Epidemiological, socio-demographic and clinical features of the early phase of the COVID-19 epidemic in Ecuador

Esteban Ortiz-Prado*,1, Katherine Simbanya-Rivera1, Ana Maria Diaz1, Alejandra Barreto1, Carla Moyano1, Vannesa Arcos1, Eduardo Vásconez-González1, Clara Paz2, Fernanda Simbanya-Guaycha3, Martin Molestina-Luzuriaga1, Raúl Fernández-Naranjo1, Javier Feijoo4, Aquiles R. Henriquez1, Lila Adana2, Andrés López Cortés5,6, Isabel Fletcher7,8, Rachel Lowe7,8,9 and Lenin Gómez-Barreno1

1One Health Research Group, Faculty of Health Science, Universidad de Las Americas, Quito, Ecuador, 2School of psychology, Universidad de Las Americas, Quito, Ecuador, National 3Scientific Association of Medical Students, Universidad Central del Ecuador, Quito, Ecuador 4Instituto de Física La Plata, Universidad Nacional de la Plata, La Plata, Argentina, 5Centro de Investigación Genética y Genómica, Facultad de Ciencias de la Salud Eugenio Espejo, Universidad UTE, Quito 170129, Ecuador, 6Red Latinoamericana de Implementación y Validación de Guías Clínicas Farmacogenómicas (RELIVAF-CYTED), Quito, Ecuador, 7Centre for Mathematical Modelling of Infectious Diseases, London School of Hygiene & Tropical Medicine, London, United Kingdom, 8Centre on Climate Change and Planetary Health, London School of Hygiene & Tropical Medicine, London, United Kingdom, 9Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain

*Corresponding author: Esteban Ortiz-Prado One Health Research Group, Universidad de las Américas, Quito, Ecuador Calle de los Colimes y Avenida De los Granados, Quito 170137, Ecuador. Email: e.ortizprado@gmail.com Phone: +593995760693
Abstract

**Background:** The SARS-CoV-2 virus has spread all over the world infecting more than 3,585,936 people from over 210 countries and caused more than 245,803 deaths worldwide. We report the first epidemiological, socio-demographic, and clinical findings for the first 9,468 confirmed COVID-19 cases in Ecuador.

**Methods:** We conducted a descriptive cross-sectional analysis of 9,468 COVID-19 confirmed cases in Ecuador from 27 February to 18 April 2020. The overall incidence, mortality, and case fatality rate was computed according to the entire population at risk living in a canton or a province. Disability adjusted life years, attack and crude mortality rates as well as relative risk and odds ratios were computed as an outcome.

**Results:** Since the first case reported in Ecuador on 27 Feb 2020, at least 9,468 positive COVID-19 cases of which 474 deaths were officially registered over a 54-day period. Men accounted for 55.40% (n = 5, 247) of the overall cases with an incidence rate of 60.5 per 100,000 while women accounted for 44.60 % (n = 4, 221) representing 47.2 per 100,000. The mortality rate per canton showed that cantons with a lower attack rate had higher mortality rates. Coastal cantons have a lower attack rate than the highlands and living above >2,500 m seems to be linked with a lower risk of dying (RR: 0.63 [CI 95% 0.50 - 0.79]). Fatigue was reported in 53.2% of the patients, followed by headache (43%), dry cough (41.7%), ageusia (37.1%) and anosmia (36.1%).

**Conclusion:** This study is the first of its kind in Ecuador. The results of this analysis show that men are at higher risk of dying from COVID-19 than women, which increases as with age and the presence of comorbidities. Areas with better testing capabilities reported lower CFR% and mortality, additionally cantons located above 2,500 m have lower attack and mortality rates although the risk of dying is greater among highlanders.

**Keywords:** COVID-19; SARS-CoV-2; Ecuador; Epidemiology; Latin America
Introduction

For the past few decades, the world has been exposed to a series of threats from viral outbreaks caused by emerging zoonotic diseases and in particular by a family of viruses known as coronaviruses (1). The World Health Organization recognizes at least three types of coronavirus capable of generating epidemic outbreaks, including SARS-CoV, MERS-CoV and the recently discovered SARS-CoV-2 virus (2). These viruses are responsible for causing severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and the most recently described coronavirus disease (COVID-19) (3).

Since the first reports of a cluster of atypical pneumonia cases in Wuhan, China on December 2019, the SARS-CoV-2 virus and COVID-19 has quickly spread across the globe, infecting more than 3,585,936 people and causing more than 245,803 deaths worldwide (1,4). One of the main reasons the virus has spread so rapidly is due to its airborne nature of transmission from both symptomatic and asymptomatic people, making it difficult to test, trace and isolate new cases effectively (2). The virus spreads from one person to another with considerable ease. The basic reproduction number (R0) is estimated to be between 2.7 to 3.28 (5). Although all age groups seems to be equally susceptible, it has been suggested that the higher the viral load, the longer the symptomatology and the viral shedding (6,7).

According to global data, 80% of COVID-19 patients experience a mild course of the disease and 20% require hospitalization, of which 25% need to be admitted to an intensive care unit (ICU) (2,8,9). The overall estimated mortality rate ranges from 2-7%, depending on the country, although age and the presence of comorbidities are important factors in determining the risk of dying with COVID-19 (10,11).

In order to counteract the effects of this novel coronavirus, many countries have closed their borders and asked their citizens to stay at home to prevent the spread of the virus, relying on the effectiveness of physical distancing to decrease the speed of the contagion (12,13). Although these measures are effective in reducing R0 below one to slow the virus spread, the dynamics of the pandemic are greatly influenced by numerous factors that include poverty, levels of urbanization and other socioeconomic conditions (14). Understanding the transmission dynamics in different settings can provide important clues about the advance of the pandemic, especially in areas with unequal access to health services, high population density and a high burden of neglected tropical diseases (15–18).
In this study we present the findings of an interim analysis of the epidemiological situation in Ecuador, describing the clinical characteristics and epidemiological behavior of the first 9,468 laboratory confirmed COVID-19 cases officially registered in Ecuador.

**Methods**

*Study design*

We conducted a country-wide population-based analysis of the epidemiology of COVID-19, using case data reported in Ecuador between 27 February and 18 April 2020. The database comprised men, women and children from 0 to 100 years old with a positive RT-PCR COVID-19 diagnosis, using a reverse transcription polymerase chain reaction (RT-PCR) technique, during the first 54 days of the outbreak, including the first imported and the subsequent community-acquired cases.

*Setting*

The study was conducted in Ecuador, a country located in South America, bordering with Colombia to the North, Peru to the South/East and the Pacific Ocean to the West. The country is divided into four geographical regions: 1) the coastal region, 2) the highlands or sierra region, 3) the Amazon region and 4) the insular region (Galapagos Islands). The population of Ecuador was estimated to be 17,510,643 inhabitants based on the latest available projections for 2020 (19).

