Covid-19 and the health care system of New York, US

Frederico Zavam

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1. Introduction

In the last few days we have been experiencing a major health crisis due to the novel coronavirus pandemic, and the main risks of the pandemic is not only the virus itself, but the collapse of the health system. Therefore, this work aims to analyze the distribution of hospitals and ICU beds together with data about the contamination of corona virus.

First, we will give an overview of the situation in all of the United States, and then, we will analyze the state most affected, New York. For this analysis, we used contamination data with the number of people infected, hospitalized and death by state; the distribution of hospitals and the number of beds in the United States; and the number of ICU beds per city.

2. Data source

2.1 Covid-19 cases in the United States

States Current Values of infected is obtained from COVID-19 Tracking project. The COVID Tracking Project collects information from 50 US states, the District of Columbia, and 5 other US territories to provide the most comprehensive testing data we can collect for the novel coronavirus, SARS-CoV-2. They attempt to report positive and negative results, pending tests, and total people tested for each state or district currently reporting that data. Initial basic API & CSV is available in the url: https://covidtracking.com/api/

This data was divided in this work into two types, one that has the timeline of contamination, death and number of people hospitalized by State; and another one, that is the last update of this data, that is, the “current picture”.

2.2 ICU beds in United States

Kaiser Health News evaluated the capacity of intensive care unit (ICU) beds around the nation by first identifying the number of ICU beds each hospital reported in its most recent financial cost report, filed annually to the Centers for Medicare & Medicaid Services. KHN included beds reported in the categories of intensive care unit, surgical intensive care unit, coronary care unit and burn intensive care unit. KHN's ICU bed tally does not include Veterans Affairs hospitals, which are sure to play a role in treating coronavirus victims, because VA hospitals do not file cost reports. The total number of the nation's ICU beds in the cost reports is less than the number identified by the American Hospital Association's annual survey of hospital beds, which is the other authoritative resource on hospital characteristics. Experts attributed the discrepancies to different definitions of what qualifies as an ICU bed and other factors, and told KHN both sources were equally credible. https://khn.org/news/as-coronavirus-spreads-widely-millions-of-older-americans-live-in-counties-with-no-icu-beds/

2.3 United States hospitals

This database contains locations of Hospitals for 50 states and Washington D.C., Puerto Rico and US territories. The dataset only includes hospital facilities and does not include nursing homes. Data for all the states was acquired from respective states departments or their open source websites and then geocoded and converted into a spatial database. Not Available denotes information that was either missing in the source data or data that has not been populated current version. Updated: December 2, 2019. https://catalog.data.gov/dataset/hospitals-dcdfc

2.4 New York COVID-19 data

For the neighborhood in New York City was used the dataframe by New York City Department of Health and Mental Hygiene. In:https://www.nytimes.com/interactive/2020/04/01/nyregion/nyc-coronavirus-cases-map.html. Update: April, 1, 2020. The cities data for NY is from https://www.nytimes.com/interactive/2020/us/new-york-coronavirus-

cases.html Data are based on reports by states and counties at the time of publication. Local governments may revise reported numbers as they get new information. Some deaths may be reported by officials in two different jurisdictions. When possible, deaths have been reported here in the jurisdiction where the death occurred. Read more about this data here. While the first known case in the United States was announced on Jan. 21, charts show cases since Feb. 26, when American public health officials first identified community transmission of the virus. *Cases in New York City and Kansas City, Mo., both of which span several counties, are grouped together. Cases in a state that have been reported without a specific county are listed as county “unknown.” Population data from Census Bureau.

2.5 Geospatial data

1) In order to create a Choropleth map to analyze the spatial distribution of the data, is necessary a GeoJSON file that defines the areas/boundaries of the state, county of interested. In my case, since I'm endeavoring to create a US map, I want a GeoJSON that defines the boundaries of all US state and county.
2) In order to create a Choropleth map to analyzes the spatial distribution of the data, is necessary a GeoJSON file that defines the areas/boundaries of the borough. In my case, since I'm endeavoring to create a NYC map, I want a GeoJSON that defines the boundaries of all boroughs in NY.

3. Background of the problem

3.1 Numbers of infected each state

In the US, the most affected state is New York, according to US health department data. As seen below on the Choropleth map with confirmed cases by States using a Python visualization library Folium, developed for the sole purpose of visualizing geospatial data (Figure 1).

state	positive	death
New York	188694.0	9385.0
New Jersey	61850.0	2350.0
Massachusetts	25475.0	756.0
Michigan	24638.0	1487.0
Pennsylvania	22833.0	507.0

