Coronavirus disease spreading linked to socio-economical factors in Quito-Ecuador

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Keywords

Coronavirus

Abstract

Coronavirus disease (COVID-19) outbreak has caused a global economic crisis with a major impact on Latin America region. The effectiveness of governments efforts in reducing the propagation of the disease within the region varies between countries and cities. Provided the rich-poor inequality well-known in Latin America, it is explored a relation between socio-economical conditions within certain regions and the nature of the propagation itself. Ecuador has been one of the most hit-by-the-pandemy countries in the world since the beginning of the pandemic crisis, however, the country itself was not hit uniformally, for which this article is aimed to give some insights of whether inequality had an impact on the propagation of the disease within the country, taking one of the most contrasted cities in Ecuador, Quito, as a case of study.

1 Introduction

Coronavirus pandemic has cause a big impact on the global economy, being third-world countries the most affected. Even though the first case of Covid-19 in Latin America was reported on February 26 in Brazil, as of May the situation escalated making Latin America the new epicenter[**?**]. Countries within the region have imposed quarantine and sets of restrictions. Nonetheless, propagation has not decreased as expected.

Ecuador was the first country within the region to impose such restrictions; notwithstanding, during the first three months of the outbreak, the most affected country in the region, and one of the three most affected countries in the world. However, the propagation of the disease within the country has not shown itself uniform, being at the very beginning Guayaquil city the most affected, followed by the capital, Quito. Being the three main cities in Ecuador Guayaquil, Quito and Cuenca, and provided Guayaquil and Quito are the most unequal within the country, Quito is taken fit for a case of study.

1.1 Viral Infection Rate

It is well known that a virus spreads following an exponential function. This is

$$N(t) = N_0 e^{at} \tag{1}$$

where $N(t)$ is the number of infected people over time, N_0 is the initial number of infected people in an environment, e is the euler number, a is the rate at which the infection spreads at a particular time, and t is time. This equation is valid when no measures are taken in order to reduce infection, such as lockdowns or vaccines. When data was taken, at the very beginning of pandemy, lockdown has been already imposed. Given the early stages of the epidemic it is hard to know whether the data, with graphs resembling a linear function, indeed follow a linear pattern or an exponential function. Because of this uncertainty the analysis performed in order to check for a relation between income of the population in a sector and its spread rate was done over the assumption that the data follows a linear pattern and a second scenario where it follows an exponential pattern.

2 Methods

Provided the propagation of the disease has varied a lot between sectors of Quito, at first one might believe such variation depended on each sector's population, as at first sight, some of the most affected sectors, namely, the ones with the highest number of cases, were also the most populated. However, not every sector corresponded to this idea, whereby for the study, two main parameters were set: number of habitants per sector and average rental price within each sector. The latter gives us an idea of the affordability of the people living within each sector, and thereby an estimated salary.

For purposes of observing the propagation, the data collection also included the number of cases per day reported to COE, within a period of time starting April 29, 2020 and ending on June 6, 2020.

It becomes highly important to remark that unfortunately, for political reasons, data reported daily by government was not precisely accurate. However, this study pretends to show only patterns on how the propagation varied according to the parameters previously mentioned.

2.1 Data Collection

Quito is divided in 48 sectors. For each sector, data for three parameters were collected: number of coronavirus-positive patients reported, number of habitants and average rental price. Number of coronavirus-positive cases along with the date they were reported, were obtained from COE's main page, entered from infographics reported daily, within the period of time mentioned above. Number of habitants for each sector was obtained from the census report from 2010, which until the date the data was collected, was the last census report. Finally, average rental price was the statistical average obtained from a dataset that contained different rental prices as published on advertisements, and disclosure of such information by some habitants living in a specific sector.

2.2 Data Processing

All the data obtained was entered on a csv file, and then fetched and processed using Jupyter Notebook. The graphics where processed using python programming language in Jupyter Notebook environment.

