Statistical Tests linking the current global crisis by COVID-19 to the presence of 5G technology.

Summary

This document describes the statistical analysis based on official numbers to test whether 5G technology has any relation to the current coronavirus crisis that causes COVID-19. It does not intend at all to conclude that it is the only cause of a phenomenon as complex as the one we are observing, neither to measure the magnitude of the 5G technology influence over the COVID-19.

Background

Several authors have warned about the potential health damage generated by 5g technology. According to T-Mobile, one of the companies that already offers the technology, this is how the 5g works: 5G spectrum includes all type of spectrum including low band, mid band and high band spectrum.

High-band millimeter wave frequencies have higher bandwidth available to transfer more data in heavily populated urban areas but require cellular towers to be nearby and have limited penetration into buildings. The mid band balances speed and range, providing wider coverage than the high band and it's less affected by buildings. However, much of its bandwidth is already in use, hence 5G can't grow much longer. The low band, like our powerful 600 MHz spectrum, travels farther than other bands (hundreds of square miles) and offers a better and more reliable signal indoors and outdoors."

In the face of the current epidemiological catastrophe concerning COVID-19, the idea of investigating whether there could be a correlation between the existence of 5g technology and the size of the COVID-19 crisis emerged.

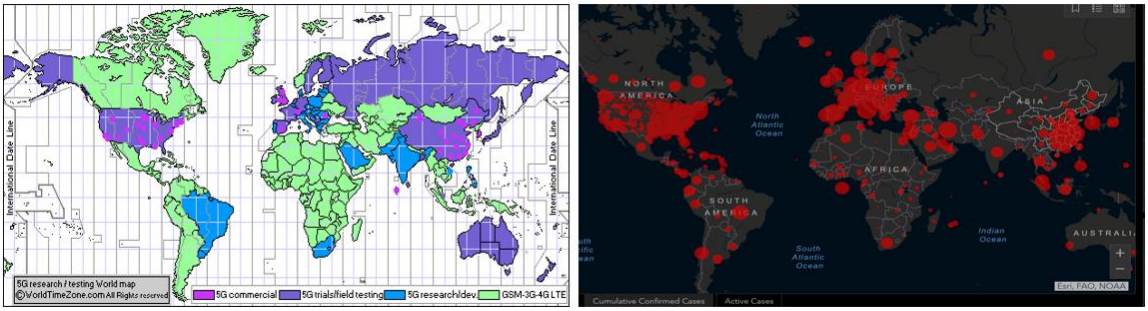

Figure 1. Comparison of the 5G technology and the number of cases of COVID-19. Sources: Left figure: *WorldTimeZone*, Right figure: *Johns Hopkins Coronavirus Resource Center*.

Comparing the similarities of the two maps of Figure 1, hypothesis arises that there is a correlation between the presence of 5g technology and the existence of an epidemiological crisis by COVID-19. Of course I do not mean to say that the coronavirus spreads more where the technology exists, but rather that the signal emanating from the 5g antennas weakens

the immune system of people, which helps the virus infection to a greater number of people in the countries where this technology already exists.

Firstly, I reviewed the launching dates of 5G technology presented by the source WolrdTimeZone.com and I noticed that, in general, the release dates of the technology match with those of the outbreak. For example, in South Korea the first 5G connection satellite was launched on November 25, 2019, while in China on November 1, 2019, (China's three major state telecom operators rolled out 5G nationwide (50 cities) on November 1, 2019). Meanwhile, in the United States, different mobile service companies have begun to provide coverage gradually, Sprint, in cities such as Atlanta, Dallas, Houston, and Kansas City since May 2019, Chicago since July, Los Angeles, New York, Phoenix and Washington D.C. since the end of August. T-Mobile says it launched the 5G network nationwide on December 6, 2019, with coverage in 5,000 cities and 200 million people (low band).

According to the source, Japan and Russia do not have yet 5G developments. Switzerland instead, launched technology since April 17, 2019 in 54 cities, and Carrier Sunrise covers 309 Swiss villages since November 2019. Another curious case is Spain, heavily hit by the virus, where, since November 25, 2019, Vodafone / Huawei offered the technology in 15 major cities. We could analyze on a case-by-case basis, country by country, qualitatively, but in order to prove whether the hypothesis is true or not, we need to perform a statistical analysis of the data.

Information.

There are several sources with official number of infected cases, as well as deaths, recoveries, etc., which are updated day by day. However, I decided to use the database provided by Worldometers, because it contains a summary to the latest day. The database contains the total number of infected cases, the total number of deaths, among other country-level variables.

On the other hand, there is no database with the number of 5G antennas or worldwide services providing the 5G. The Ookla provider, which is a global source of metrics over the internet, provides an interactive map with the number of 5G services offered geographically.

Figure 2. Map with the number of worldwide deployments of 5G. Source: Ookla.

Due to the lack of database of the 5G deployments, I visually counted the number of deployments of 5G provided by Ookla for each country. Hence, there is a measurement error caused by eye-count. According to the source, there are 7,293 deployments worldwide and the visual count yielded 7,189 deployments, i.e. a 1.43% error.

Regression Analysis.