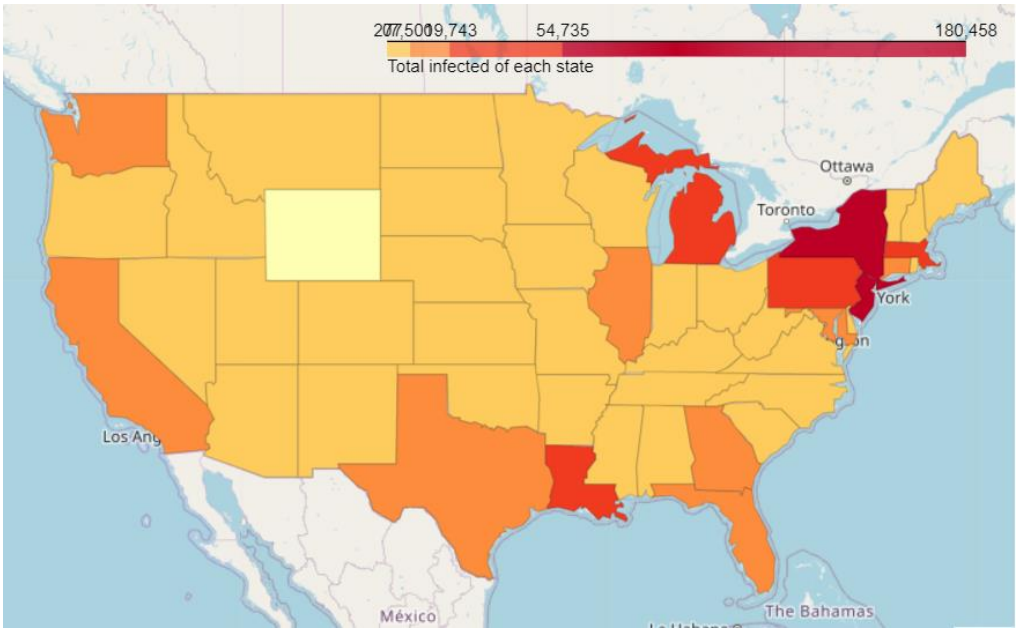

Figure 1: Choropleth map of the US with the total infected of each state in April 10, 2020

3.2 Numbers of ICU beds each State

And, as the problem of the pandemic is the collapse of the health system generated by the lack of beds in the ICU, it is necessary to analyze where the beds are distributed in the US. The map below shows the number of ICU beds in each state (Figure 2). And, as we can see, some states, even with the largest number of infected, also have one of the largest number of beds, as occurs with New York (4th).

State	ICU Beds	Residents Aged 60+ Per Each ICU Bed
California	7338	68758.0
Texas	6199	99694.0
Florida	5604	52222.0
New York	3952	72521.0
Ohio	3314	97902.0

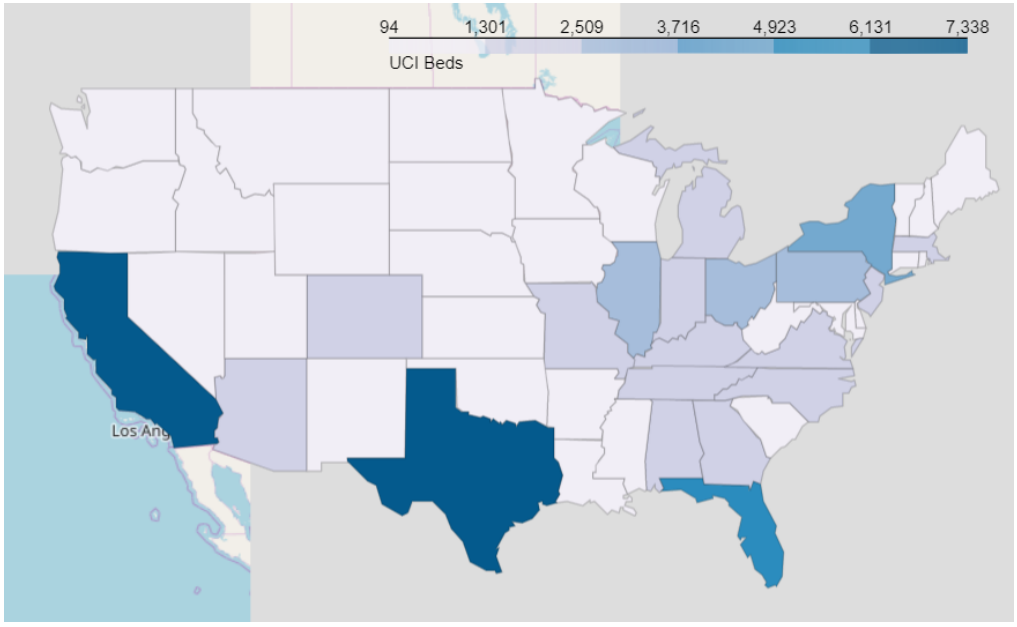

Figure 2: Choropleth map of the US with the total ICU beds of each state.

3.3 Numbers of hospitals beds each State

It is also important to analyze the numbers of beds, they have the potential to become semi-intensive therapy beds if they are properly equipped. And as can be seen, they follow more or less the same order of magnitude as the ICU beds. With California and Texas leading with the largest amount of both, ICU and normal beds (Figure 3).

