Setting** 24 provinces in Ecuador-221 cantons. **Population**: data including 233.277 confirmed COVID-19 cases of Ecuador. **Primary and secondary outcome measures** COVID-19 CFR and crude cause-specific death rate weight calculated using province-country level data from health ministry of Ecuador in data website.

Results

Ecuadors CFR is 4,03%, analyzed by cantons the CFR increases to a median of 5,75%, with cantons like Playas with a CFR of 32,39%. The morbidity rate has a median of 795,31 per 100 000 hab. with the highest rate in Isabela-Galápagos (10185,49), Aguarico-Orellana (9506,75) and Baños-Tungurahua (4156,85). And the crude COVID-19 death rate has a median of 39,73 per 100 000 hab. with the highest rate in Penipe-Chimborazo (201,29), 24 de Mayo-Manabí (143,79) and San Pedro de Huaca-Carchi (134,36). The correlations show relations with sociodemographic factors like poverty, ethnicity and scholarity.

Conclusion

The CFR is the proxy indicator of COVID-19 impact in Ecuador and the analysis made by location give us new information about the specific impact of this disease.

Background

SARS-CoV-2 virus identified as the cause of COVID-19, declared a pandemic since march 11, 2020(1); the virus was first identified in Wuhan, of the Hubei province in China, in December 2019, and become a major concern worldwide(2) .

COVID-19 is knows as a respiratory disease with rapid spread whose etiological agent is an RNA virus related to the coronavirus family; it remains unknown which animal is the intermediary host(3). The reproduction rate of SARS-CoV-2 has a R between 2,4 and 3,3 (4, 5), the most frequent symptoms are fever, cough and dyspnea(6).

According to the data collected towards the COVID-19 the information updated at march 15, 2021 shows a cumulative global cases of 119.956.955 people infected by the virus over 192 countries with 2.655.280 global deaths worldwide(7). The estimated global CFR is around 2,17%(7). In Latin America and the Caribbean the first case reported was in Sao Paulo, Brazil 25 February 2020.

The epidemiological presentation of COVID-19 is dynamic and changes over time; the most affected region at the beginning was Asia; nowadays, America is leading the chart, with US as the first country followed by Brazil; and becoming the region most affected of COVID-19(8).

On 2020, 232.370 cases of COVID-19 were identified in Ecuador and involved people from all 24 provinces of the country with severe cases of pneumonia due to SARS-CoV2 (severe acute respiratory syndrome coronavirus 2). On February 29, 2020 the first case of COVID-19 was reported; and Ecuador was the third country of the region to confirm a case(9). The first provinces to report

positive cases were Clusters of patients with COVID-19 located on the coast of Ecuador, a substantial number of critically ill patients were diagnosed. Since then, the number of cases identified had rapidly increased, mainly in Pichincha (Andean region), Guayas and Manabí (Coast region).

Epidemiological surveillance

Ecuador is the eighth country in Latin America of COVID-19 cases(10), and also has a very high case-fatality rate. The case fatality rate is a health proportion that relates the population with a disease and the deaths caused by the disease during an specific period of time; it is used to measure the impact of the disease on the population, and it has been used to evaluate COVID-19 impact as an epidemiological indicator(11). There is lack of published studies of country-level demographic characteristics on COVID-19 fatality rates. This article reviews the Ecuadorian experience with COVID-19 with emphasis on fatalities by location.

Socioeconomic conditions have demonstrated a role regarding the spread of infections and the impact on job loss, poverty increase and economic crisis. Our study concentrates on the statistical analyzes of the association between COVID-19 CFR and socioeconomic indicators.

The Republic of Ecuador is a country located in South-America, covers 276 840 km2 and its borders are Colombia and Peru. Composed by 3 continental regions: Andean, Coast, and Amazonia and one Insular region; Ecuador is divided by 24 provinces formed by smaller political divisions called cantons.