The database contains 197 countries with the number of total infected cases, their total population, as well as the number of 5G deployments in each country. One can build a Regression model that explains the number of coronavirus cases through the number of deployments of 5G through the following formula:

$$y = \beta_0 + \beta_1 x$$

Where:

y represents the number of coronavirus cases.
x represents the number of deployments of 5G
β_0 the Y- intercept.
β_1 is the Regression coefficient.

Result of the Regression model:

The REG Procedure
Model: MODEL1
Dependent Variable: Cases Cases

Number of Observations Read	197
Number of Observations Used	197

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	11174263328	11174263328	78.64	<.0001
Error	195	27709558795	142100302		
Corrected Total	196	38883822122			

Root MSE	11921	R-Square	0.2874
Dependent Mean	3499.31472	Adj R-Sq	0.2837
Coeff Var	340.65479		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	2795.01234	853.01194	3.28	0.0012
_5gTech	5gTech	1	19.29998	2.17643	8.87	<.0001

Figure 3. Summary Results of the Regression Model.

According to the Analysis of Variance, we observed that the p-value is less than 0.001. This means that with 95% of confidence level, the deployments of 5G affects the number of coronavirus cases.

Furthermore, if we analyse the variable 5GTech we can see that the p-value is also less than 0.001, Hence with 95% of confidence level, there is statistical evidence that the variable 5GTech affects the number of cases. The Estimation of the parameter of the variable 5GTech is 19.3. This means that for every implementation of the 5G there will be 19.3 more cases of coronavirus.

It is important to analyse the Coefficient of Determination, known as R-squared. This coefficient is a statistical measure that represents the proportion of the variance for the number of COVID-19 cases that is being explained by the 5GTech variable in the regression model.

For this particular case, R-squared is 0.2874, i.e., 28.74% of the variability in the number of cases with COVID-19 is explained by the 5G technology. Notice that this number is not large enough, this phenomenon can be explained by the fact that there are several variables involved in the crisis of Coronavirus. In this exercise it is not our interest to measure the quantitative impact of 5G technology on COVID-19, but simply to check whether it has an effect or not.

Test of Independence

Another technique for testing whether there is a relationship between the two variables is the test of independence (Chi-square). This test is used when categorical information is available, rather than numerical variables. A transformation into dichotomous variables, i.e. 0 and 1, can be done to the above variables. This can be useful because the numerical variable regarding the number of 5G antennas can skew the results by not representing percentage of coverage within the country, or the number of inhabitants "covered" by technology. By transforming the variable into dichotomous variable, we will only be interested in knowing whether 5G technology exists in the country or not. The same can be done with the variable regarding the number of cases with Covid-19. We can assign a value of 1 to countries that have crises and 0 to those that do not. We will define that the country has a coronavirus crisis if the number of cases per million inhabitants is greater than 500.

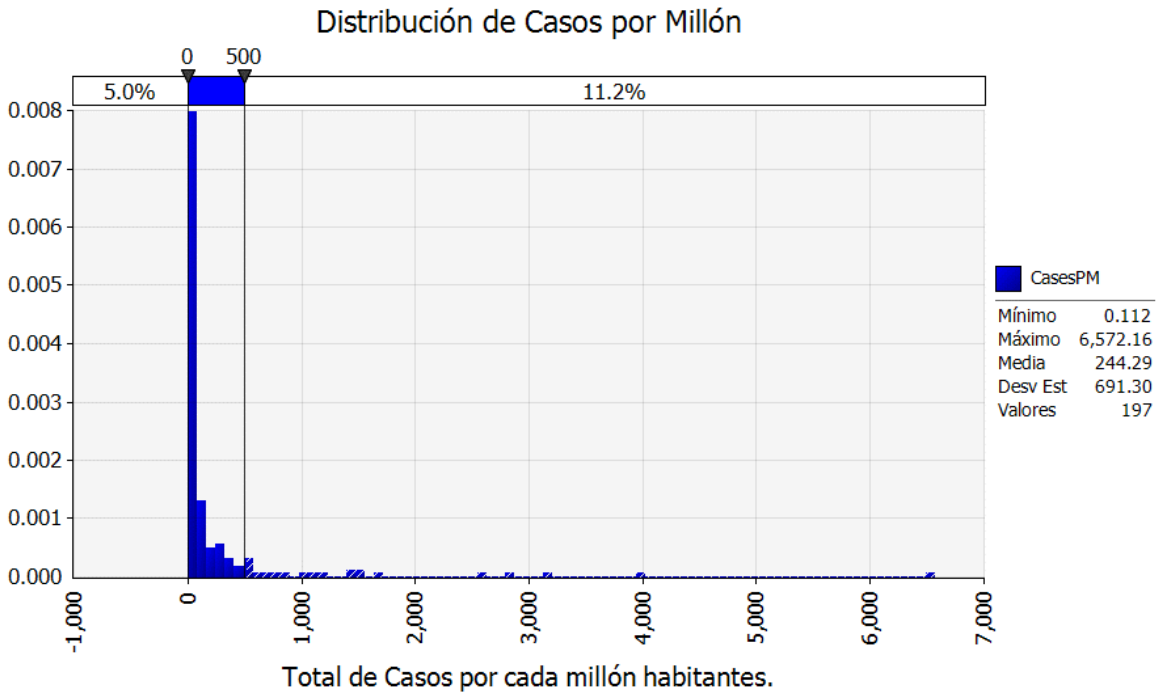

Figure 4. Distribution of the number of cases per million inhabitants.