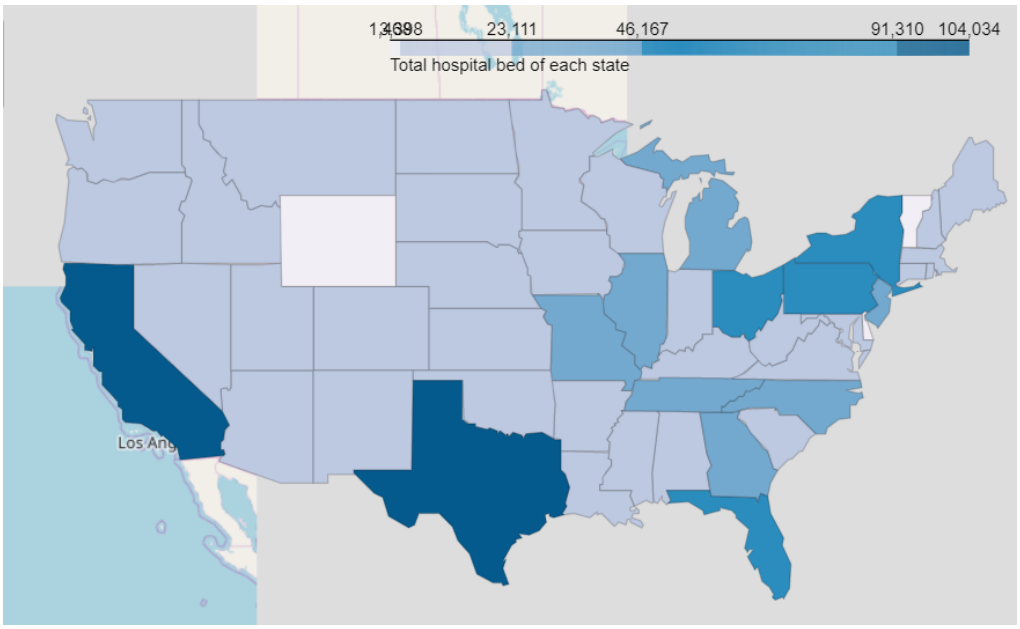

Figure 3: Choropleth map of the US with the total ICU beds of each state

3.4 Balance between hospitalized people and ICU and Hospital beds

The question is that if these beds are sufficient to attend all hospitalized people. Therefore, to analyze this question, it is necessary to subtract the numbers of hospitalized people, by the number of ICU beds and see if the balance is positive or negative. And as we can see in the graphs below (Figure 4 and 5), the situation is very critical in New York if not considering the new beds created by the field hospital.

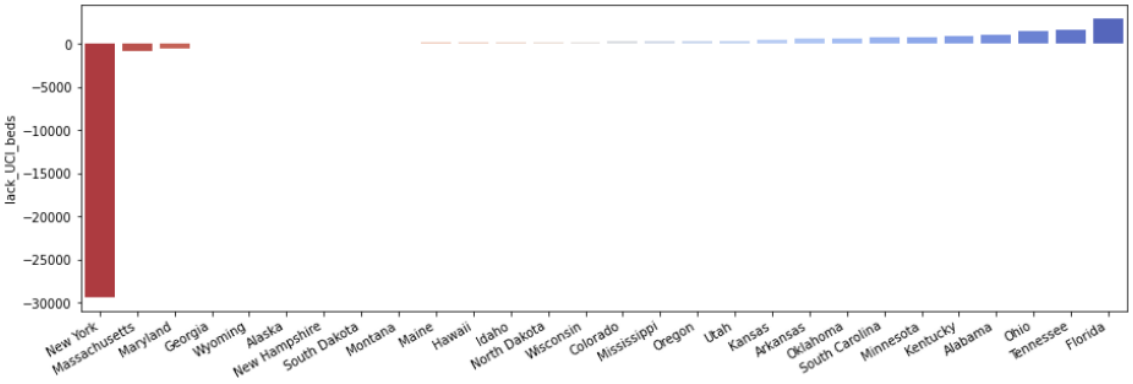

Figure 4: Graphs with the balance between hospital people and UCI beds in each state.

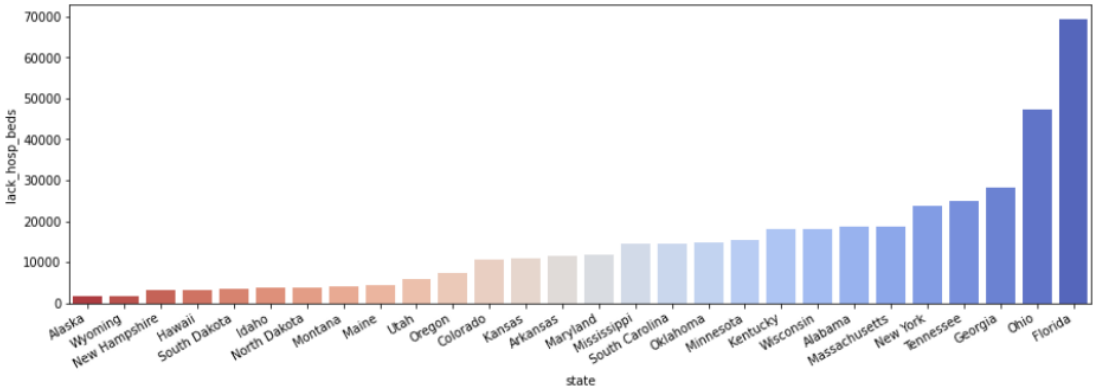

Figure 5: *Graphs with the balance between hospital people and hospital beds in each state.*

3.5 Relationship between the limit of ICU beds and the fatality rate

The importance of not crossing the ICU bed limits can be seen in the two graphs below (Figure 6.a and 6.b) using the New York data. From the day that the numbers of hospitalized people pass the ICU bed limit (2020-03-25), the fatality rate increases considerably.