During COVID-19 pandemic a wide range of public health studies have been published, the factors that affects spread of the virus is one of the critical characteristics of COVID-19 that relays on the epidemic mechanism, mobility, and management strategies. Epidemiological statistical analysis is frequently used to show the correlations patterns of infectious diseases and environmental qualities of the population to identify clusters and prevent potential spreads(12–15).

An infectious disease surveillance is considered as a public health method that detects important risks and it is used to inform the planning of public health interventions or further investigations. At the outset of COVID-19 outbreak, the Ministry of Health (MSP) applied a surveillance system to collect information on all people with COVID-19 throughout the country according to the guidelines published by the World Health Organization (WHO) on January 30, 2020. The Emergency Committee-WHO declared that the 2019-nCoV is a PHEIC (Public Health Emergency of International Concern) so the MSP introduce in the national surveillance thorough the investigation chart “EPI 1”.

Data on all COVID-19 cases were obtained from all 24 Ecuadorian provinces. COVID-19 cases were identified by reverse transcriptase-polymerase chain reaction (RT-PCR) (16, 17). The fatality rate was defined as number of deaths in person who tested positive for SARS-CoV-2 divided by number of SARS-CoV-2 cases(18). The overall fatality rate of persons with confirmed COVID-19 in the Ecuadorian population (accessed: March 14, 2021), was 6,16% (14.371/233.227 cases). This rate is higher than observed in other countries of the region like Perú (3,3%), Brazil (2,6%), Panamá (1,7%) and Colombia (2,6%) and the factors related to this data needs to be further studied.

Methods

Data on COVID-19 – Ecuador (MSP) and literature search

The COVID-19 dataset used in this study was downloaded from the web page: https://public.tableau.com/profile/direcci.n.nacional.de.vigilancia.epidemiol.gica.msp#!/vizhome/COVID19ecu_MSP_DNVE/COVID-19MSP, accessed on march 13, 2021; which is a data maintained by the organization: MSP- Dirección Nacional de Vigilancia Epidemiológica and updated daily. The dataset contents country level data on confirmed cases, deaths, and testings. The data from sociodemographic indicators was downloaded from the Instituto Nacional de Estadisticas y Censos” (INEC) from the last national survey done on 2010.

We conducted a systematic literature research of online databases, the terms and relative varinas were as follows: COVID-19, 2019-nCoV; fatality rate. We also reviewed references included on articles for guaranteeing comprehension and accuracy of the data

collected.

Data extraction and quality assessment - Epidemiological rates

Data extraction and evaluation of literature quality were managed independently by two investigators (F.K and J.X). Microsoft Excel database was used to saved available information, including demographic data. The case fatality rate of COVID-19 was calculated as the number of total deaths due to COVID-19 divided by the number of total confirmed COVID-19 cases of year 2020, accessed on march 13 2021, multiplied by 100. It was calculated in this study as it might reflect the severity of COVID-19 and it is an indirect measure of the efficiency of healthcare response(19).

The morbidity rate of COVID-19 was calculated as the number of confirmed COVID-19 cases till December 31, 2020 divided by the total population multiplied by 100.000.

The crude cause-specific death rate of COVID-19 was calculated as the number of total deaths due to COVID-19 till December 31,2020 divided by the total population multiplied by 100.000(20), this epidemiological rates shows the impact of COVID-19 on the general population.

Statistical analysis of data

Microsoft Excel was used to calculate rates; SPSS 22.0 software was used to perform statistical analysis. The distribution had a $p < 0,001$ and the inferential analysis was made using Spearman correlation and Kruskall-Wallis.

Results

Descriptive characteristics of the variables

In total, 232.370 confirmed COVID-19 cases and 10.293 deaths from 24 provinces of Ecuador from Mars to December 2020 were included. A total population of 17 468 736. The national CFR calculated is 5,74% (Mdn = 4,04; Range = 32,39) with a morbidity rate of 1 172,63 (Mdn = 795,31; Range = 10 095,49); the average of confirmed cases by canton is 1051,45. The descriptive statistics of the 221 cantons by regions of the variables analyzed are shown in Table 1.