Figure 4 illustrates that on average there are 244.29 cases of coronavirus per million inhabitants. This is a typical case of a "fractal" distribution, in the sense that most observations are close to zero (high bar close to 0), while there are a few observations with extremely high values. The median is 35.51, which means that the probability that a country has less than 35.51 cases per million is 50%. In the same way, the probability that there are more than 35.51 cases per million in a country is 50% too. We can see that the median is very distant from the mean (35.51 vs. 244.29), this is because the right tail of the distribution, which represents countries that present a critical situation have a value that is many times higher than the average. For example, San Marino, a small country that lies within Italy, has an indicator of 6,572 cases per million, representing 9.15 standard deviations above the mean.

Using the previous threshold for the “countries in crisis”, we can observe in Figure 4 that there are 11.2% of the countries in that situation. Another criterion could be used, or the threshold could be modified to discriminate a different proportion of critical cases.

The following contingency table shows the information of the 197 countries, it summarizes the number of countries with or without crises and the number of countries with or without 5G technology.

5g / COVID	With Crisis	Without Crisis	Total
With 5GTech	8	26	34
Without 5GTech	14	149	163
Total	22	175	197

Table 1. Contingency Table of countries with COVID-19 crisis and 5G technology.

Table 1 is very easy to read, just look for the cell that contains the desired combination. For example, 8 represents the number of countries that have 5G technology and that have coronavirus crisis. There are 149 countries without 5G technology and no COVID-19 crisis, mainly countries in Africa and Latin America.

With this information, it is possible to test independence between the two variables with the Chi-Square test. This test does not demonstrate causation, i.e. the test will not prove whether x causes y, or if y causes x, it simply indicates if there is independence between the 2 variables or not. What the test does is to assume that there is independence between the variables and calculate the probability that that assertion is true.

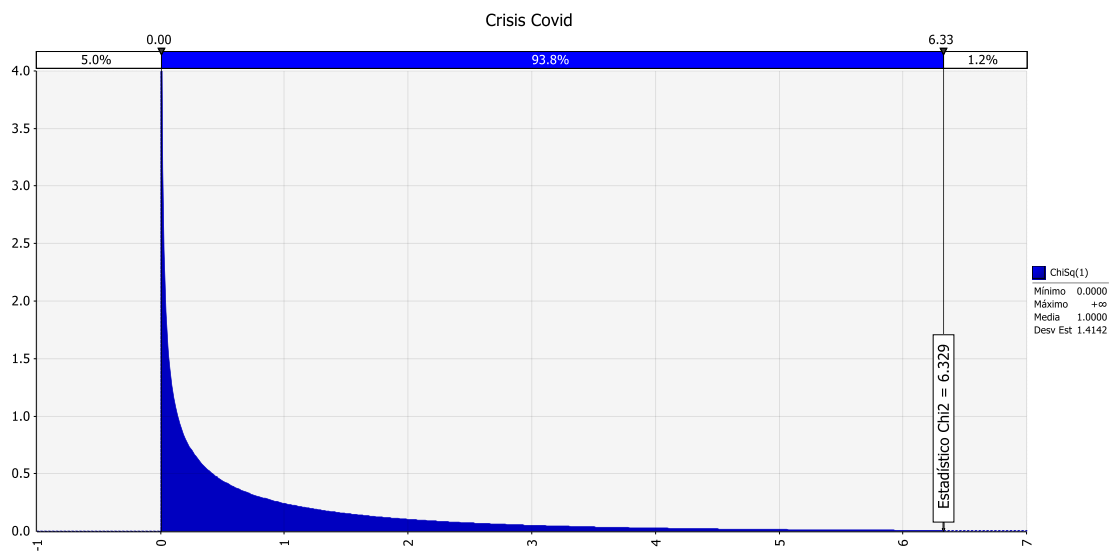

Figure 5. Chi-squared distribution χ^2 with 1 degree of freedom.

The test statistic is equal to 6.3299. The associated p-value for the test statistic is equal to 1.2%, i.e. the probability that the COVID-19 crisis and the presence of 5G technology are independent is significantly low. Hence, with 95% of confidence level we can conclude that the 2 variables are **NOT INDEPENDENT**.

Conclusions

It was statistically proven that the presence of 5G Technology and the fact that a country is in crisis of COVD-19 are **NOT INDEPENDENT**. As we stablished before, it is not possible to determine the magnitude of the impact between the two variables, obviously, there are many other factors involved in the crisis of Coronavirus. The aim of this study was only to determine whether both variables are related or not.

Appendix.

Below are the data used to the Chi-Square test separated by groups.

1. Countries with COVID-19 Crisis and 5G Technology.

País	Casos por Mill	5gTe
Austria	891.59	133
Germany	636.64	67
Hubei	1,165.77	1
Italy	1,430.62	13
Monaco	1,070.28	4
Norway	732.67	2
Spain	1,545.25	18
Switzerland	1,545.65	648

This group consists of European countries with the greatest crisis and with 5G deployments. Note. It was decided to add Hubei as if it were a country, due to the fact that China's total population is too big and causes China to have no "crisis."