*Data*

We obtained socio-demographic variables, such as age, sex, marital status and place of residence from the Ministry of Health (MoH) registries. Clinical data including date of onset of symptoms, date of diagnosis and date of death, as well as the presence of comorbidities, pregnancy and influenza vaccination history were also obtained. Epidemiological information including city and province of registration, elevation, occupation, travel history and institution of diagnosis were analyzed. We also obtained the results of tests performed nationwide up until 18th April, 2020 and developed testing trends per days, including positive, negative, suspicious and not processed tests. The information was transferred to our research team after presenting a formal petition and signing a confidentiality agreement with the MoH to protect patient’s rights.
From the online self-reporting tool delivered through the MoH surveillance department, clinical information about signs and symptoms, as well as civil status and educational attainment were obtained from the 856 outpatients (COVID-19 positive) that fulfill the voluntary self-reporting tool.

The number of deaths used in this analysis were officially reported as COVID-19 using the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD) code: U07.1 COVID-19, virus identified, U07.2 COVID-19, virus not identified.

In order to estimate the number of additional deaths that were not diagnosed as COVID-19 during March and April 2020, we compared the COVID-19 database with the National Death Registry, including fatalities registered as Acute Respiratory Distress Syndrome (ICD J80).

**Study size and sample size calculation**

This study included 9,468 RT-PCR confirmed COVID-19 patients and the first 474 officially reported deaths.

In terms of the number of patients required \((x)\) to complete the self-reported symptoms tool distributed by the MoH, the sample size \((n)\) and margin of error \((E)\) were given by the following formula:

\[
x = Z(c/100)^2 r(100-r)
\]

\[
n = \frac{N x}{((N-1)E^2 + x)}
\]

\[
E = \sqrt{\frac{(N - n)x}{n(N-1)}}
\]

Where \(N\) is the population size (9,468), \((r)\) is the fraction of expected responses (50%), and \(Z(c/100)\) is the critical value for the confidence level \((c)\).

The total number of completed answers required according to the calculations was 621 in order to achieve a 99% confidence level. Through a convenience-based sampling technique 856 patients were included. The self-reporting tool was sent to all patients not hospitalized who were under epidemiological surveillance by the MoH and we included only those who voluntarily agree to provide information on educational attainment, symptomatology and civil status.
Descriptive statistics

The overall incidence (attack rate), mortality rate, and case fatality rate were computed according to the entire population at risk living in a canton or a province. Information from the first 9,468 COVID-19 confirmed patients in Ecuador were compared with the population at risk, obtained from the publicly available canton- and province-level sex-specific projections. Measurements of frequency (counts, absolute and relative percentages), central tendency (median), dispersion (interquartile range) and absolute differences were calculated for all categorical and continuous variables. Case fatality rates (CFR%) were computed using the number of cases officially reported while the dichotomized variable (alive or died) was used as an outcome of the confirmed cases. CFR% were adjusted to mitigate the effect in crude CFR% estimation. We computed the time distribution from hospital admission to the time of using the methodology reported by Russel 2020(20).

Positive test rates (PTR%) were calculated using the number of positive test results divided by the total number of tests conducted. The attack and crude mortality rates per canton and province were computed per 100,000 inhabitants. Important landmark dates are included in Supplementary Figure 1.

Inferential statistical

To examine associations, relative risks (RR) and 95% confidence intervals were computed for all age groups using female cases as the reference level. We performed a relative risk (RR) analysis of the total number of expected cases by the population at risk in all the groups to obtain the likelihood of dying due to COVID-19. In order to control for the effects of sex, age and comorbidities, an adjusted logistic regression was performed using the final outcome (alive or died) as a response variable. The geographical distribution of residence was divided into high (>= 2,500 m) and low altitude (< 2,500), in order to analyze the differences within these populations using a t-test with a 0.05 significance level.

Burden of Disease

The number of years of healthy life lost due to COVID-19 among the reported cases were calculated using Disability-Adjusted Life Years (DALY). DALYs are the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to
Disability (YLD) caused by the consequences of the disease (21). YLL were calculated from the number of deaths per age group multiplied by the standard life expectancy at the age of death. We used the life expectancy table developed by the 2010 Global Burden of Disease study, with a life expectancy at birth of 86 for both males and females (22). To estimate YLD, the total number of cases in the study period was multiplied by the average duration of the disease reported by the International Severe Acute Respiratory and Emerging Infections Consortium (ISARIC) COVID-19 database and the disability weights corresponding to the different degrees of severity of infectious diseases included in the 2013 Global Burden of Disease study (23,24).

Ethical consideration

This secondary data analysis of anonymized, un-identifiable information received ethical exemption from the Universidad de las Americas Ethics Committee CEISH on March 10th, 2020. The phone calls and the information retrieved during the follow-up period was obtained by health professionals not linked to this project as part of their standard of care treatment for patients with COVID-19. The information from those reports were posteriorly anonymized ensuring no sensitive information was shared with any member of our research project. According to the international good clinical and research practices and in accordance with the Ecuadorian law, observational studies that do not jeopardize the rights of patients are exempt from obtaining full ethical approval.

Results:

There were 9,468 positive COVID-19 cases and 474 officially reported deaths in Ecuador from 27 February – 18 April 2020 (54-day period). Men accounted for 55.4% (n = 5,247) of overall cases with an incidence rate of 60.5 per 100,000 while women accounted for 44.6% of cases (n = 4,221) and an incidence of 47.2 per 100,000.

Age and sex analysis

The median age of positive cases was 42 (IQR: 32-56) in men and 39 (IQR: 30-54) in women. The median age of dying was 62 (IQR: 51-70) in men and 65 (IQR: 56-74) in women. The RR concerning death as an outcome was significantly higher for men older than 19 years old, although the likelihood of dying from COVID-19 was only significantly higher among men.
from 35 to 69 years old compared to women (Figure 1). In terms of CFR%, men were more prone to die in almost every age group. The case fatality rate for men and women increased with age and these numbers were almost double among men (Figure 1, Supplementary Table 1).

![Age pyramid for COVID-19 cases and deaths](image)

**Figure 1** Top panel: Age pyramids for COVID-19 confirmed cases and officially reported deaths. Lower panel: Case Fatality rate (%) by age and sex (blue for women, purple for men) represent rates by single age, locally weighted regression curves.