The provinces with the highest CFR are Santa Elena (14,04%), Chimborazo (12,02) and Guayas (9,89), the highest morbidity rate are in Galápagos (5099,47), Orellana (3045,79) and Pastaza (2448,73) and the highest crude mortality rate are in the provinces of Santa Elena (102,54), Manabí (86,55) and Carchi (86,25).

Table 1
Descriptive statistics

	Fatality rate (%)	Attack rate (x 1 000)	Crude Mortality rate (x 100 000)
Amazonic (41)	1,82* (DE ± 1,95)	14,91*** (DE ± 14,99)	27,96 (DE ± 25,85)
Coast (84)	8,26* (DE ± 5,08)	5,92*** (DE ± 5,36)	48,02*** (DE ± 36,29)
Insular (3)	0,63 (DE ± 0,67)	31,47*** (DE ± 44,44)	31,03 (DE ± 7,01)
Andean (93)	3,53*** (DE ± 4,17)	9,32*** (DE ± 8,00)	33,46*** (DE ± 32,11)
Kolmogorov-Smirnov * p < 0,05; ** p < 0,01; *** p < 0.001 N:221 cantons			
Source: Prepared by the authors for the present investigation.			

The variables calculated have an asymmetrical distribution, the analysis of variance shows that the highest variability is in morbidity rate, all calculated rates have positive asymmetry with leptocurtosis.

Fatality rate gender and population age

Ecuador has reported different case fatality ratios between different population age and gender. The Table 2 shows the age-specific fatality rate in Ecuador. The highest case fatality rate is among people > 65 years old (29,09%), being higher in male (34,65%). It calls the attention that the third position is in the group population less than 1 year old with a 3,73% of CFR (Table 2).

Table 2
Case fatality rate by age and gender in Ecuador, 2020

	Ecuador					
	Total		Female		Male	
	No. of deaths (% of total)	Case-fatality rate, %	No. of deaths (% of total)	Case-fatality rate, %	No. of deaths (% of total)	Case-fatality rate, %
All	14371	6,16	4817 (33,52)	4,35	9554 (66,48)	7,79
Age groups, y						
0	18 (0,13)	4,02	9 (0,19)	4,35	9 (0,09)	3,73
1–4	11 (0,08)	1,06	6 (0,13)	1,24	5 (0,05)	0,89
5–9	12 (0,08)	0,64	6 (0,13)	0,64	6 (0,06)	0,64
10–14	9 (0,06)	0,27	3 (0,06)	0,18	6 (0,06)	0,35
15–19	17 (0,12)	0,25	12 (0,25)	0,33	5 (0,05)	0,15
20–49	1401 (9,75)	0,99	426 (8,85)	0,63	975 (10,21)	1,31
50–64	4087 (28,44)	8,63	1252 (25,99)	5,56	2835 (29,67)	11,41
≥ 65	**8816 (61,35)**	29,09	**3103 (64,41)**	22,45	**5713 (59,8)**	34,65

Source: Prepared by the authors for the present investigation.

COVID-19 case-fatality rate distribution

A total of 221 cantons were included with 10.293 deaths and a fatality rate of 4,43%. The results of distribution of COVID-19 case-fatality rate of the 221 cantons is shown in Fig. 1. The mean and median case fatality rate are 5,75% and 4,04% respectively (Table 1), with the highest rate is in Playas-Guayas (32,39%), Colta-Chimborazo (25,33%) and Coronel Marcelino Maridueña-Guayas (22,23%), Guamote (18,48%) and Penipe (16,67%) (Fig. 1).

The cantons that had a CFR above 5,74% were 85 (38,5%), from the total of cantons 62 (72,9%) are located at the coast, 21 (24,7%) are located at the Andean region and 2 (2,4%) belong to the amazonic region. The Insular region showed a CFR less than the average.