2. Countries with COVID-19 Crisis without 5G technology.

País	Casos por Mill	5gTe
Andorra	3,986.28	-
Belgium	788.12	-
Channel Islands	506.15	-
Faeroe Islands	3,172.13	-
France	505.01	-
Gibraltar	1,662.16	-
Iceland	2,822.04	-
Liechtenstein	1,468.74	-
Luxembourg	2,563.99	-
Montserrat	1,001.60	-
Netherlands	569.72	-
Portugal	507.03	-
San Marino	6,572.16	-
Saint Barthelemy	506.23	-

Among this group we can find Europeans countries with COVID-19 crisis but without 5G technology, however, they have been exposed to both migration and the proximity of countries that do have 5G technology. There are also some islands such as Montserrat and San Barth that fell within this group because of their small population size.

3. Countries without COVID-19 crisis with 5G technology.

País	Casos por Mill	5gTe
Australia	142.55	52
Bahrain	277.98	6
China	56.55	80
Estonia	486.23	1
Finland	210.62	25
Hungary	35.51	1
Ireland	429.54	21
Kuwait	55.03	154
Latvia	161.70	5
Maldives	29.60	5
New Zealand	93.53	10
Oman	29.77	17
Philippines	9.81	3
Poland	39.13	1
Qatar	195.07	4
Romania	75.48	22
South Korea	184.87	181
Saudi Arabia	34.56	37
South Africa	19.73	3
Suriname	13.64	1
Thailand	17.84	9
Trinidad and Tobago	52.88	3
United Arab Emirates	47.32	20
United Kingdom	251.73	189
Uruguay	78.88	1
United States	319.41	5,451

All listed countries are in my opinion at great risk. We found, for example, South Korea, which, while apparently emerging from the contingency, had a crisis at some point. Other cases such as the United Kingdom and the United States have a large number of 5G deployments and while they were not categorized as "in crisis", they have a fairly high number of cases per million as well, I have no doubt that in some days they would be classified as "in crisis" too. We also see China within this group for the reason explained above that the denominator for the index used is very large (China's total population) yielding a relatively low index value (56.55).

4. Countries without COVID-19 crisis and without 5G technology.

País	Casos por Millón	5gTech
Afghanistan	2.83	-
Albania	68.46	-
Algeria	9.33	-
Angola	0.12	-
Anguilla	133.31	-
Antigua and Barbuda	71.48	-
Argentina	15.27	-
Armenia	125.54	-
Aruba	309.09	-
Azerbaijan	16.27	-
Bahamas	25.43	-
Bangladesh	0.29	-
Barbados	90.47	-
Belarus	9.95	-
Belize	5.03	-
Benin	0.49	-
Bermuda	272.97	-
Bhutan	3.89	-
Bolivia	6.34	-
Bosnia and Herzegovina	78.33	-
Brazil	16.36	-
British Virgin Islands	66.16	-
Brunei	274.30	-
Bulgaria	45.05	-
Burkina Faso	9.90	-
Cabo Verde	8.99	-
Cambodia	5.92	-
Cameroon	3.43	-
Canada	126.04	-
Cayman Islands	121.72	-
Chad	0.18	-
Chile	99.86	-
Colombia	10.59	-
Congo	0.72	-
Costa Rica	51.63	-
Croatia	160.04	-
Cuba	10.51	-
Curaçao	48.75	-
Cyprus	134.18	-
Czech Republic (Czechia)	237.28	-
Denmark	379.99	-
Djibouti	12.15	-
Dominica	152.81	-
Dominican Republic	66.28	-

Ecuador	92.22	-
Egypt	5.24	-
El Salvador	2.93	-
Equatorial Guinea	8.55	-
Eritrea	1.69	-
Eswatini	7.76	-
Ethiopia	0.14	-
Fiji	5.58	-
French Guiana	93.75	-
French Polynesia	106.80	-
Gabon	3.15	-
Gambia	1.24	-
Georgia	21.31	-
Ghana	4.41	-
Greece	92.68	-
Greenland	176.15	-
Grenada	62.21	-
Guadeloupe	239.93	-
Guatemala	1.79	-
Guinea	0.61	-
Guinea-Bissau	1.02	-
Guyana	6.36	-
Haiti	0.70	-
Honduras	9.59	-
Hong Kong	74.70	-
India	0.68	-
Indonesia	4.22	-
Iran	421.56	-
Iraq	12.58	-
Isle of Man	376.32	-
Israel	399.74	-
Côte d'Ivoire	3.83	-
Jamaica	10.13	-
Japan	11.85	-
Jordan	23.03	-
Kazakhstan	10.86	-
Kenya	0.71	-
Kyrgyzstan	8.89	-
Laos	0.82	-
Lebanon	60.36	-
Liberia	0.59	-
Libya	0.15	-
Lithuania	140.32	-
Macao	52.36	-
Madagascar	0.94	-
Malaysia	71.68	-
Mali	0.89	-
Malta	337.45	-
Martinique	247.82	-