**Socio-demographic variables**

**Ethnicity**

The majority of COVID-19 cases occurred among Mestizos 78% (n = 7,367), followed by indigenous 0.79% (n = 75), white/Caucasians 0.84% (n = 40) and Afro-Ecuadorians/Black with ~0.1% (n = 16) (Table 1). These differences were compared with the national distribution for each ethnic group according to the 2010 national census (19). Educational attainment information is displayed in appendix 1.
Table 1 Socio-Demographic variables among women and men (n = 9,468). The affected group was compared with the total ethnic population distribution nationally.

| Ethnicity (% of Ecuadorian distribution) | Women |   |   |   | Men |   |   |   |
|-----------------------------------------|-------|---|---|---|-----|---|---|---|
|                                        | Deaths (n = 137) | CFR% | Alive (n = 4,084) |   |   | Death (n = 337) | CFR% | Alive (n = 4,910) |   |   |
| Afro Ecuadorian (7.2%)                  | 0     | 0% | 4   | 0.1% | 0% | 0   | 0% | 2   | 0% | 0% |
| Caucasian (6.1%)                        | 1     | 0.7% | 16 | 0.4% | 5.9% | 0 | 0% | 23 | 0.5% | 0% |
| Indigenous (7%)                         | 2     | 1.5% | 30 | 0.7% | 6.3% | 5 | 1.5% | 38 | 0.8% | 11.6% |
| Mestizo/a (71.9%)                       | 128   | 93.4% | 3,197 | 78.3% | 3.8% | 314 | 93.2% | 3,728 | 75.9% | 7.8% |
| Montubio (7.4%)                         | 3     | 2.2% | 39 | 1.0% | 7.1% | 10 | 3.0% | 40 | 0.8% | 20% |
| Mulato                                  | 0     | 0% | 3   | 0.1% | 0.0% | 0 | 0% | 2 | 0% | 0% |
| Black                                   | 0     | 0% | 4   | 0.1% | 0.0% | 0 | 0% | 6 | 0.1% | 0% |
| Others (0.3%)                           | 1     | 0.7% | 8 | 0.2% | 11.1% | 0 | 0% | 6 | 0.1% | 0% |
| No data                                 | 2     | 1.5% | 783 | 19.2% | 0.3% | 8 | 2.4% | 1,065 | 21.7% | 0.7% |

| Healthcare provider |   |   |   |   |   |   |   |   |   |   |
|---------------------|---|---|---|---|---|---|---|---|---|---|
| Private provider    | 6 | 4% | 995 | 24.4% | 0.6% | 12 | 3.6% | 1,424 | 29% | 0.8% |
| Public provider     | 131 | 96% | 3,089 | 75.6% | 4.1% | 325 | 96.4% | 3,486 | 71% | 8.5% |

| Comorbidities |   |   |   |   |   |   |   |   |   |   |
|---------------|---|---|---|---|---|---|---|---|---|---|
| No            | 115 | 83.9% | 3,893 | 95.3% | 2.9% | 282 | 83.7% | 4,640 | 94.5% | 5.7% |
| Yes           | 22  | 16.1% | 191  | 4.7% | 10.3% | 55  | 16.3% | 270  | 5.5% | 16.9% |

| Travel History Abroad |   |   |   |   |   |   |   |   |   |   |
|-----------------------|---|---|---|---|---|---|---|---|---|---|
|                       |   |   |   |   |   |   |   |   |   |   |

Occupation and work-related risk

The results of COVID-19 mortality by occupation showed that 19% of infected people (n = 1800) are health professionals (Supplementary Table 2). From this group medical doctors (n = 876) were the most affected professionals in Ecuador, representing at least 9.3% of all reported cases (Figure 2).

Nurses were the second most affected group making up 3.3% (n = 309) of COVID-19 cases (Supplementary Table 2). The majority of people who tested positive work in manual labor (n = 1,390). In terms of fatality, the small number of inmates seem to be at the highest risk of dying with a RR of 7.75 [p value: 0.020, 1.3-44.0], followed by retired elderly people with a RR of 5.6 [p value: <0.0001, 3.5-9.0] and unemployed with 4.47 [p value: <0.0001, 2.8-6.9].
The likelihood of dying was higher among ‘blue collar’ workers, civil servants (police officers, soldiers, members of the navy, firefighters and other agents), unemployed, retirees and prisoners (Supplementary Table 2). Although a small number of cases were reported among politicians (n = 18), the CFR% for this group was zero, followed by nurses (0.3%), other health care professionals (0.7%) and medical doctors with a CFR% of 1.6%.

**Vaccination history, comorbidities and pregnancy history among COVID-19 patients**

Approximately 99% of patients (n = 9,384) did not report any vaccination history in the last year and only 0.9% (n = 84) of patients reported having been vaccinated. From those not vaccinated, 471 patients died whilst only three patients who had not been vaccinated died. The risk of dying among those not vaccinated was higher than patients who had been vaccinated, although the difference was not statistically significant (1.40 [95% CI: 0.46 to 4.28]). The RR of pregnant women dying was not found to be statistically significant (RR: 2.05 [0.785 to 5.36] p value: 0.14), although 6.7% of pregnant women in the study (n = 60) were reported to have died due to COVID-19.

The median age of COVID-19 patients reporting comorbidities in Ecuador was 59 (IQR: 49-68) years old, whilst those without comorbidities had a median age of 42 years old (IQR: 32-55). When the presence of comorbidities was incorporated into an adjusted logistic regression model, the presence of comorbidities, being male and older than 65 years old increased the risk of dying by almost 130% (OR: 2.27 [1.72- 3.00, p value <0.001]), 100% (OR: 2.03[1.65-2.50, p value < 0.001]) and 470% (OR: 5.74 [4.7- 7.0, p value <0.001]), respectively (Table 2).

### Table 2 Adjusted logistic regression using final outcome (death/Alive) as a dependent variable and the presence of comorbidities, sex and age of the patients as a covariate.

| Parameter estimate | Odds ratio | 95% LCI | 95% UCI | p-value |
|--------------------|------------|--------|---------|---------|
| Presence of Comorbidities |            |        |         |         |
| No (Reference)     |            |        |         |         |
| Yes                | 0.82       | 2.27   | 1.72    | 3.00    | <0.001  |
| Sex                |            |        |         |         |
| Women (Reference)  |            |        |         |         |
| Men                | 0.71       | 2.03   | 1.65    | 2.50    | <0.001  |
| Age                |            |        |         |         |
| <65 of age         |            |        |         |         |
>65 of age 1.74 5.744 4.71 7.00 <0.001
Dependent variable: Death/Alive final outcome

LCI: lower confidence interval; UCI: upper confidence interval

Symptoms assessment

The patients who were under epidemiological surveillance by the MoH (n = 856) self-reported their symptoms experienced during the preceding 14 days using an online self-reporting tool. The most common symptom described was fatigue or general tiredness (53.2%), followed by headaches (43%), and dry cough (41.7%). 37.1% of the patients reported loss of taste (ageusia), 36.1% reported loss of smell (anosmia) and 35% reported muscle and joint pain (Figure 3).