Of the provinces with a CFR above the average the number of cantons that have a highest CFR are: 3 cantons in Santa Elena (100%), 20 cantons in Manabí (90,9%), 10 cantons in Los Ríos (76,9%), 19 cantons in Guayas (76%) and 7 cantons in Chimborazo (70%).

The correlation results between CFR and hovel housing type were moderate with a value of rho(219) = .517, p = < .001 (Table 3)

Table 3
Correlations with sociodemographic characteristics and CFR

		Correlation Coefficient $rho_{(219)}$
Sociodemographic	Average people/house	-0,127
	Population density	0,437***
	Average scholarity (ys)	-0,134*
	Rural %	-0,171*
	Poverty %	0,224**
	Economically inactive population %	0,362***
	Illiterate %	0,214**
Ethnicity (%)	Indigenous %	-0,328***
	Afroecuadorian %	0,289***
	Montubia %	0,452***
	Mestizo %	-0,16**
Housing type (%)	House	-0,168*
	Appartment	0,012
	Room	-0,166*
	Mediagua	-0,044
	Ranch	0,238***
	Hovel	0,517***
	Hut	0,116
	Other housing	0,1
Scholarity (%)	None	0,238***
	Alfabethization center	0,142*
	Preschool	0,247***
	Primary school	0,124
	Highschool	0,188*
	Basic education	-0,367***
	Bachillerato	-0,381***
	Post bachillerato	-0,172*
	College	-0,022
	Postgraduate	-0,082
	Not known	0,215**
Insurance type (%)	With insurance	-0,292***
	Without insurance	0,243***

Source: Prepared by the authors for the present investigation.

		Correlation Coefficient $rho_{(219)}$
Basic Services acess (%)	Drinking water	-0,173**
	No electricity	0,034
	Garbage management	0,011
	Excretal disposal	-0,218**
	Computer	-0,356***
	Conventional phone	-0,349***
	Mobile service	0,087
	Internet service	0,009
* p < .05; ** p < .01; *** p < .001		
Source: Prepared by the authors for the present investigation.		

Crude COVID-19 death rate

Distribution of crude COVID-19 death rate of the 221 cantons is shown in Fig. 2, 61 cantons have a Crude COVID-19 death rate above 58,92 (27,6%)(Fig. 2). The most affected region is the coast with 28 cantons (45,9%), followed by the Andean region with 24 cantons (39,3%) and the amazonic region with 9 cantons (14,8%).

The distribution of proportions by provinces are Santa Elena 3 cantons (100%), Santo Domingo de los Tsáchilas 2 cantons (100%), Carchi 5 cantons (83,3%), Manabí 15 cantons (68,2%) and Napo with 3 cantons (60%).

The mean and median crude death rate are 46,09 cases per 100.000 and 39,72 cases per 100.000 respectively (Table 1), with the highest rate in Penipe-Chimborazo (201,29), 24 de Mayo-Manabí (143,79), San Pedro de Huaca-Carchi (134,36), Playas-Guayas (134,17) and Rocafuerte -Manabí (134,01).

The 28 cantons with the highest crude mortality rate of the coast represent the 33,3% of the region, the 24 cantons of the Andean region represent the 25,8% and the 9 cantons of amazonic region are the 22% of the region.

Discussion

The overall case fatality rate calculated in Ecuador (4,43%) till December 2020 is substantially higher than in other countries of the region and higher than the worldwide case fatality(21). When data were stratified by age group, the case- fatality rate in Ecuador appear very similar for age groups 1 to 19 years, but rates are higher in Ecuador among male individuals aged 50 or older; also in the population less than 1 year old. The distribution of cases is extremely different analyzed by gender with a higher infection rate on males than females. The cause of perceived reduced susceptibility of females needs further investigation in order to improve protective measures.

The demographic characteristics of the Ecuadorian population differ from other countries. By 2020, approximately 8% of the Ecuadorian population was aged 65 years or older(22). COVID-19 has proved to have higher rates of mortality in older patients, in Ecuador. The epidemiological analysis shows that males have a higher fatality rate compared by gender as seen in the study of Long-quan et al, the reason for it requires further investigation(23).