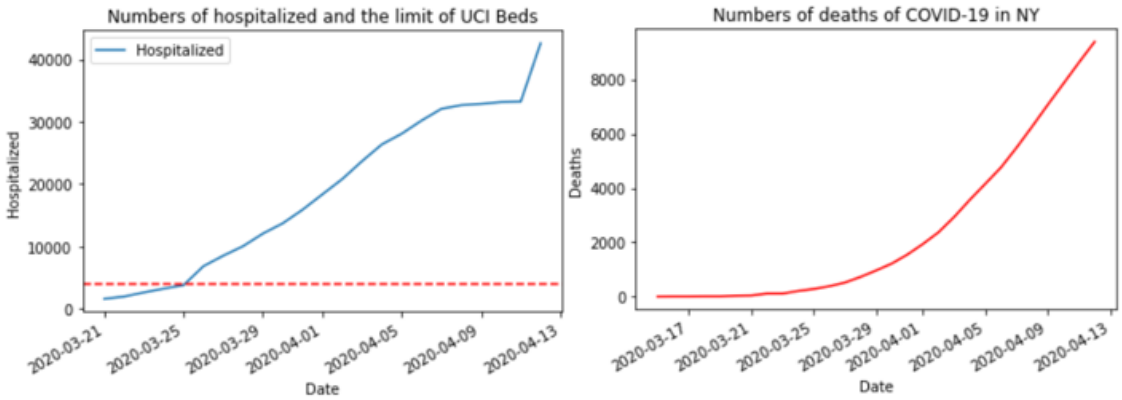

Figure 6: Numbers of hospitalized people and death at timeline.

4. New York healthy system and COVID-19

4.1 Infected and the boroughs

When you look at the boroughs with the most people infected (Figure 7), Queens is the region with the highest number, followed by Brooklyn, Bronx, Manhattan and Staten Island.

Borough	Total cases
Queens	12467
Brooklyn	10735
Bronx	7183
Manhattan	6106
Staten Island	2355

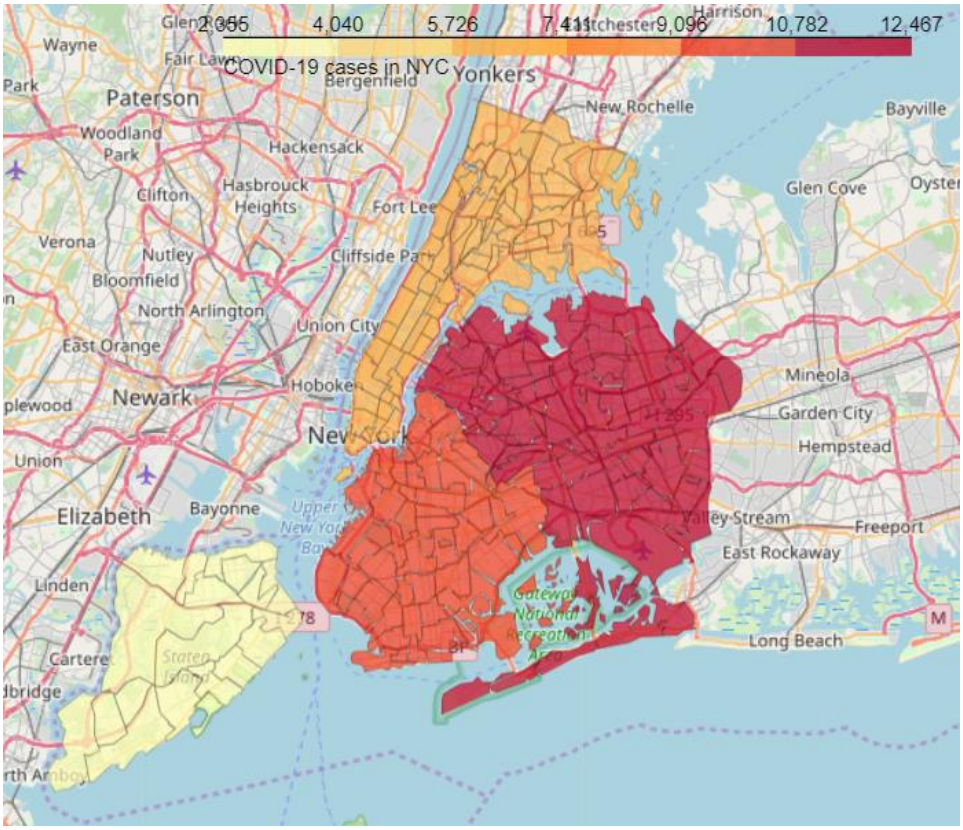

Figure 7: Choropleth map of the NYC with the total ICU beds of each infected each borough.

But the region with the highest density of infected, using zip code contamination data, is the southern region of Manhattan (Figure 8).