Figure 3  List of symptoms by frequency of presentation among mild to moderate patients with a RT-PCR positive COVID-19 test.

Epidemiological analysis

Contact Tracing

The results from the self-reporting tool (n = 856) suggested that 42.6% (n = 365) of patients did not have contact with anyone after COVID-19 diagnosis, 11.8% (n = 101) reported that they might have been in contact with 1 to 5 people, 4.9% (n = 42) might have contacted 6 to
10 people, and 5.8% (n = 50) might have contacted more than 10 people after diagnosis. The other 34.9% (n = 299) of the cohort did not recall such information.

**Travel history and nationality**

In Ecuador, 99.3% of the patients were Ecuadorians (n = 9,400), 0.30% (n = 44) were from other countries in Latin-America and the other 0.40% (n = 24) were either from Europe, North America or Asia. In terms of the number of imported cases, at least 11 patients with confirmed COVID-19 had travelled from five countries, while at least 132 cases had a recognized epidemiological connection with people who had travelled to at least one of more than 25 different countries (Figure 4).

![Figure 4](https://example.com/figure4.png)

**Figure 4** Epidemiological distribution of 11 imported and 132 communitarian transmission with direct travel history among COVID-19 confirmed patients in Ecuador.
Days since diagnosis

Among the total 9,468 COVID-19 patients, the median time elapsed between the onset of symptoms and the time of medical attention was four days (IQR: 1-8 days). However, from the onset of symptoms to the day of notification nine days elapsed (IQR: 5-14 days). At the end of February only six cases had been diagnosed in Ecuador. However, when observed retrospectively using the date of the onset of diagnosis, we concluded that 29 patients were already sick (Figure 5). The number of unconfirmed cases remained high until March 24th when a partial lock-down was implemented in Ecuador (Figure 5).

The median time elapsed from the onset of symptoms to the day of death was 11 days (IQR: 7-15 days) for the 474 patients that died due to COVID-19 in Ecuador (Figure 6). The median time between first day of medical attention until death was five days (IQR: 2-8 days). The median time between case notification and death was four days (IQR: 2-7 days).

Attack rate (confirmed cases per 100,000 people)

The overall attack rate was 51.1 per 100,000 people. Sex-specific attack rates of COVID-19 was 60.5 per 100,000 for men and 47.2 per 100,000 for women. In terms of age-adjusted attack rates per 100,000, the lowest attack rate was amongst children from 0-4 years old (2.86 per
100,000), while the highest attack rate was found in patients aged between 55 and 59 years (111 per 100,000).

Mortality Rates (confirmed deaths per 100,000 people)

The overall confirmed mortality rate was 2.7 per 100,000 people. This value ranged from 0.1 to 20.1 per 100,000 people at risk, with 90-95 years of age being the most affected group with a crude age specific mortality rate of 20 per 100,000 people. From the official reports, 474 deaths were recorded due to COVID-19 (RT-PCR confirmed).

During March and April 2020, Ecuador experienced a sharp increase in its overall mortality. In 2018, at least 23,973 deaths were officially reported between January to April, in the following year, 25,061 and during January to April 15th, 2020, 29,392 were registered, indicating an increase in more than 15% compared with the previous year. The increase over the same period from 2018 to 2019 was just 4.4%.

We analyzed the total number of deaths included in the National Registry. From March 1st to April 18th, 2020, 4,780 reported deaths were related to acute respiratory distress syndrome (ARDS) in Ecuador (37%). From the total of ARDS-related deaths, 1,283 were probable COVID-19 (U07.2 clinically-epidemiologically diagnosed), 809 were registered as suspected COVID-19 (U07.2) and 474 confirmed COVID-19 cases (U07.1) (Figure 6).
Confirmed COVID-19 cases and deaths linked to suspected and confirmed COVID-19, during the first 58 days of the outbreak. The first case was reported on day 1 based on the onset of symptomatology (February 15th) and day 16th based on the date of medical attention (February 27th).

**Geodemographic distribution**

*Result by region and elevation*

In Ecuador, the coastal region had a higher attack rate than the highlands (p value: 0.011), and living above >2,500 m was associated with a lower risk of dying (RR: 0.63 [CI 95% 0.50 - 0.79]) compared to populations living at higher altitudes (Appendix 1).

*Daily new cases and deaths by province*

Galapagos (157.3/100,000), Guayas (146.9/100,000), Cañar (49.1/100,000), Santa Elena (37.8/100,000) and El Oro (35.6/100,000) provinces had the greatest attack rates per 100,000.

In terms of the crude mortality rate, the provinces of El Oro (7.82/100,000), Chimborazo (4.7/100,000), Guayas (4.44/100,000), Santo Domingo de los Tsachilas (4.14/100,000) and Bolivar (2.85/100,000) provinces had the greatest mortality crude rate per 100,000 (Figure 7 and Supplementary File 1).
Figure 7 Daily new confirmed cases and deaths per province due to COVID-19, Ecuador February-April 2020.

**Trends by cantons**

The cantons with the highest attack rates of COVID-19 are Samborondon with (386.7/100,000), followed by Santa Cruz with (187.1/100,000), Daule (177.9/100,000), Guayaquil (177.1/100,000) and Milagro (155.6/100,000). On the other hand, Puebloviejo (2.23/100,000), Eloy Alfaro (2.19/100,000), Shushufindi (1.72/100,000), San Lorenzo (1.59/100,000) and Cayambe (0.92/100,000) reported the lowest incidence of COVID-19 in Ecuador (Supplementary file 1 and Figure 8).
We found that cantons with a lower attack rate had higher mortality rates. For instance, Portovelo (21.3/100,000), Playas (18.4/100,000), Santa Rosa (15.8/100,000), Suscal (15.3/100,000) and Penipe (14.3/100,000) reported the highest mortality rate per 100,000 people. Guayaquil with a mortality rate of 5.8/100,000 was the city with the highest number of confirmed COVID-19 deaths, while Samborondon (3.9/100,000) the canton with the highest attack rate, reported only four deaths until April the 18th (Figure 8). In terms of CFR% per canton, Tosagua, Cevallos, Las Naves, Puerto Quito and Quinsaloma reported a 100% case fatality rate among the fewer cases reported (1-2 each one) while other cantons such as Playas, Santa Rosa or Riobamba have reported CFR% higher than 23% (Supplementary File 1).

