Statistical Analysis to find an impact of temperature on novel coronavirus (COVID-19)

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Abstract

The study tries to explain the impact of high temperature on the number of confirmed cases by excluding all measures that have been taken by specific governments in certain global hotspots like New York City, Lombardy, Madrid (Spain) and Maharashtra. Some statistical analysis like F-statistical test, ANOVA and t-test have been performed to know how much variance is there among the regions for the parameters 1) proportion of cumulative confirmed cases to the whole population and 2) mean temperature. The analysis includes graphs to have a clear visualization at a first glance for all four zones that have been taken for case study and ends with the all statistical results, discussion and conclusion of the tests that have been performed.

Keywords: f-statistical test, ANOVA (Analysis of Variance), t-test, temperature, Coronavirus, Pearson's Correlation

Introduction

The outbreak of this novel SARS-CoV-2 overwhelmed the global health system making an outrageous mark on each and every aspect of life be it social, economic and psychological. All around the world researchers and scientists are trying to solve the mystery or questions behind the spread of this virus which is highly contagious looking at all those parameters which can help in curbing the spread as, till now it has affected almost 4,553,432 people globally. In this particular paper we are looking at those parts of the world which have been highly impacted by this pandemic and trying to relate & analyse how much temperature as a parameter can help in controlling the spread. The data has been looked from 10th March 2020 onwards till 23rd April 2020, New York has been the worst hit by this pandemic till 23rd April 2020 having 1,45,855 number of confirmed cases, on second Lombardy with number of confirmed cases 70,165, third is Madrid with 61,588 and lastly Maharashtra with 5652.

The aim is to look for how much variance is there in number of confirmed cases and the variance in the temperature, thus having similarity or less variance in the temperature parameter can relate to have less variance among the number of confirmed cases in all these four zones that have been taken into consideration for the case study.

Materials and Methods

Data collection for confirmed COVID-19 cases for all the zones have been taken from Wikipedia site and the temperature data has been taken on hourly basis from the IBM weather data as per the longitude & latitude of the concerned regions from 10th March 2020 to 23rd April 2020.

To have certain view regarding the relationship between the two variables we get the cumulative proportion value of the confirmed cases to the whole population and the average or mean temperature. With the help of graphical representations, we'll able to visualize that area with relatively high temperature has comparatively less cases as compared to areas with low temperature which is going maximum till 18 degree Celsius.

Figure 1 Graph of **average mean temperature** of the hourly data for all the four areas New York, Lombardy, Madrid and Maharashtra.

Figure 2 Graph of **Cumulative mean of confirmed cases** for all the four regions.

Having a deterministic view of above visualizations, the statistical analysis has been performed. In order to determine variance in number of confirmed cases and daily mean temperature for two parameters cumulative mean proportion of the population of confirmed cases and the average temperature for each specified region F- statistical analysis test as well as ANOVA for the unequal variance and t-test have been performed. The confidence level or alpha value of 95% has been taken into consideration in performing all the above-mentioned test. The Pearson's Correlation coefficient test has also been analysed to evaluate the impact or strength of these two quantitative variables.

Both the f-test and ANOVA help to observe the significant difference or variability around or within the population but the difference with the ANOVA is that it tells the combined variability of different groups from the overall or large distribution and to have precise information about the means of different groups multiple t-test with unequal variance has been performed. The multiple t-test would be the ad hoc test to let us know exactly which groups has difference in means.

The hypothesis that have been created for the statistical tests are:

H_0 : - The variance of two groups are equal.

H_1 : - The variance of two groups are not equal.

Result and Discussion

There is a significant negative correlation we'll able to establish between these two variables with the "Pearson Correlation" method

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Pearson's product-moment correlation