Mauritania	1.08	-
Mauritius	80.20	-
Mayotte	183.27	-
Mexico	5.56	-
Moldova	49.33	-
Mongolia	3.66	-
Montenegro	130.56	-
Morocco	9.70	-
Mozambique	0.26	-
Myanmar	0.15	-
Namibia	3.15	-
Nepal	0.17	-
New Caledonia	52.54	-
Nicaragua	0.60	-
Niger	0.41	-
Nigeria	0.39	-
North Macedonia	115.68	-
Pakistan	6.41	-
State of Palestine	19.01	-
Panama	182.17	-
Papua New Guinea	0.11	-
Paraguay	7.85	-
Peru	19.26	-
Russia	8.66	-
Rwanda	4.17	-
Réunion	161.95	-
Saint Kitts & Nevis	37.59	-
Saint Lucia	16.34	-
Saint Martin	284.49	-
Senegal	7.76	-
Serbia	75.42	-
Seychelles	71.18	-
Singapore	137.09	-
Sint Maarten	69.97	-
Slovakia	53.48	-
Slovenia	329.01	-
Somalia	0.19	-
Sri Lanka	5.28	-
St. Vincent & Grenadines	9.01	-
Sudan	0.11	-
Sweden	303.88	-
Syria	0.29	-
Taiwan	11.88	-
Tanzania	0.22	-
Timor-Leste	0.76	-
Togo	3.02	-
Tunisia	19.21	-
Turkey	67.56	-

Turks and Caicos	51.66	-
Uganda	0.50	-
Ukraine	7.11	-
Uzbekistan	3.11	-
Venezuela	3.97	-
Vietnam	1.79	-
Zambia	1.52	-
Zimbabwe	0.47	-

In the latter group we find most of the countries, many of them Africans and Latin American countries that have a low coronavirus index, however there are also some Europeans who have the closest index to the threshold established to discriminate them into “crisis (500 cases per million)” like Sweden, Denmark, Malta, Israel, among others. Finally, we look at countries like Russia and Mexico that have a low rate perhaps due in part to the non-technology existence there yet.

Notes.

A high percentage of the countries in group 3 could have been classified as group 1 if we choose a lower classification threshold (lower than 500 cases per million), for example the United Kingdom and the United States are very close to this threshold. On the other hand, there are countries in this group with 5G technology but that may have less relationship with China and that is why they have not had a seed of infection, such are the cases of Saudi Arabia, Bahrain, Qatar, United Arab Emirates, etc.

On the other hand, a high percentage of group 2 countries could also be classified as group 1 because, although they do not have yet 5G technology, they are countries that lie together in Europe and have nearby antennas, for example, Liechtenstein, Luxembourg, Belgium and The Netherlands which are practically surrounded by countries that do have the technology, in addition of course the closeness that exists between them. By broadening the 5G coverage criterion a little, these countries could also be considered within Group 1, could be one explanation of the reason for being in crisis by COVID-19. Had all these examples been classified as part of Group 1, the test statistic would had been even more significant since these 2 groups are the ones that fuel the hypothesis of independence. In other words, under the assumption that both variables were independent, we should expect to see the same number of countries in each of the 4 groups.

Analysis for the United States.

At the moment the previous analysis was conducted (March 28th), the situation in the United States, at least from a statistical stand point was not critical yet. But, as was stated before, it was just a matter of time before the USA fell into the critical group of countries. Since then, and with daily addition of county-level data for the whole USA, a visual analysis was performed.

As of today (April 1st) it has not been possible to perform the same Chi2 hypothesis test because Ookla could not provide the data for commercial reasons.

The analysis that follows shows, on a county level, the same index described above (Cases per million inhabitants), so that it is easier to geographically analyse where the red spots are. As a means of comparison, a map with 5G deployments is attached to the right.

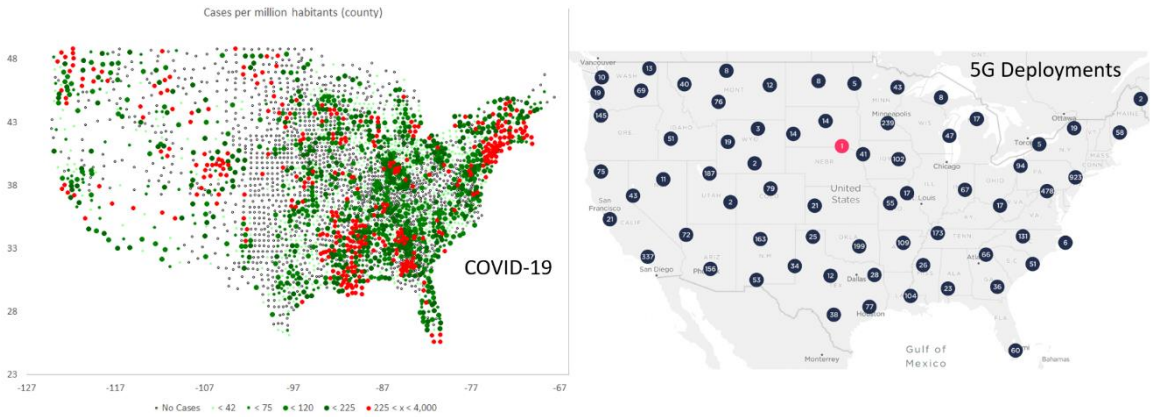

Figure 6. USA Map with cases per million inhabitants on a county level and 5G deployments.