**Burden of Disease analysis**

In terms of years of life lost prematurely (YLL), COVID-19 predominantly caused deaths among older adults, especially men. Nevertheless in a period of less than 54 days from the start of the outbreak, at least 3,207 years were lost prematurely among women and more than 8,847 among men (Table 3). In the study period COVID-19 caused a loss of 12,112 healthy life years, with an average of 1.27 DALY per case. From the estimated burden, 99.5% is attributable to the years of life lost due to premature mortality among the study population, with an average of 25.4 YLL per death. The population within 20 to 64 years old contributed to 74.4% of the burden, followed by the elderly with 24.2% of the burden (Supplementary table 4).
COVID-19 Testing Trends in Ecuador

Test performed

In Ecuador, since the start of the outbreak, a total of 19,875 tests have been carried out nationwide, which resulted in 1,126 tests per million inhabitants. Of the accumulated total tests, 48% of these were positive and less than 0.5% were not conclusive or suspicious. There were 12,751 unprocessed tests up to April 18th, 2020 even though nasopharyngeal swab samples were taken (Supplementary Figure 2 and Appendix 2).

Discussion

Ecuador has been the worst hit country in the Latin American region from the COVID-19 pandemic (25–27). Since the first case confirmed in Ecuador on 27 Feb 2020, at least 9,468 positive COVID-19 cases of which 474 deaths were officially registered over a 54-day period.

The images of corpses in the streets and the difficulty of burying the dead occupied the main pages of all the newspapers around the world (25–27). Overcrowded hospitals and laboratories were overwhelmed by an excessive number of cases, causing a confirmed toll of 474 COVID-19 related deaths and 809 registered suspicious deaths up to April 18th 2020 (28). On April 18, the National Emergency Operations Committee reported 1,061 patients discharged from hospital, 369 hospitalized patients, and 7,564 COVID-19 positives cases, who were stable in home isolation (29). Data from the region indicates that Ecuador, along with Panama, are the two most affected countries in Latin America. Ecuador ranks 23rd worldwide in the numbers of deaths per million inhabitants (30,31). When COVID-19 suspicious deaths are included in the formula, Ecuador ranks 15th, behind France (5th), United Kingdom (4th), Italy (3rd) and Spain (2nd) (31).

At the beginning of the pandemic, Ecuador registered a single case on February 27, when in reality, looking retrospectively, there were already 19 undetected cases. Only two weeks later, there were 11 officially registered cases but at least 119 undetected cases (Figure 5). After 54 days, a total of 9,468 positive COVID-19 cases and 474 officially reported deaths, with a sex distribution (55.4% men) that seems similar to that reported in China (58% men) and Italy (59.8% men) (32–34). The mortality rate for women (3.35%) is almost half of that for men (6.86%). The median age was 42 in men and 39 in women and the age group most affected was
the group from 19-50 years old representing 59.6% of the entire cohort, almost doubling the same age group reported in Italy (24.0%) and very similar to the age distribution from China (33,34). The reason behind these trends might be due to the fact that Italy has one of the oldest populations in the world. According to the latest data, Italy has 14 million residents over the age of 65 (22%) with an average age of 45.7 years, while in Ecuador the average population is 26.6 years old (11,35,36).

In addition, median age of deaths related to COVID-19 are among younger groups than that reported in Italy or Spain and although this is related to the demographics of each country, it may also be related to the system's response and the number of abrupt deaths in a very short period of time (37–39). According to the Health Services Report published by the National institute of Statistics (INEC), Ecuador has less than 2,000 respirators nationwide and less than 700 in Guayas, the province most affected by this pandemic (40). The lack of intensive care units in the country (less the 400 ICU units in 2017) and the lack of available beds during the first peak of the pandemic in Ecuador is probably one of the reasons behind the high death toll reported locally (40). Although the hypostatized protective effect of living at above certain elevation on the pathophysiology of COVID-19 has been described, the effect of hypoxia, adaptation and mortality caused by SARS CoV-2 at higher altitudes is still unknown (41). Our findings demonstrate that there is some association between high altitude living and mortality, nevertheless further studies are required before any conclusions can be drawn.

In terms of age, the patients between 0 and 50 years old reported a CFR of 1.6%, compared to 0.4% in Italy, 0.4% in China and 0.6% in Spain from the same age groups (11,38,39). When adjusting for sex, age and the presence of comorbidities, mortality increased significantly among elderly men, which is consistent with other regional studies (33,42).

The existence of comorbidities is linked with augmented age and therefore increased risk of mortality in COVID-19 patients. The age of patients reporting comorbidities in Ecuador was higher than those without comorbidities. In terms of risk, patients with comorbidities had a CFR% of 10.3% in women and 16.9 % in men, higher than those without comorbidities and in both sexes CGF% averaged 4%. These findings are equivalent to previous studies that have shown that the presence of comorbidities increases the risk in COVID-19 patients to be admitted to the ICU or die due to this disease (37,42,43).
In terms of ethnicity, it is important to point out that self-identified Montubios and Indigenous have a CFR% of 14% and 9% respectively, which is surprisingly higher than Mestizos (6%) and other ethnic groups living in Ecuador. This is probably due to reduced healthcare access for vulnerable groups (44). For influenza, ethnic minorities have the highest estimated fatality rate, most likely due to their social determinants of health, social inequalities and reduced access to health care, especially in rural areas (45,46).

Although the clinical features of COVID-19 are widely studied in moderate and severe hospitalized patients, information on patients with a less severe symptoms is scarce. We collected self-reported data on symptoms from a sample of patients in home isolation. 53% presented with fatigue, 43% headaches and 42% a dry cough which is in agreement with studies from other settings. However a higher proportion of patients reported ageusia (37%) and anosmia (36%), when compared to studies from China (5.1% and 5.6%, respectively) and Italy reporting anosmia in 19.4% of patients (2,47).

One of the main limitations in understanding the development of COVID-19 in Ecuador is the lack of molecular testing capabilities (48). In January, alarms went off with the first suspected COVID-19 case in Ecuador, alarms that denoted the poor readiness of the public health system that took more than 15 days to rule-out a highly suspicious COVID-19 patient, who died with the diagnosis of hepatitis B and atypical pneumonia (49,50). At the beginning of the outbreak, the World Health Organization (WHO) emphasized the importance of testing capabilities in order to improve case tracing and diseases detection worldwide. Nevertheless, Ecuador has not enough capabilities to perform molecular diagnosis (RT-PCR), limiting epidemiological surveillance strategies and case tracing (30,51). For this reason, the number of samples taken exceeds the local molecular diagnosis capabilities, causing that thousands of tests are not been reported in a daily basis (25,26). Despite the limitations, in some areas of the country, especially richer areas, such as Samborondon, testing rates are as high as those seen in Iceland or even close to those seen in the US (52). This trend might be driven by those patients who were able to pay for their diagnosis and their medical treatment. Therefore, their high attack rate is interpreted as better access to health resources and that is why mortality is also low among these cantons. Although social status and monthly income was not assessed, in Ecuador, blue collar workers have less monetary income than health care and white-collar workers (53,54). In Ecuador, it is hypothesized that labor workers and the unemployed have less access to health services, therefore the high case fatality rates among these groups is significantly
higher than those in more privileged positions such as politicians, medical doctors or health workers. These results could indicate that poor working conditions, poverty and therefore limited access to health services could be linked to the high mortality rates reported among the most vulnerable groups, a situation described previously (55,56).