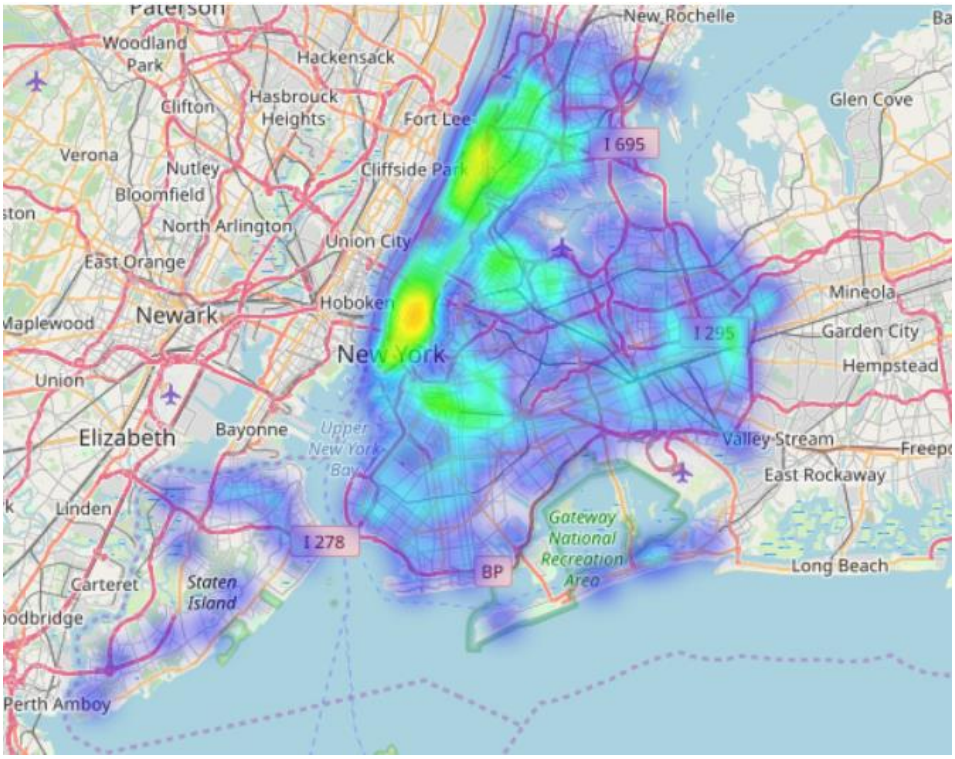

Figure 8: Density of infected people in map of the NYC.

4.2 Hospitals and bed distribution in NYC

According to data obtained, the state of NY has 243 hospitals. Most of them are general acute care hospitals (Figure 9). The 34 hospital for psychiatric issues was dropped, because, in my opinion, it would do little to help patients with breathing problems. Then, the graph below shows the number of each type of hospital.

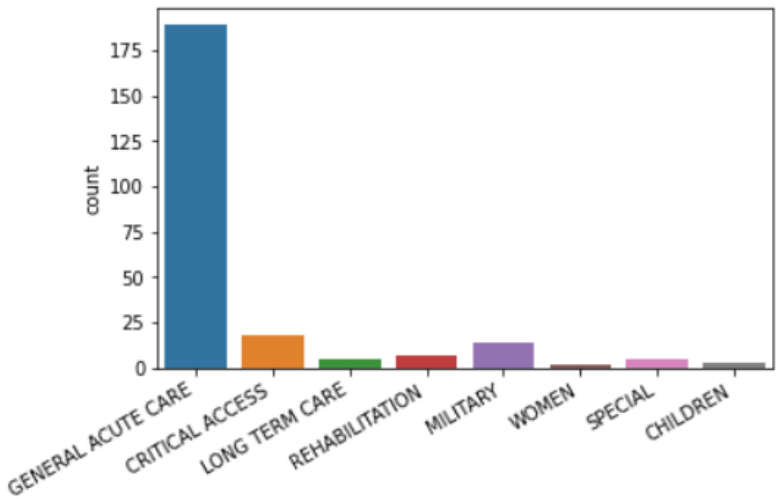

Figure 9: Numbers of each type of hospital in NYC.

The maps below show where the beds are distribute (Figure 10), and then where the hospitals in NYC are located (Figure 11) using the Bubble maps in the folium library.