2.3 Data Analysis

As previously mentioned, two scenarios where taken for the analysis. In the first one, given the assumption the data follows a linear pattern, a linear regression was performed over each sector obtaining C and D (Least Squares). Parameter C was set in the x-axis, whereas *average rental* in each sector was set to the y-axis.

In the second scenario, parameter a from (1) earlier was calculated with number of cases, initial and final, well-known, following the equation resulting from (1):

$$\frac{\log \frac{N}{N_0}}{t} = a \tag{2}$$

Nevertheless, the ratio $\frac{N}{N_0}$ does not reflect the proportion in which each sector had more or less progatation; this would have been the case if both N and N_0 were prime numbers. Since that's not the case, both were both reduced $N_0 - 1$, leaving $N_0 = 1$ for each sector. Parameter a was set in the x-axis, and *average rental* in y-axis.

3 Results

3.1 General insights

For purposes of relating number of habitants within each sector with the disease propagation ratio, first the dataset was sorted according to the population. Figure 1 shows the population of each sector, from the less populated one to the most.

The dataset was also sorted according to the average rental price per sector, as shown in figure 2.

Number of cases reported daily per sector. For purposes of legibility, the graphics show the number of cases reported per sector within the study period in the dataset having been grouped in sets of four sectors, as shown in section *Graphs*.

Among all sectors, two groups were identified to share some initial conditions, but different in terms of average rental price. In one group Cotocollado and Cumbayá were compared to each other, due to the fact that both share a similar population, though both lie in the two different poles in terms of average rental price. This in order to set apart population from disease's spread rate. The second group is Cumbayá compared along with Ferroviaria, due to the fact that both had initial number of reported-as-positive cases; this to set apart initial number of confirmed cases from disease's spread rate. Group 1 is shown in figure 3, and Group 2 is shown in figure 4.

3.2 Linear Regression and Curve Fitting

3.2.1 First Scenario: Linear pattern of infection

In figure 5 it is shown linear regression, as considered in the first scenario previously detailed, performed in the first two sectors. Red lines are the linear functions that best fits to data and it can be appreciated that each one has a different slope, which corresponds to the propagation ration for purposes of analysis, and labeled as C.

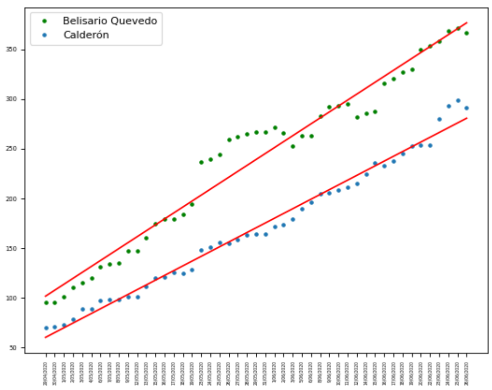


Figure 5: Regression Plot of two first sectors for purposes of readability.

A pattern is observed in figure 6 when C and *average rental* per sector is plotted, along with the function that best fits to the data.

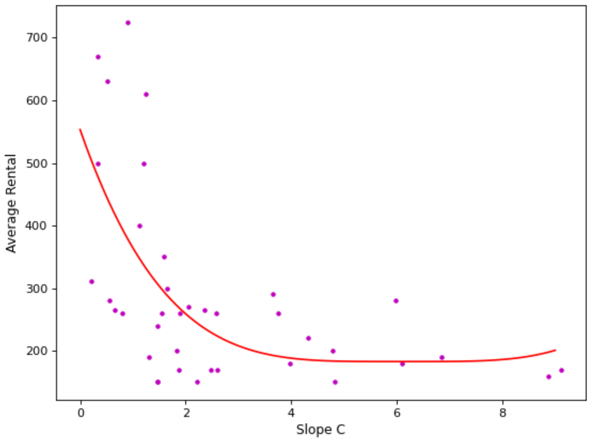


Figure 6: Plot of C as infection rate and average rental.

3.2.2 Second Scenario: Exponential pattern of infection

Figure 7 is the plot of Parameter a and average rental per sector, along with the function that best fit the data.