At the same time, we can see that despite low mortality, contagion among health personnel is very high, emphasising the importance of offering good personal protection equipment in a timely manner (57).

The CFR% and PTR% values reported in Ecuador are considerably higher than other countries such as Italy with 17.27% on April 8th (23). This is probably due to the high impact that COVID-19 had on the already over-stretched health system, especially in areas with a syndemic scenario (e.g. co-occurring epidemics of dengue and other neglected tropical diseases) (48,58).

Low testing capabilities and high number of suspicious COVID-19 deaths likely distort the calculation age-specific attack and mortality rates across cantons. We found a median delay of two days between the day of sampling to the day of notification and the low number of reported tests (test per million people and the overall count) in the region (30). This impacts the ability of contact tracing and other prevention strategies to interrupt SARS-CoV-2 transmission (59).

Analyzing the years of life lost due to SARS-CoV-2 is challenging due to the uncertainty around the length of the different phases of the disease and the clinical spectrum of the severity of the disease. These uncertainties make it difficult to estimate disability weights that are a crucial component for the DALY calculation. In our study 99.5% of the burden was attributable to the years of life lost due to premature mortality among the study population, with an average of 25.4 YLL per death, and 1.27 DALY per each case of COVID-19. Even though COVID-19 related deaths are higher among elderly populations in developing countries with weakened health systems, mortality is also overstretched among younger populations (60).

The data shows that Ecuador has suffered an unprecedented crisis in terms of health. Much of the information collected in this work suggests that the response capabilities in terms of epidemiological surveillance, diagnosis and contact tracing are well below the desired level. Diagnostic platforms are scarce, and the acquisition of diagnostic primers and kits was especially difficult at the beginning of the pandemic. In Ecuador, the poor testing response...
described in this document goes along with the increasingly high demand for laboratory components, forcing laboratory employees to work around the clock (30,51).

At present, the testing strategy includes improving and diversifying the offer of diagnostic tests (RT-PCR), implementing algorithms for the proper management of rapid tests for the detection of antibodies or antigens, to better control the apparition of new cases at the community level.

**Limitations**

The main limitation in this analysis is the lack of specific data regarding the type of comorbidities and the presence of clinical manifestations during the initial evaluation. This limitation is also evident when reviewing the follow-up file, which includes only the date of death and the date when the case was discharged and closed. During the evaluation of the self-reported symptoms tool, the information was only received from patients who were willing to read the online survey or healthy enough to have the tool in their hands during the follow-up. The fact that testing was performed mainly among symptomatic patients means that many asymptomatic cases were unaccounted for. It is likely that limited testing capabilities and the low number of tests performed might affect the overall mortality and attack rates.

There is uncertainty around the clinical spectrum of the disease and the length of its different phases, making it difficult to assign the appropriate disability weights that are a crucial component for the YLD calculations. There is a need for more studies using patient reported outcomes, like health-related quality of life and reporting average lengths of symptoms.

Despite these limitations, this study represents the first systematic epidemiological effort to quantify the magnitude of COVID-19 in Ecuador based on national health statistics. This study will provide the foundation for the implementation of evidence-based public health policies to address different programs. The development of a national registry for COVID-19 would help gather more accurate publicly available data in Ecuador.

**Conclusions**

This is the first epidemiological study of the socio-demographic distribution of COVID-19 in Ecuador and one of the very few reported in Latin America. The results demonstrate the
vulnerability of the health system to contain, mitigate, treat and adequately diagnose this type of new viral disease that spread across the country at a speed that exceeds the speed of response. It is also evident that there has been a high number of infections among medical personnel, which probably occurred during the first weeks of the outbreak in the country, and although the rate of attack was high, mortality in this group was very low, probably due to better access to health. We also found the type of employment and being unemployed is strongly associated with overall mortality due to COVID-19 in Ecuador, suggesting that poverty is an important driver of the final outcome for this disease. Lastly, strengthening of community-based surveillance and case tracing response capacities is essential to prevent further advance of the disease within the community.

Supporting information

**Supplementary Figure 1:** The timeline of important landmarks during the early phase of the Ecuadorian pandemic (TIFF).

**Supplementary Figure 2:** The Individualized Cumulative number of confirmed cases and deaths per province (TIFF).

**Supplementary Figure 3:** Test Performed since the day 1 (Feb 27th) and test that resulted negative (black), positive (Blue), Suspicious (Red) and not processed (Peach)(TIFF).

**Supplementary Table 1:** Case fatality Rate (CFR%) and Relative Risk (RR) calculation among Women and men from different age groups (N=9,468) using a significant level of 0.05% (PDF).

**Supplementary Table 2:** Case Fatality Rate % by occupation in Ecuador due to COVID-19. Relative risk was estimated using the White-Collar jobs as a reference group. Significance was set at an alpha level of 0.05 (PDF).

**Supplementary Table 3:** Descriptive analysis of the RT-PCR Testing capabilities in Ecuador (PDF).

**Supplementary File 1:** Supporting data of COVID-19 cases per province, canton and region

**Appendix 1:** Result by region and elevation (PDF)

**Appendix 2:** Test performed (PDF)
Acknowledgement

The authors thank Rebeca Bravo who was very keen in editing our maps for this publication as well as the staff from the National Direction of Epidemiology for sharing the official database after fulfilling their requirements.

We greatly appreciate the work carried out by Dr. Ignacia Paez and her team of Community Mental Health professionals from the Ministry of Public Health, for their role of distributing the self-reporting symptomology tool among the entire cohort of patients who were under constant monitoring from the official epidemiological department of the MoH.

Disclosure Statement

Esteban Ortiz-Prado was invited to advice the government during the first week of the pandemic, nevertheless, this invitation was carried out to many others scientist whom did not received any economic retribution for their work and this temporary role did not interfered with the analysis of the results in any way. The other authors have no conflict of interest to declare.

Funding Sources

This work was funded by the Universidad de Las Américas throughout their annual general research projects funds.

Authors' Contributions

Esteban Ortiz-Prado was fully responsible of the conceptualization of the project, the methodological approach, the statistical analysis, the data acquisition and the interpretation of the results. He drafted the main manuscript and create some of the figures of this work.

Lenin Gómez-Barreno, Katherine Simbaña-Rivera were responsible for the conceptualization of the manuscript. They were responsible for the analysis of the data while providing critical revisions of the rest of the manuscript and elaboration of the discussion section.

Aquiles R. Henriquez was fully responsible for the DALY and burden of disease analysis. Andrés López Cortés was responsible for the creation of figures. Ana Maria Diaz, Alejandra
Barreto, Carla Moyano, Vannesa Arcos, Eduardo Vásconez-González and Clara Paz were involved in the data analysis of the self-reporting symptomatology tool.