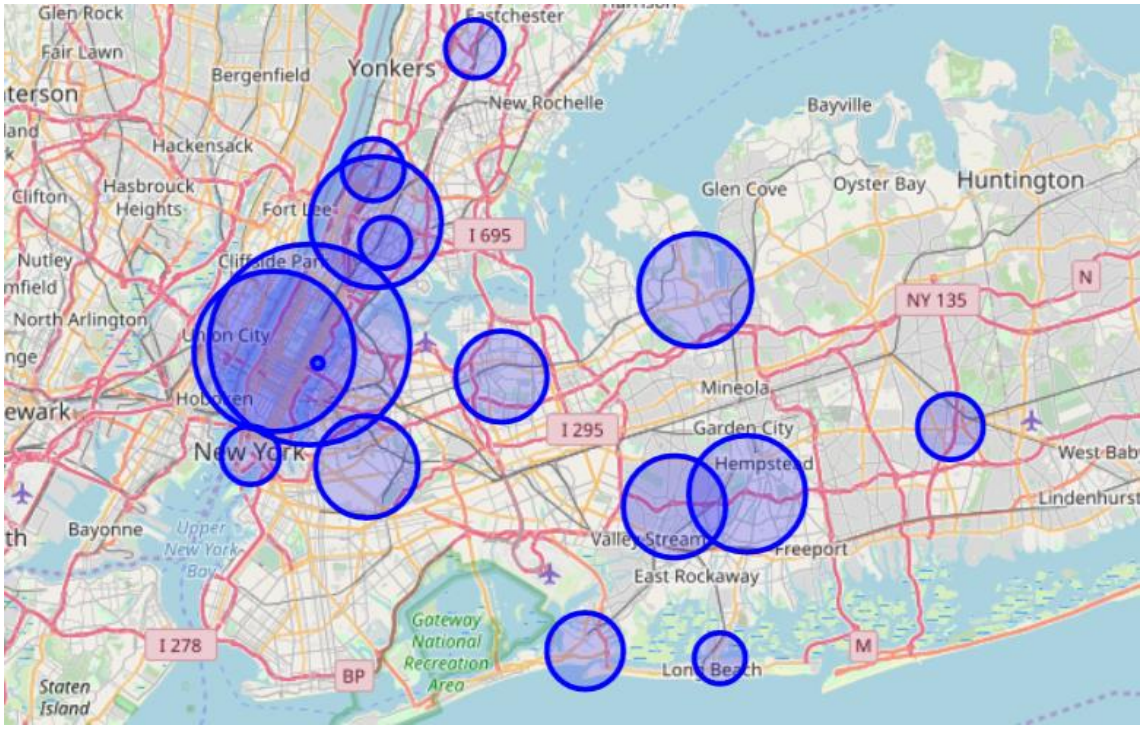

Figure 10: Bubble map with the proportion and distribution of hospital bed in NYC.

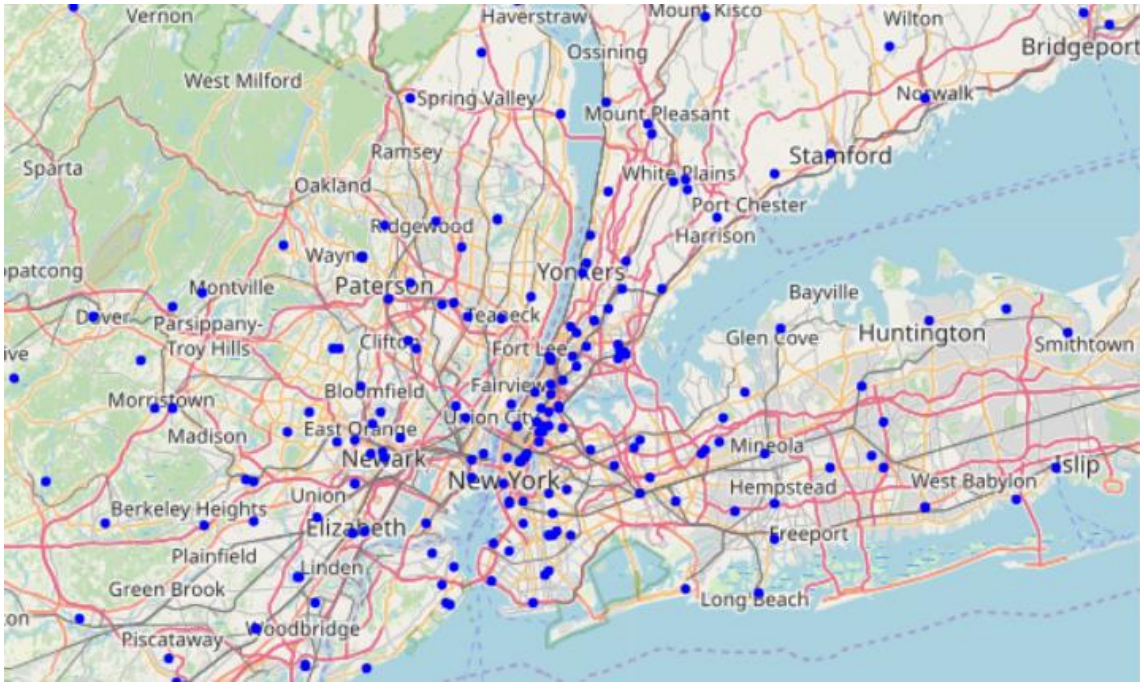

Figure 11: Distribution of hospitals in NYC.

5. DBScan Clustering

5.1 DBScan clustering hospitals based on their location

DBSCAN form sklearn library can runs DBSCAN clustering from vector array or distance matrix. In this case, we pass it the Numpy array Clus dataSet to find core samples of high density and expands clusters from them (Figure 12).