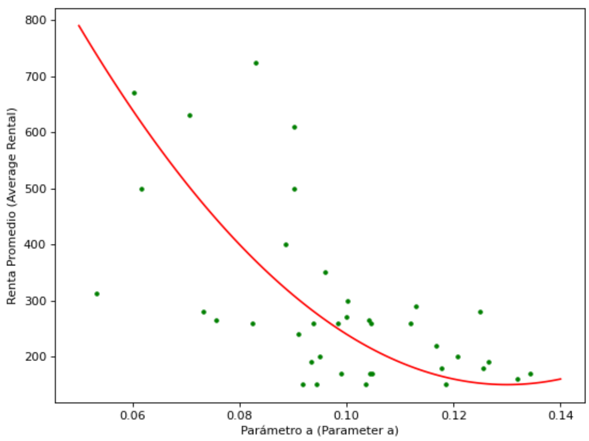


Figure 7: Plot of parameter a as infection rate and average rental.

4 Conclusions

In first scenario it can be observed a strong correlation between the average rental of a sector (which relates with the expected income of its habitants) and sector's propagation rate.

In second scenario the correlation is not very strong when average rental is high, but still observable.

In any case, it becomes clear that the socio-economical factor in ecuadorian population affects propagation rate, which can be explained due to people being able to stick to the lockdown. Informal job is a phenomena that displays the most among low-income people, not to mention the fact that services as delivery are not usual among these people, which means that staying home for low-income people is a matter of survival.