Fernanda Simbaña contributed with the regional data acquisition and the systematization of the literature review. Martin Molestina-Luzuriaga and Raul Fernandez collaborated with the statistical analysis and the methodological approach as well as the creation of some of the figures for the analysis.

Lila Adana improved the discussion in terms of the social impact of COVID-19 among workers and contributed with the final draft of this manuscript.

Finally, Rachel Lowe critically reviewed the document and helped us improved the final version of this manuscript, enhancing the quality of the analysis and the general approach.

References

1. Peeri NC, Shrestha N, Rahman MS, Zaki R, Tan Z, Bibi S, et al. The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned? Int J Epidemiol. 2020;

2. Ortiz-Prado E, Simbaña-Rivera K, Gomez-Barreno L, Rubio-Neira M, Guaman LP, Kyriakidis N, et al. Clinical, Molecular and Epidemiological Characterization of the SARS-CoV2 Virus and the Coronavirus Disease 2019 (COVID-19): A Comprehensive Literature Review. 16 de abril de 2020 [citado 18 de abril de 2020]; Disponible en: https://www.preprints.org/manuscript/202004.0283/v1

3. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. J Autoimmun. 2020;102433.

4. Gilbert M, Pullano G, Pinotti F, Valdano E, Poletto C, Boëlle P-Y, et al. Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study. The Lancet. 2020;395(10227):871–877.

5. Liu Y, Gayle AA, Wilder-Smith A, Rocklöv J. The reproductive number of COVID-19 is higher compared to SARS coronavirus. J Travel Med. 2020;

6. Liu Y, Yan L-M, Wan L, Xiang T-X, Le A, Liu J-M, et al. Viral dynamics in mild and severe cases of COVID-19. Lancet Infect Dis. 2020;

7. Jones TC, Mühlemann B, Veith T, Zuchowski M, Hofmann J, Steint A, et al. An analysis of SARS-CoV-2 viral load by patient age [Internet]. Forschungsnetz Zoonotische Infektionskrankheiten; 2020. Disponible en: https://zoonosen.charite.de/
8. Cascella M, Rajnik M, Cuomo A, Dulebohn SC, Di Napoli R. Features, evaluation and treatment coronavirus (COVID-19). En: StatPearls [Internet]. StatPearls Publishing; 2020.

9. Liu K, Chen Y, Lin R, Han K. Clinical features of COVID-19 in elderly patients: A comparison with young and middle-aged patients. J Infect. 2020;

10. Novel CPERE. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. Zhonghua Liu Xing Bing Xue Za Zhi Zhonghua Liuxingbingxue Zazhi. 2020;41(2):145.

11. Onder G, Rezza G, Brusaferro S. Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy. Jama. 2020;

12. Lewnard JA, Lo NC. Scientific and ethical basis for social-distancing interventions against COVID-19. Lancet Infect Dis. 2020;

13. Dalton C, Corbett S, Katelaris A. Pre-emptive low cost social distancing and enhanced hygiene implemented before local COVID-19 transmission could decrease the number and severity of cases. Med J Aust. 2020;212(10):1.

14. WHO. Ethical considerations in developing a public health response to pandemic influenza. Geneva: World Health Organization; 2007.

15. Hotez PJ, Basanez M-G, Acosta-Serrano A, Grillet ME. Venezuela and its rising vector-borne neglected diseases. PLoS Negl Trop Dis. 2017;11(6).

16. Rodriguez-Morales AJ, Bolivar-Mejia A, Alarcón-Olave C, Calvo-Betancourt LS. Plasmodium vivax malaria in Latin America. En: Neglected Tropical Diseases-Latin America and the Caribbean. Springer; 2015. p. 89–111.

17. Borchering RK, Huang AT, Mier-y-Teran-Romero L, Rojas DP, Rodriguez-Barraquer I, Katzelnick LC, et al. Impacts of Zika emergence in Latin America on endemic dengue transmission. Nat Commun. 2019;10(1):1–9.

18. Lopez-Gatell H, Hernandez-Avila M, Avila JEH, Alpuce-Aranda CM. Dengue in Latin America: a persistent and growing public health challenge. En: Neglected Tropical Diseases-Latin America and the Caribbean. Springer; 2015. p. 203–224.

19. INEC. Censo de Población y Vivienda. 2010.

20. Russel T, Hellewell J, Abbot S. Using a delay-adjusted case fatality ratio to estimate under-reporting. Available Cent Math Model Infect Dis Repos Here. 2020;

21. Develeschauwer B, McDonald S, Haagsma J, Praet N, Havelaar A, Speybroeck N. The DALY Calculator—A GUI for stochastic DALY calculation in R. 2014;

22. Murray CJ, Ezzati M, Flaxman AD, Lim S, Lozano R, Michaud C, et al. GBD 2010: design, definitions, and metrics. The Lancet. 2012;380(9859):2063–2066.
23. ISARIC. International Severe Acute Respiratory and Emerging Infections Consortium [Internet]. 2020 [citado 25 de abril de 2020]. Disponible en: https://isaric.tghn.org/covid-19-clinical-research-resources/

24. Salomon JA, Haagsma JA, Davis A, de Noordhout CM, Polinder S, Havelaar AH, et al. Disability weights for the Global Burden of Disease 2013 study. Lancet Glob Health. 2015;3(11):e712–e723.

25. Analytica O. COVID-19 will have devastating impact on Ecuador. Emerald Expert Brief. (oxan-db).

26. Torres I, Sacoto F. Coronavirus in Ecuador | Think Global Health [Internet]. Council on Foreign Relations. [citado 30 de abril de 2020]. Disponible en: https://www.thinkglobalhealth.org/article/coronavirus-ecuador

27. Altman D, Valarezo JC. Deaths and desperation mount in Ecuador, epicenter of coronavirus pandemic in Latin America [Internet]. The Conversation. [citado 30 de abril de 2020]. Disponible en: http://theconversation.com/deaths-and-desperation-mountain-in-ecuador-epicenter-of-coronavirus-pandemic-in-latin-america-137015

28. Registro Civil. Cifras de defunciones correspondientes a los años 2018, 2019 y 2020 [Internet]. 2020 [citado 30 de abril de 2020]. Disponible en: https://www.registrocivil.gob.ec/cifras/

29. Comité de Operaciones de Emergencia Nacional. Situación nacional por COVID-19 (Coronavirus) [Internet]. Ecuador; 2020. Report No.: 55. Disponible en: https://www.gestionderiesgos.gob.ec/wp-content/uploads/2020/04/INFOGRAFIA-NACIONALCOV19-COE-NACIONAL-19042020-08h00.pdf

30. Simbana-Rivera K, Gomez-Barreno L, Guerrero J, Simbana-Guaycha F, Fernandez R, Lopez-Cortes A, et al. Interim Analysis of Pandemic Coronavirus Disease 2019 (COVID-19) and the SARS-CoV-2 virus in Latin America and the Caribbean: Morbidity, Mortality and Molecular Testing Trends in the Region. medRxiv. 29 de abril de 2020;2020.04.25.20079863.