Each dot on the map on the left indicates the centroid of each county, white dots indicate those counties with zero cases as of March 28th. As the size of the dot turns bigger and with a darker shade of green the number of cases per million inhabitants increases. The red spots indicate those counties with more than 225 cases per million inhabitants. The map shows zones where the situation is turning critical, however a state by state analysis can be of more use.

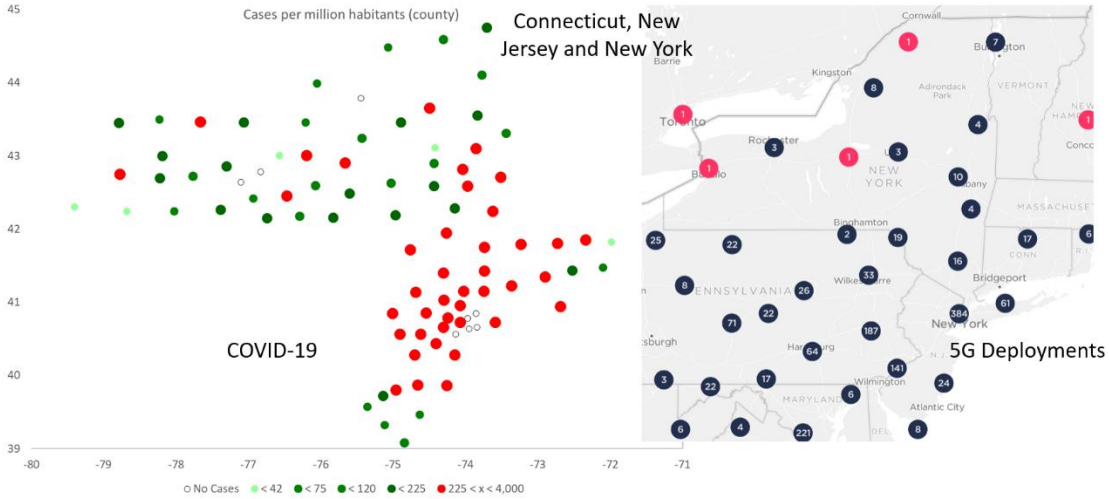

Figure 7. New York area Map

As we zoom in the map and focus on the most critical zone which corresponds to the New York City Area, we can see the number of counties that lie nearby New York City with a large index value. For instance, the county of Rockland (FIPS = 36087) and Westchester (FIPS = 36119) have very large indices of 5,819.7 and 8,139.5 cases per million inhabitants respectively. Both counties lie just north of Manhattan side by side along the Hudson River. Westchester has almost a million inhabitants (949,113, according to the U.S. Census), so one might think that having a red spot might be due to the large population that lives nearby New York City. However, keep in mind that the index used for colouring the counties is obtained by dividing the number of cases by the population of each county. Hence the comparison of counties is made independent of the population in each. It is no surprise that nearby NY city there are 384 5G deployments.

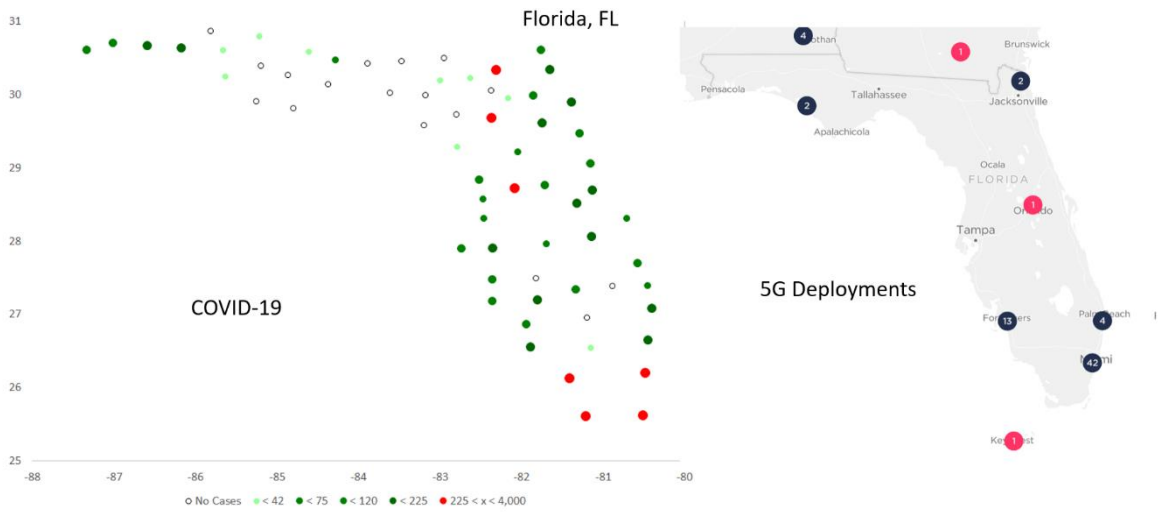

Figure 8. Florida Map

Another interesting example is the state of Florida. Once again, it seems obvious to say that the counties near Miami are the ones most critical, matching the most 5G deployments in the state with 42 according to the source.