5 Figures

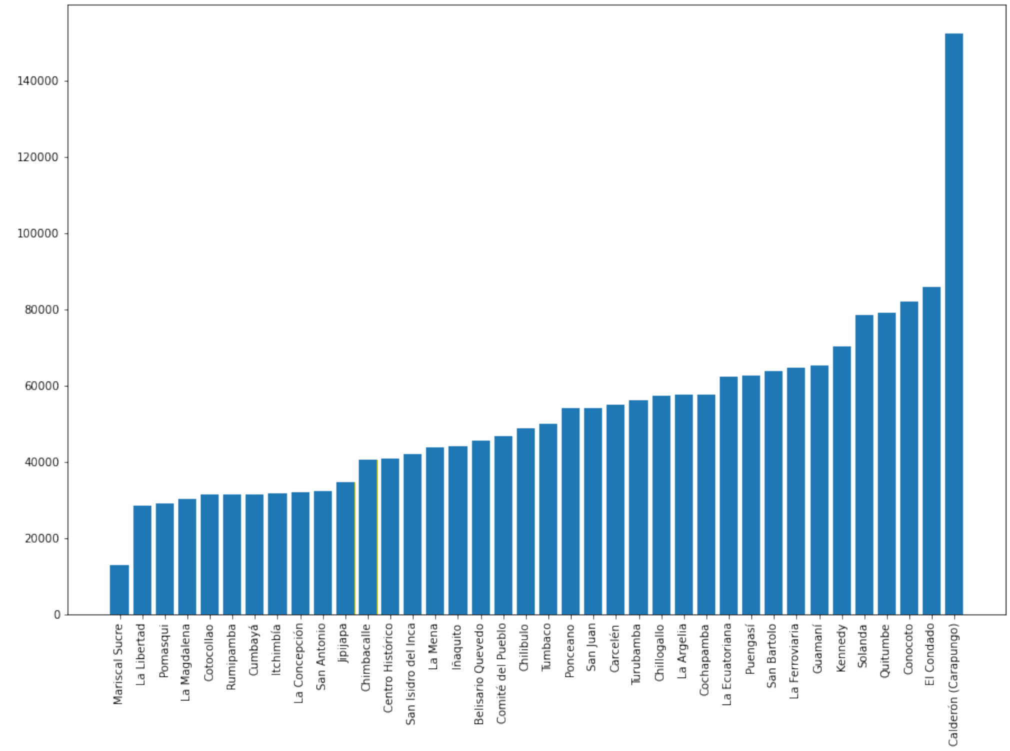


Figure 1: Population of each sector

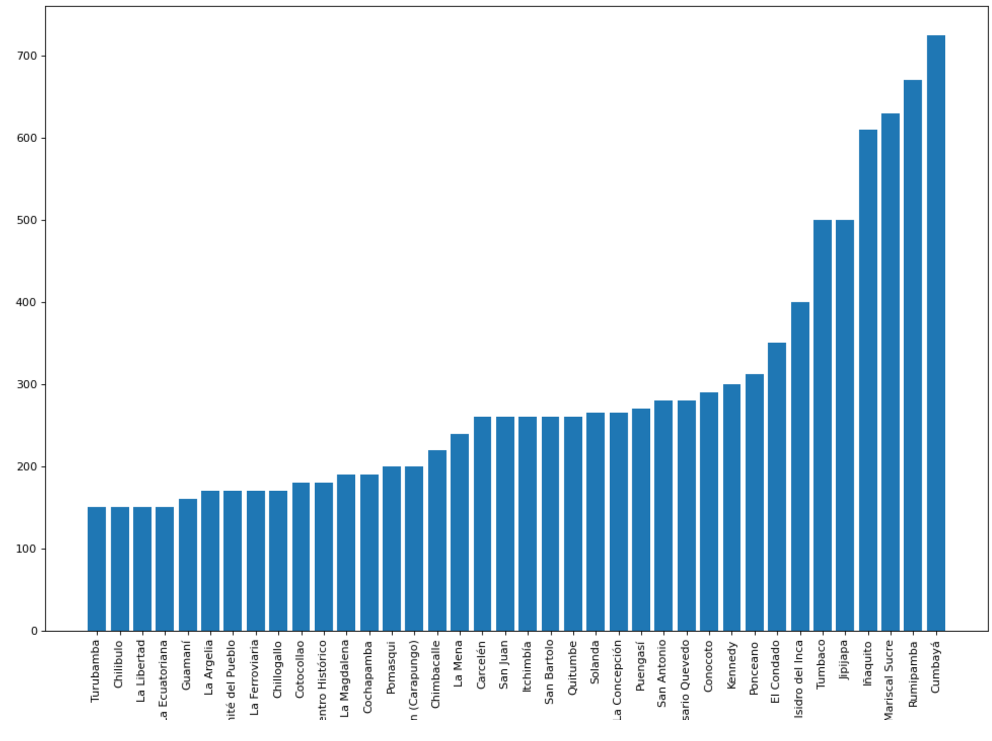


Figure 2: Average rental price per sector