COVID-19 fatality rates are challenging to assess with certainty; data from China, United Kingdom and Italy report a death rate around 0,7 to 1,3% (21, 24–26).

One of the best ways to know the impact of COVID-19 is mortality. Mortality has a wide variability among each country that probably depends on the health system response regarding effectiveness on testing policies, health system capacity and efficacy of

response to health emergencies(27). During the first reports made by Long-quan et al. the fatality rate among 1994 patients with COVID-19 was 5% (95% CI[0.01,0.11])(23).

The worldwide mortality rate is 3%. Salzberger el al. found a case fatality rate of 1,38% with their modell(28). However, this rate varies between countries (China:2,3; South Korea: 2,3; Italy: 13,1) related to population average age, age distribution and the health system capacity on diagnosis and epidemiological surveillance(21).

The mortality risk of COVID-19 shows higher rates related to aging; in China the mortality rate was less than 0,5% in patients younger than 50 years increasing to 16% in patients older than 80 years(6, 29–31). Elder patients, above 60 years show higher susceptibility to life-threatening complications derived from COVID-19 (32, 33).

Dong et al describe that children have a clinical progression and disease severity different from adults, as 90% have a mild or moderate disease; those who develop severe disease show having comorbidities that increase the mortality rate (34–36).

The CFR is not a constant epidemiological measure and it varies between populations, over time and it is modified by external factors like environment, treatments and quality of health care system(37). To report a worldwide CFR evolves multiple factors that need to be taken care of. Firstly, the capacity to diagnose due to the lack of sufficient laboratory test for COVID-19 patients. Secondly, the hessite of some COVID-19 patients to report their illness to the health system; the real values are difficult to get, and the data collection affects the fatality rate calculation(38).

In Italy the mortality was higher in patients aged 70–89(39), in Ecuador the highest mortality was around the same age but differs on the group of less than 1 year were the CFR is 4,02.

The highest rate of morbidity could be related to the surveillance strategy used in Ecuador, as the COVID-19 test are made only in symptomatic patients without the identification of patients with mild symptoms(38).

Regarding the preventive measures practice Bates et al. applied a binomial regression analysis which suggests that unemployed individuals, househusbands/housewives, or manual laborers, and individuals with elementary scholarity have lower levels of knowledge regarding COVID-19 which supports the correlation found between illiteracy and CFR by cantons and might be related to the access to official information about COVID-19(40).

During the early periods of COVID-19 in Ecuador Ortiz-Prado et al. found that men were at a higher risk of dying from COVID-19 and also it was higher in older individuals and the presence of comorbidities, as our study found the same relation regarding the sex and age(41).

Bolaño-Ortiz et al. found that the spread of COVID-19 through Latin America and the Caribbean region shows a correlation with socioeconomic indexes(42), the same correlation that we found in our study, the variables of poverty levels suggest that inequality is related to the spread of COVID-19.

Shammi et al. found a correlation of COVID-19 cases and deaths with economic indicators showing a significant correlation in between the urban poverty rate ($r = -0.77$; $p = 0.01$) and the urban extreme poverty rate ($r = -0.79$; $p = 0.01$), low poverty rates were related to higher rates of COVID-19 infection; explained by the people who have informal jobs in countries with lower Gini index values(43). It appears that there is a relation with inequality and heterogeneity in populations; Biggs et al. studied the impact on income level, inequality and poverty, health status depends on wealth distribution(44).

Poverty has proven to be a potential risk for COVID-19 and the incidence of infectious diseases are related to socioeconomic, environmental, and ecological aspects(45–47).

Education level, family income, occupation, ethnic and number of people living in a house have been considered socioeconomic factors with disparities in hospitalization for COVID-19(48).

Conclusions

In conclusion, the current data illustrates that Ecuador has a high morbidity and mortality rate of older patients with confirmed COVID-19 infection and that male population in Ecuador are more affected (1,98:1).