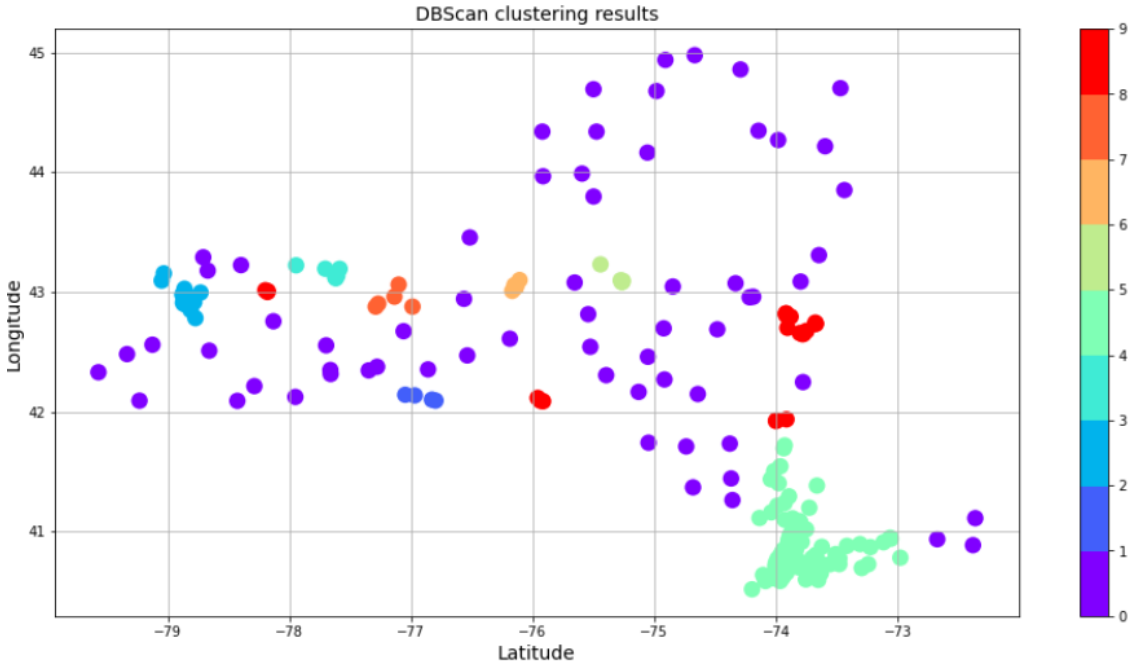

Figure 12: DBScan clustering hospitals based on thei location.

Visualization based on hospital location and beds (Figure 13).

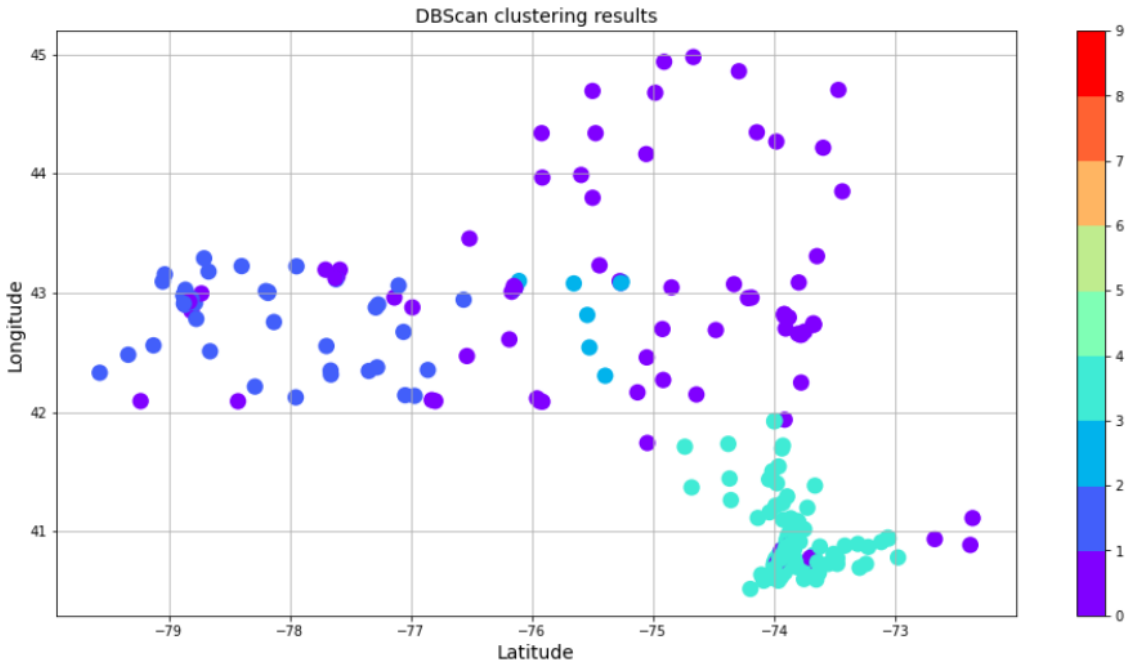

Figure 13: DBScan clustering based on location and beds

6. Conclusions

As we can see, to make an analysis of the potential risk of the corona virus in a place, it is important to analyze beyond the numbers of contaminated itself. It is important to take into account the number of hospital and ICU beds, and the density of beds and contaminants. This work is an initial way to apply an optimization work for patient distribution, as explained below.

7. Future directions

The number of contaminated, and therefore hospitalized people, grows exponentially. If the creation of hospital beds in field hospitals is not enough, it may be necessary to disperse patients to other hospitals in the region, using an optimization calculation. The map below shows a list of all hospitals in the USA. In this data, beyond latitudes and longitudes of the hospitals there is also information about the number of beds and the presence of helipads or not, which can help transfer patients.