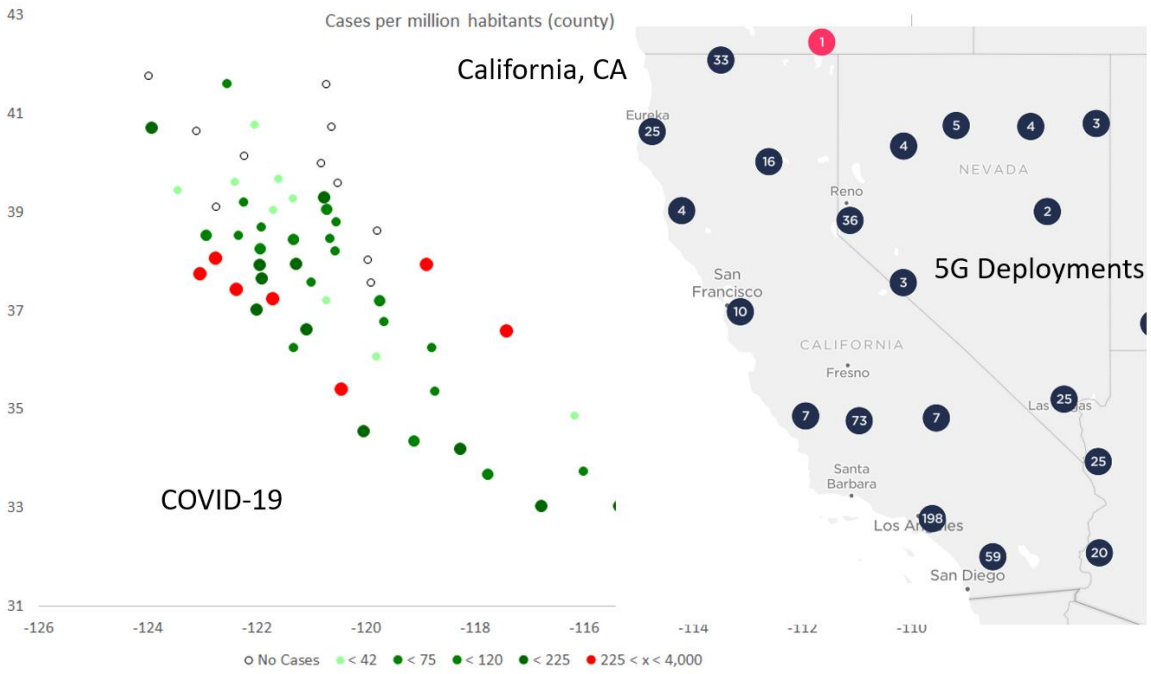

Figure 9. California Map

California grabbed my attention, not because the obvious hot spots near the metropolitan areas of San Francisco and Los Angeles, but the red dots to the east, closer to the state of Nevada. After noticing that NY city, Miami, Los Angeles, i.e. the big cities, are having red spots, one might be tempted to think that only places with large populations rise as red spots. But please notice one of the red spots in the east of the state. It refers to county 6051, called Mono. It is a large county with a small population of 14,444 inhabitants. The number of cases there might seem small (8), but the index of cases per million inhabitants is 553.86, which is alarming. It happens that there is a 5G deployment in Mammoth Lakes as this map shows:

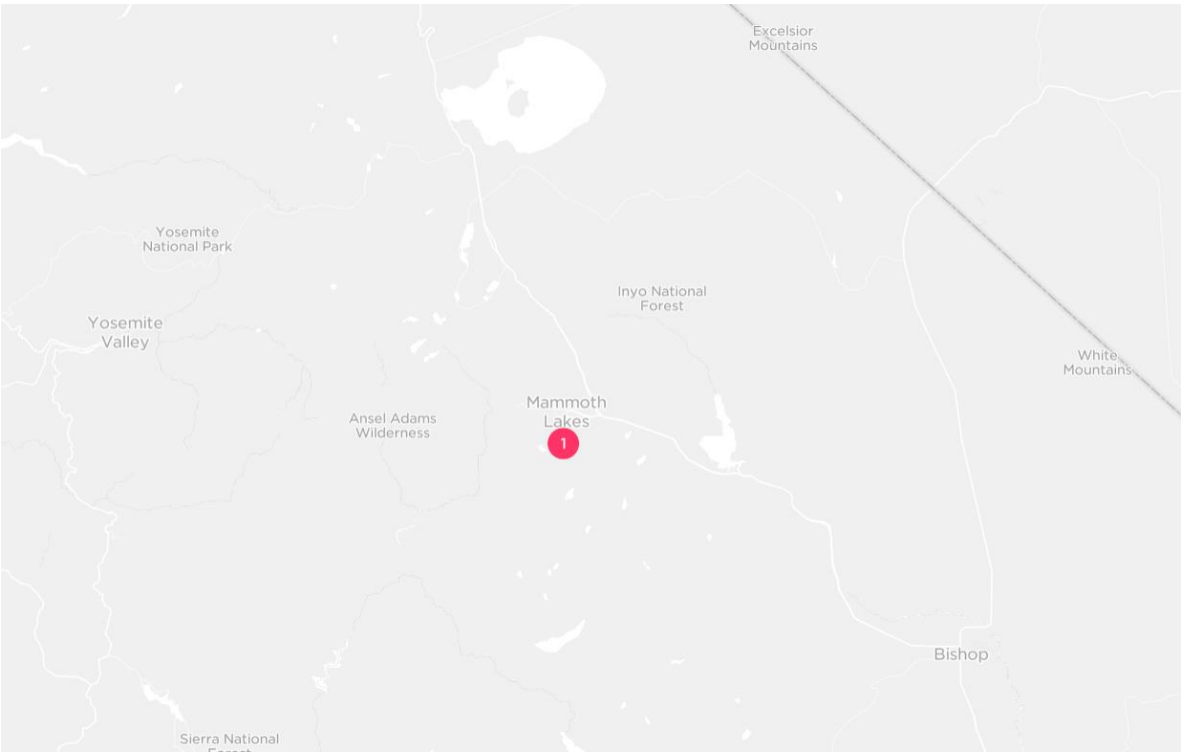

Figure 10. Zoom of the 5G deployments in the Mono, CA county (FIPS = 6051).

Washington State is where the virus first arrived to the USA, so the map for this state follows:

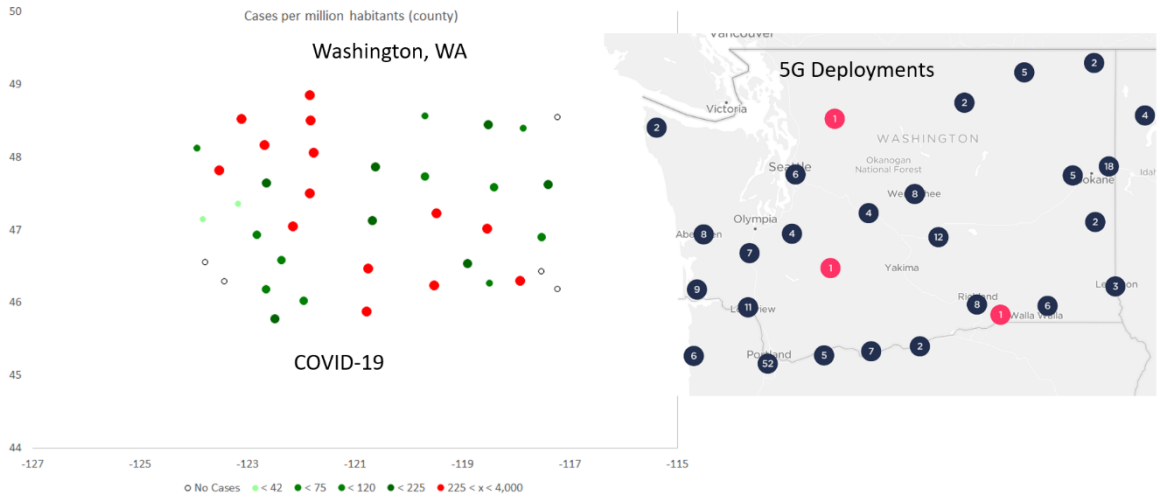

Figure 11. Washington map

As with other examples, we notice many red dots surrounding the Seattle area, where many 5G deployments are. But we can also see that the state has many other areas with critical conditions where there are also 5G deployments.

A final example is what I've coined "the radioactive oasis of America", the state of Nebraska.

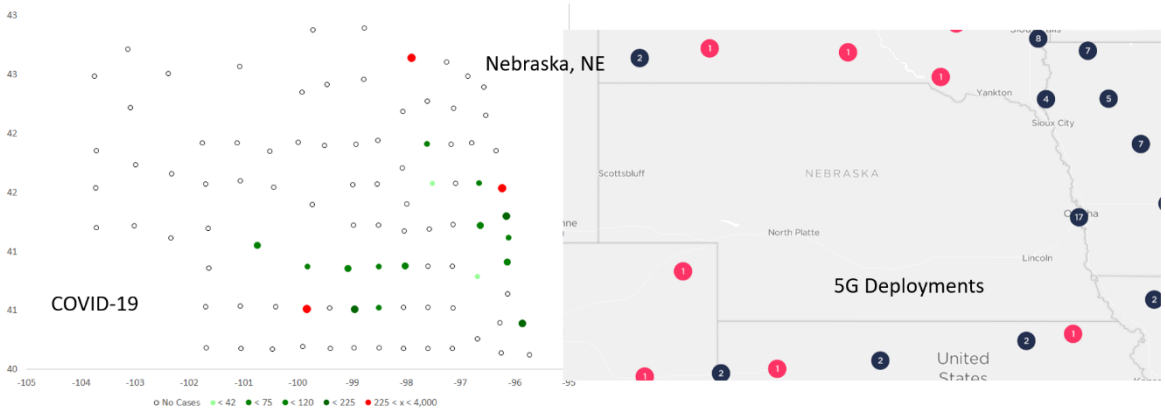

Figure 12. Nebraska Map

It grabbed my attention the fact that Nebraska is practically void of 5G deployments, and coincidentally is a state almost free of coronavirus. In the map we can notice lots of white dots, representing ZERO cases. The few counties were there are cases match, of course, the cities of Omaha and Lincoln, where we find 17 5G deployments. But the fact that 74 out of the 93 counties of the state (80%) have ZERO cases seemed odd to me to say the least. I am aware that Nebraska is a rural state where conditions for the spread of coronavirus are poor, nonetheless, it is also clear that the absence of 5G deployments in the state might have an impact on the non-existence of the virus in Nebraska.