Within Ecuador, COVID-19 deaths mainly observed among older, male patients. The increase in the number of infected patients reflects a lack of medical resources.

However, these data are limited and were derived from the first year of documented COVID-19 cases in Ecuador; a more extensive and large-scale studies are required to identify factors related to fatality rate.

From a scientific perspective, the comparisons discussed highlight the need for transparency in reporting cases policies, with clear reporting of the denominators used to calculate case-fatality rates and the age, sex and location status of affected persons when comparing COVID-19 cases and mortality rates between different regions.

This is an important information for governments and non-governmental organizations to identify characteristics that are associated with high fatality rates to develop specific measures to prevent or intervene during this health crisis and diminish the consequences related to the burden of this disease.

This study has shown some relations between sociodemographic factors with mortality caused by COVID-19 at different levels which can guide policymakers to control and prevent the COVID-19 outbreaks(49–51).

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets analysed during the current study are available in the Tableau Public- Dirección de vigilancia epidemiológica repository,
https://public.tableau.com/profile/direcci.n.nacional.de.vigilancia.epidemiol.gica.msp#!/vizhome/COVID19ecu_MSP_DNVE/COVID-19MSP

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

KMFS	Major contribution, statistical analyze
GASDH	Guidance, discussion
JXJE	Statistical analyze
FGMPH	Dicussion