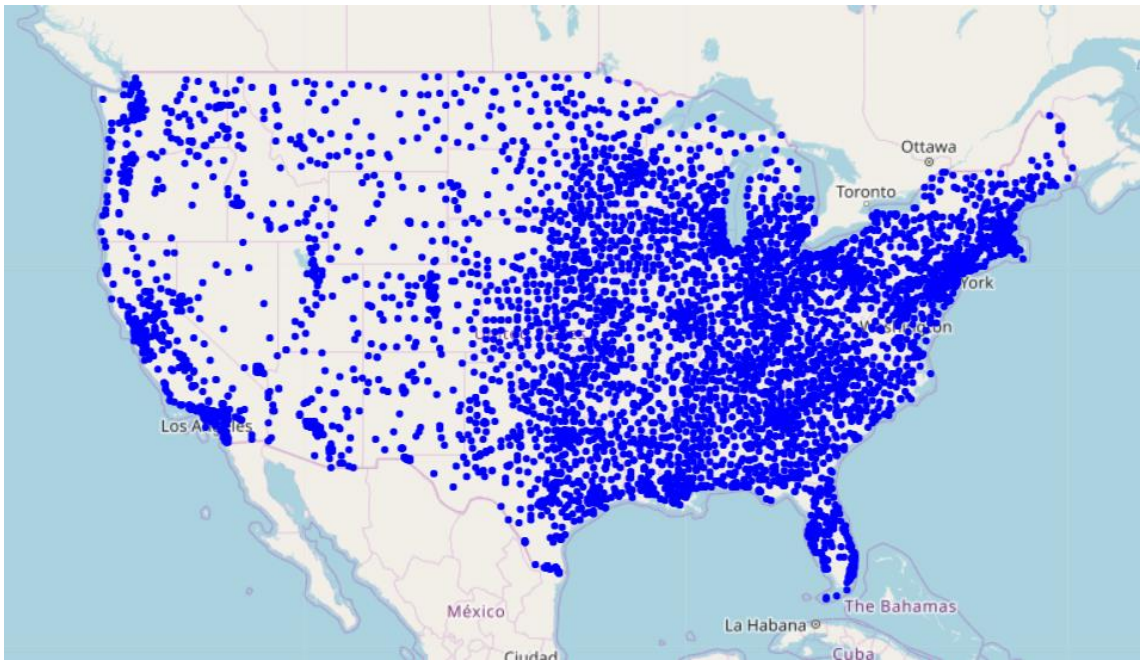

Figure 14: Location of the hospitals in the US

The idea is to have local maximum hospital beds for each borough, State, and a global maximum for the entire US. Before reaching the local maximum of the borough, patients would be distributed to other boroughs in the same State, and before reaching the local maximum of beds in the State, patients would be distributed to reach the global maximum of US beds. The graph below shows the maximum local of NY State (Figure 13), and the maximum global of the US (Figure 14).

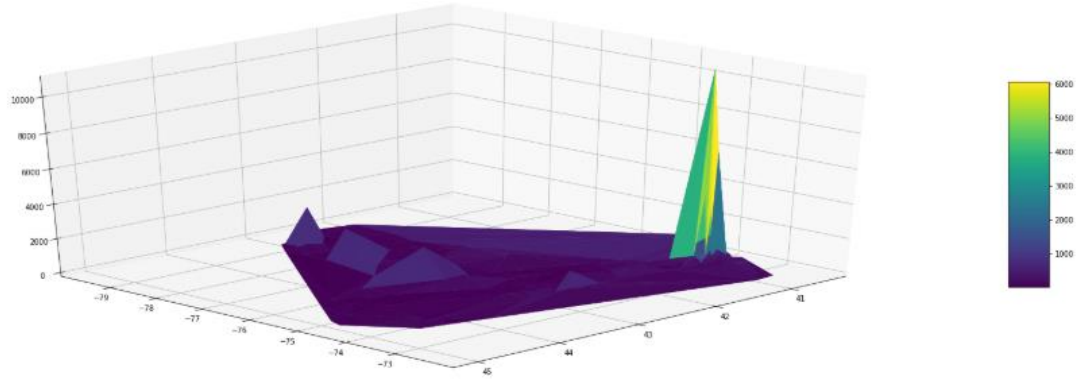

Figure 15: The 3D with Latitude, Longitude and the beds maximum capacity in the NY states, maximum local.

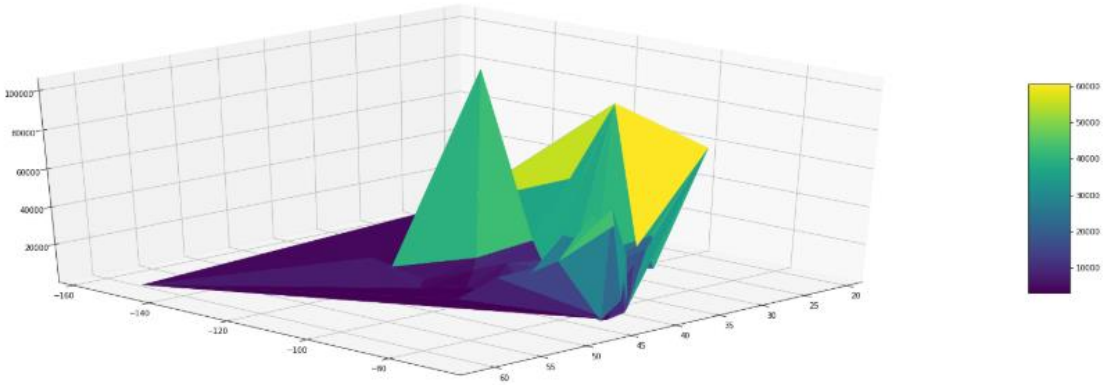

Figure 16: The 3D with Latitude, Longitude and the beds maximum capacity in the US, maximum global.