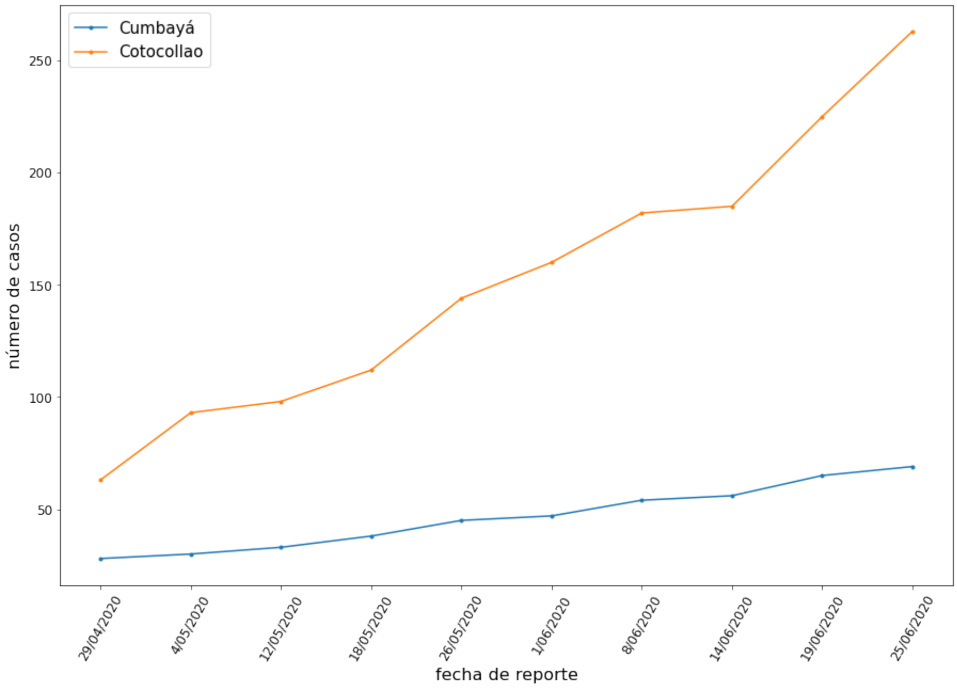


Figure 3: Disease's spread comparison between Cumbayá and Cotocollao

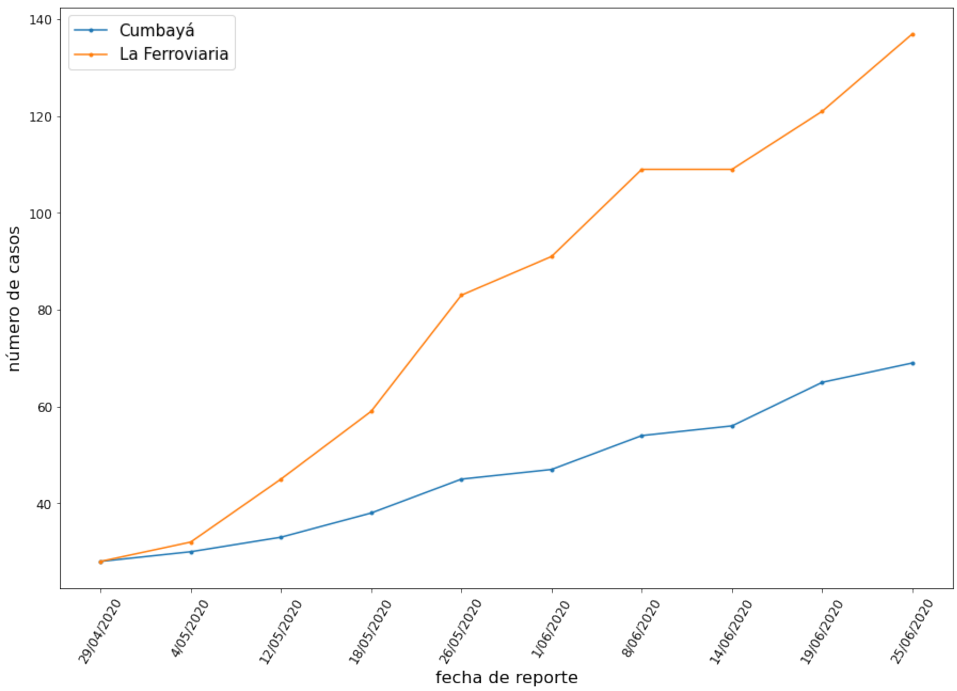
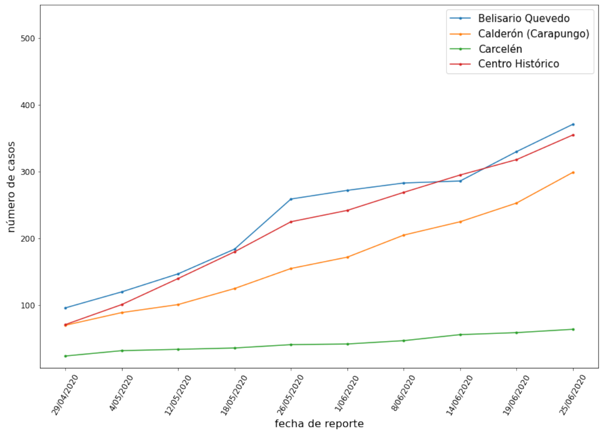