31. COVID-19 Map - Johns Hopkins Coronavirus Resource Center [Internet]. [citado 14 de abril de 2020]. Disponible en: https://coronavirus.jhu.edu/map.html

32. Guan W, Ni Z, Hu Y, Liang W, Ou C, He J, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med. 2020;

33. CDCC V. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19)—China, 2020. China CDC Wkly. 2020;2(8):113–122.

34. Livingston E, Bucher K. Coronavirus disease 2019 (COVID-19) in Italy. Jama. 2020;323(14):1335–1335.

35. Polidori MC, Maggi S, Mattace-Raso F, Pilotto A. The unavoidable costs of frailty: a geriatric perspective in the time of COVID-19. Geriatr Care. 2020;6(1).

36. INEC. Proyecciones poblacionales en Ecuador [Internet]. 2018. Disponible en: http://www.ecuadorencifras.gob.ec/proyecciones-poblacionales/
37. Riccardo F, Ajelli M, Andrianou X, Bella A, Del Manso M, Fabiani M, et al. Epidemiological characteristics of COVID-19 cases in Italy and estimates of the reproductive numbers one month into the epidemic. medRxiv. 2020;

38. Forte F. Spain: coronavirus mortality rate by age 2020 [Internet]. Statista. 2020 [citado 30 de abril de 2020]. Disponible en: https://www.statista.com/statistics/1105596/covid-19-mortality-rate-by-age-group-in-spain-march/

39. Porcheddu R, Serra C, Kelvin D, Kelvin N, Rubino S. Similarity in case fatality rates (CFR) of COVID-19/SARS-COV-2 in Italy and China. J Infect Dev Ctries. 2020;14(02):125–128.

40. INEC. Anuario de Estadística de Salud: Recursos y Actividades 2017 [Internet]. 2018. Disponible en: https://www.ecuadorencifras.gob.ec/documentos/web-inec/Estadisticas_Sociales/Recursos_Actividades_de_Salud/Publicaciones/Anuario_Rec_Act_Salud_2014.pdf

41. Arias-Reyes C, Zubieta-DeUrioste N, Poma-Machicao L, Aliaga-Raudan F, Carvajal-Rodriguez F, Dutschmann M, et al. Does the pathogenesis of SARS-CoV-2 virus decrease at high-altitude? Respir Physiol Neurobiol. 2020;103443.

42. Guan W, Liang W, Zhao Y, Liang H, Chen Z, Li Y, et al. Comorbidity and its impact on 1590 patients with Covid-19 in China: A Nationwide Analysis. Eur Respir J [Internet]. 26 de marzo de 2020 [citado 30 de abril de 2020]; Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7098485/

43. Kim DD, Goel A. Estimating case fatality rates of COVID-19. Lancet Infect Dis. 2020;

44. Leime CAA, Rodríguez GPP. La pertenencia étnica y el acceso a los servicios de salud: Caso de indígenas y afrodescendientes ecuatorianos en el periodo 2006-2015. Rev Publicando. 2017;4(11 (1)):618–638.

45. Steyn N, Binny RN, Hannah K, Hendy S, James A, Kukutai T, et al. Estimated inequities in COVID-19 infection fatality rates by ethnicity for Aotearoa New Zealand. medRxiv. 2020;

46. La Ruche G, Tarantola A, Barboza P, Vaillant L, Gueguen J, Gastellu-Etchegorry M. The 2009 pandemic H1N1 influenza and indigenous populations of the Americas and the Pacific. Eurosurveillance. 2009;14(42):19366.

47. Vaira LA, Salzano G, Deiana G, De Riu G. Anosmia and ageusia: common findings in COVID-19 patients. The Laryngoscope. 2020;

48. Navarro J-C, Arrivillaga-Henriquez J, Salazar-Loor J, Rodriguez-Morales AJ. COVID-19 and dengue, co-epidemics in Ecuador and other countries in Latin America: Pushing strained health care systems over the edge. Travel Med Infect Dis. 2020;

49. Fallece paciente chino aislado en Quito con resultado negativo para coronavirus, confirma Salud [Internet]. El Comercio. 2020 [citado 1 de mayo de 2020]. Disponible en: http://www.elcomercio.com/actualidad/paciente-chino-fallece-negativo-coronavirus.html
50. Ecuador prende las alarmas ante posible caso de coronavirus [Internet]. RCN Radio. 2020 [citado 1 de mayo de 2020]. Disponible en: https://www.rcnradio.com/internacional/ecuador-investiga-primer-caso-sospechoso-de-coronavirus

51. Torres I, Sacoto F. Localising an asset-based COVID-19 response in Ecuador. The Lancet. 2020;

52. Data on COVID-19 testing [Internet]. Our World in Data. [citado 4 de abril de 2020]. Disponible en: https://ourworldindata.org/covid-testing

53. Berdegué J, Reardon T, Escobar G. Empleo e ingreso rurales no agrícolas en América Latina y el Caribe. Desarro Empl Rural No Agríc. 2000;28.

54. von Bonsdorff MB, Seitsamo J, von Bonsdorff ME, Ilmarinen J, Nygård C-H, Rantanen T. Job strain among blue-collar and white-collar employees as a determinant of total mortality: a 28-year population-based follow-up. BMJ Open. 2012;2(2):e000860.

55. Benzeval M, Judge K. Income and health: the time dimension. Soc Sci Med. 2001;52(9):1371–1390.

56. Bernstein SF, Rehkopf D, Tuljapurkar S, Horvitz CC. Poverty dynamics, poverty thresholds and mortality: An age-stage Markovian model. PloS One. 2018;13(5).

57. WHO. Rational use of personal protective equipment for coronavirus disease (COVID-19): interim guidance, 27 February 2020. World Health Organization; 2020.

58. Cimerman S, Chebabo A, da Cunha CA, Rodriguez-Morales AJ. Deep Impact of COVID-19 in the HealthCare of Latin America: the case of Brazil. Braz J Infect Dis. 2020;

59. Hellewell J, Abbott S, Gimma A, Bosse NI, Jarvis CI, Russell TW, et al. Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. Lancet Glob Health. 2020;

60. Mokdad AH, Forouzanfar MH, Daoud F, Mokdad AA, El Bcheraoui C, Moradi-Lakeh M, et al. Global burden of diseases, injuries, and risk factors for young people’s health during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet. 2016;387(10036):2383–2401.