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Figures

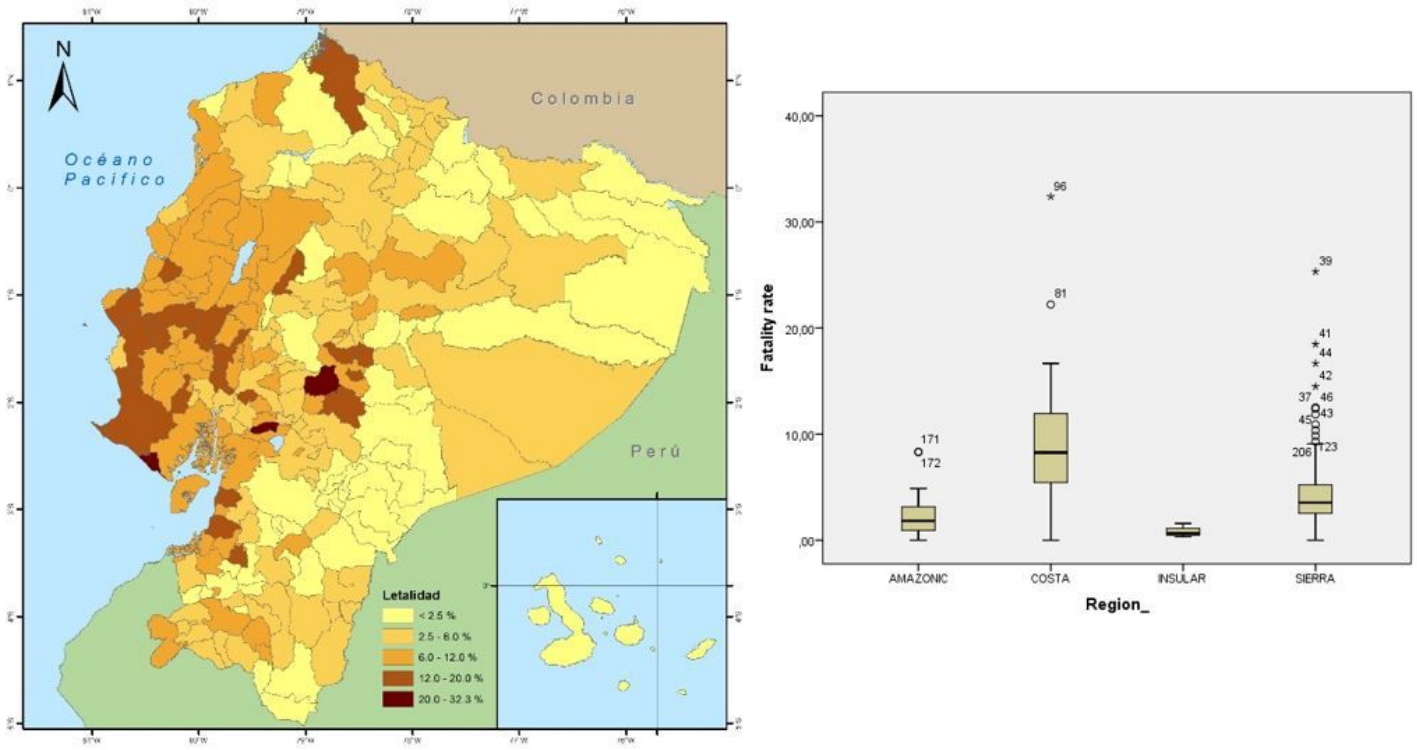

Figure 1

Case Fatality rate distribution Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

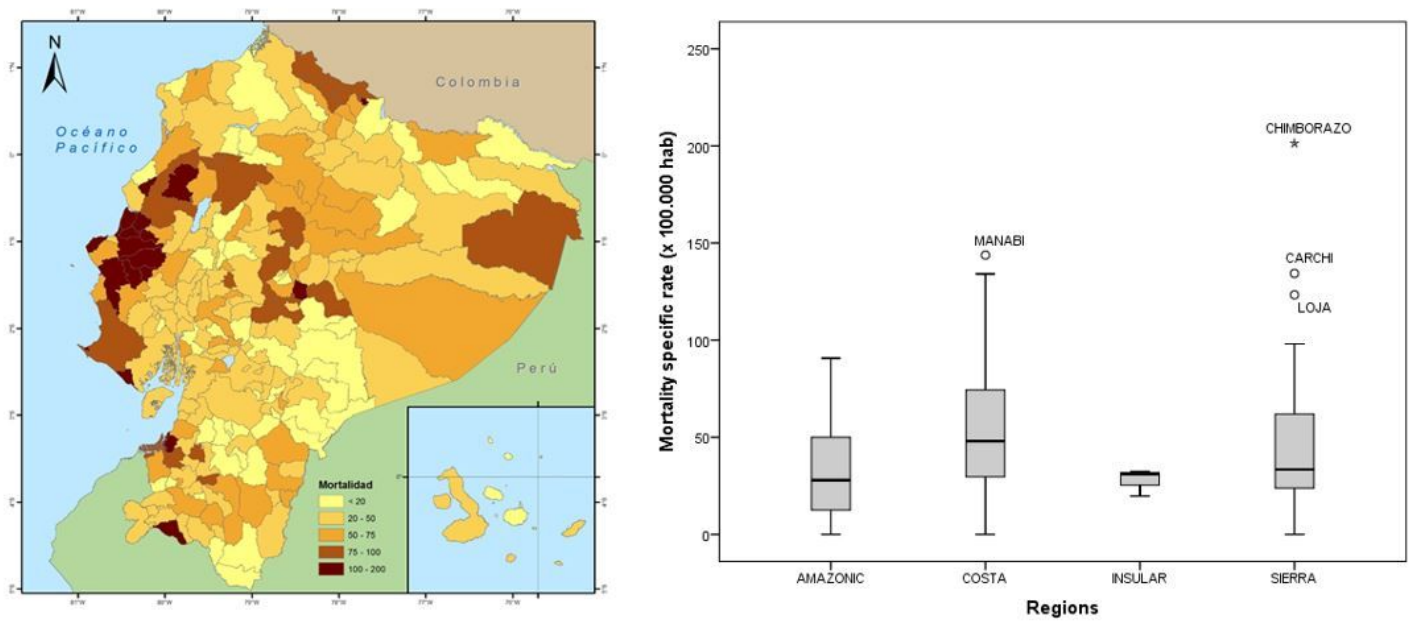

Figure 2

Crude death rate Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its

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