Figure 4: Disease's spread comparison between Cumbayá and Ferroviaria

6 Graphs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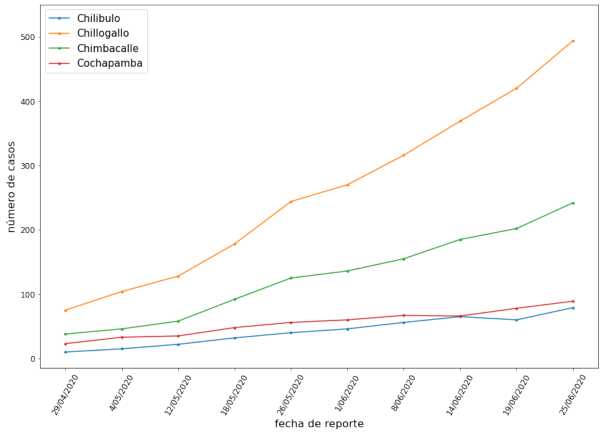
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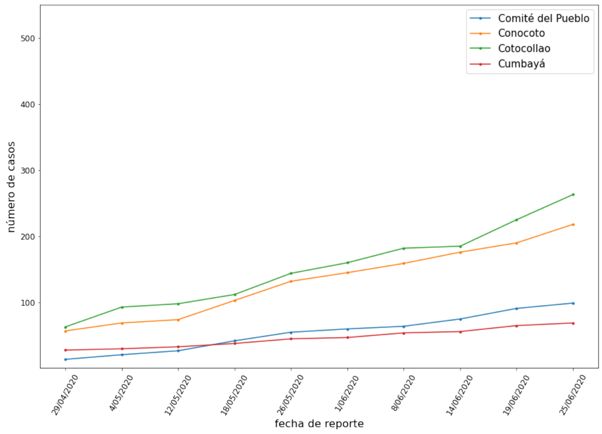
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Cumbayá
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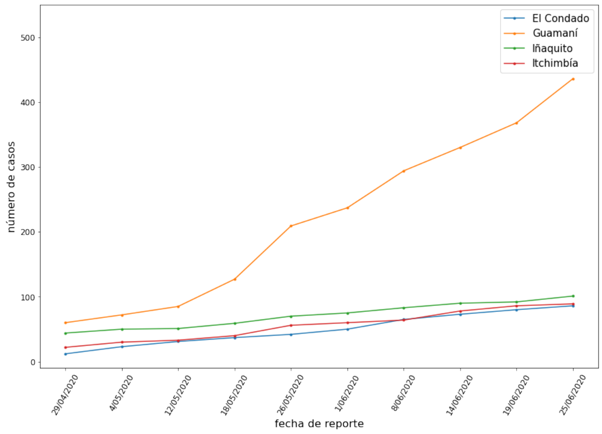
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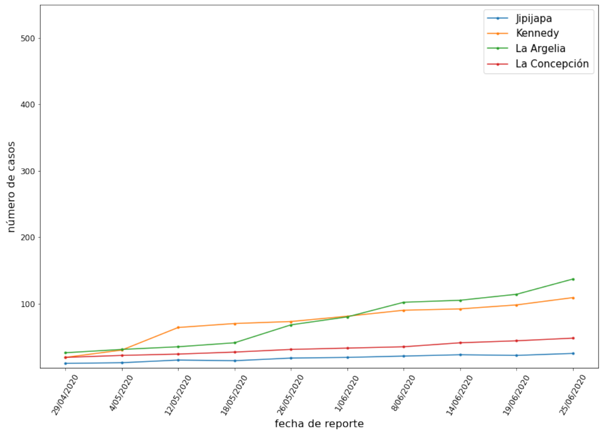
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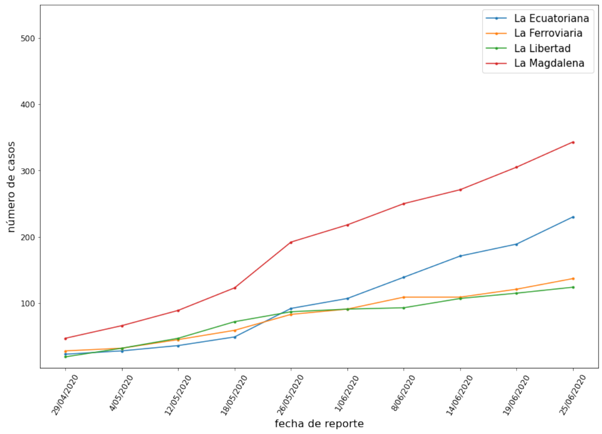
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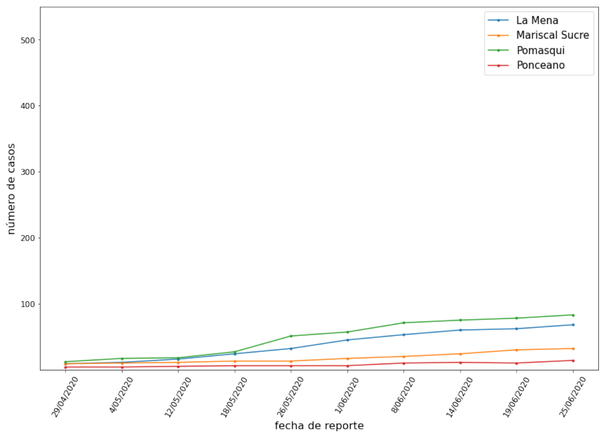
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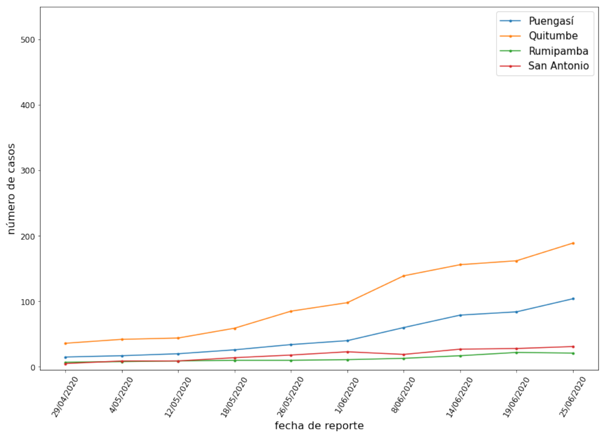
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Rumipamba
San Antonio
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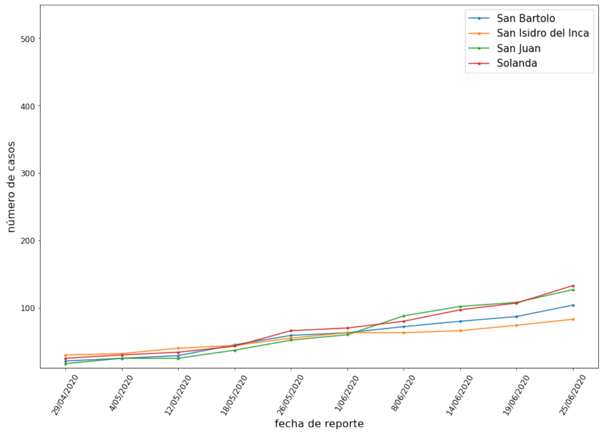

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Solanda
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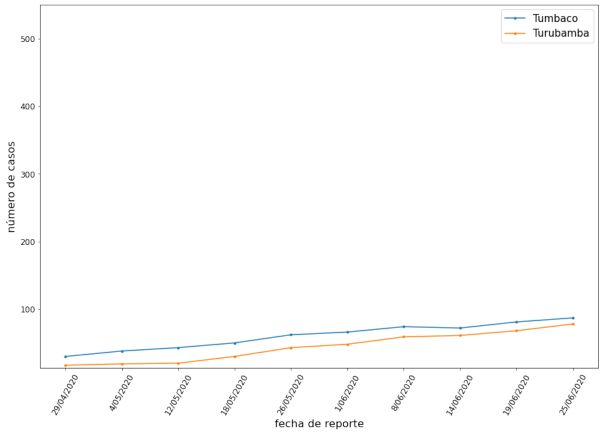

Tumbaco
Turubamba
número de casos
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