data: Temp and Cases
t = -6.3496, df = 178, p-value = 1.743e-09
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.5419357 -0.3024847
sample estimates:
      cor
-0.4297355
```

Figure 3 Pearson Correlation of two Variables Mean temperature and Cumulative Confirmed Cases

This shows that there is significant negative correlation between the two parameters as correlation values is -42 or approx. -43 which shows a strong negative correlation with p value 1.743e-09 less than the 0.05 significance level. Thus, increase in temperature leads to decrease in number of cases to have more specificity about the results further statistical analysis has been performed. **F-test for Cumulative Confirmed Cases.**

Table 1

F-Test Two-Sample for Variances Madrid_Lombardy		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.002066	0.002403
Variance	2.02E-06	1.22E-06
Observations	45	45
df	44	44
F	1.660731	
P(F<=f) one-tail	0.04805	
F Critical one-tail	1.650935	

Table 2

F-Test Two-Sample for Variances Madrid_NewYork		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.00206597	0.00102
Variance	2.02358E-06	1E-06
Observations	45	45
df	44	44
F	2.014188241	
P(F<=f) one-tail	0.01111628	
F Critical one-tail	1.650934533	

Table 3

F-Test Two-Sample for Variances Madrid_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.002066	1.99E-06
Variance	2.02E-06	6.48E-12
Observations	45	45
df	44	44
F	312428.6	
P(F<=f) one-tail	1.4E-109	
F Critical one-tail	1.650935	

Table 4

F-Test Two-Sample for Variances Lombardy_NewYork		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.002403	0.00102
Variance	1.22E-06	1E-06
Observations	45	45
df	44	44
F	1.212832	
P(F<=f) one-tail	0.262435	
F Critical one-tail	1.650935	

Table 5

Table 6

F-Test Two-Sample for Variances Lombardy_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.002403	1.99E-06
Variance	1.22E-06	6.48E-12
Observations	45	45
df	44	44
F	188127.2	
P(F<=f) one-tail	9.6E-105	
F Critical one-tail	1.650935	

F-Test Two-Sample for Variances NewYork_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.001020358	1.99E-06
Variance	1.00466E-06	6.48E-12
Observations	45	45
df	44	44
F	155113.9184	
P(F<=f) one-tail	6.7236E-103	
F Critical one-tail	1.650934533	

F-test for Mean temperature

Table 7

F-Test Two-Sample for Variances Lombardy_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	11.46205	29.40018
Variance	12.34137	2.78051
Observations	46	46
df	45	45
F	4.438528	
P(F<=f) one-tail	9.35E-07	
F Critical one-tail	1.641516	

Table 9
Table

Table 8

F-Test Two-Sample for Variances Lombardy_NY		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	11.46205	9.291395
Variance	12.34137	8.192638
Observations	46	46
df	45	45
F	1.506398	
P(F<=f) one-tail	0.086611	
F Critical one-tail	1.641516	

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F-Test Two-Sample for Variances Madrid_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	12.26495	29.40018
Variance	9.625608	2.78051
Observations	46	46
df	45	45
F	3.461814	
P(F<=f) one-tail	2.91E-05	
F Critical one-tail	1.641516	

F-Test Two-Sample for Variances Lombardy_Madrid		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	11.46205	12.26495
Variance	12.34137	9.625608
Observations	46	46
df	45	45
F	1.282139	
P(F<=f) one-tail	0.203858	
F Critical one-tail	1.641516	

Table 11

F-Test Two-Sample for Variances Madrid_NY		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	12.26495	9.291395
Variance	9.625608	8.192638
Observations	46	46
df	45	45
F	1.17491	
P(F<=f) one-tail	0.295507	
F Critical one-tail	1.641516	

Table 12

F-Test Two-Sample for Variances NY_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	9.291395	29.40018
Variance	8.192638	2.78051
Observations	46	46
df	45	45
F	2.946451	
P(F<=f) one-tail	0.000214	
F Critical one-tail	1.641516	

ANOVA Result for Confirmed cases

To get the value for difference in each group "*t-test*" being performed and the results being attached below for each region "*confirmed COVID-19 cases*"

Table 13

t-Test: Two-Sample Assuming Unequal Variances Madrid_Lombardy		
	Variable 1	Variable 2
Mean	0.00206597	0.002403
Variance	2.02358E-06	1.22E-06
Observations	45	45
Hypothesized Mean Difference	0	
df	83	
t Stat	-1.254023507	
P(T<=t) one-tail	0.106676931	
t Critical one-tail	1.663420175	
P(T<=t) two-tail	0.213353862	
t Critical two-tail	1.98895978	

Table 14

t-Test: Two-Sample Assuming Unequal Variances Madrid_NY		
	Variable 1	Variable 2
Mean	0.002066	0.00102
Variance	2.02E-06	1E-06
Observations	45	45
Hypothesized Mean Difference	0	
df	79	
t Stat	4.030707	
P(T<=t) one-tail	6.36E-05	
t Critical one-tail	1.664371	
P(T<=t) two-tail	0.000127	
t Critical two-tail	1.99045	

Table 15

t-Test: Two-Sample Assuming Unequal Variances Madrid_Maharashtra		
	Variable 1	Variable 2
Mean	0.002066	1.99E-06
Variance	2.02E-06	6.48E-12
Observations	45	45
Hypothesized Mean Difference	0	
df	44	
t Stat	9.73311	
P(T<=t) one-tail	7.64E-13	
t Critical one-tail	1.68023	
P(T<=t) two-tail	1.53E-12	
t Critical two-tail	2.015368	

Table 16

t-Test: Two-Sample Assuming Unequal Variances Lombardy_NY		
	Variable 1	Variable 2
Mean	0.002402567	0.00102
Variance	1.21849E-06	1E-06
Observations	45	45
Hypothesized Mean Difference	0	
df	87	
t Stat	6.21864032	
P(T<=t) one-tail	8.46725E-09	
t Critical one-tail	1.662557349	
P(T<=t) two-tail	1.69345E-08	
t Critical two-tail	1.987608282	

```

      Df      Sum Sq   Mean Sq F value Pr(>F)
Regions    3 0.0001595 5.316e-05  50.08 <2e-16 ***
Residuals 176 0.0001869 1.060e-06
---
signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Figure 4 Analysis of Variance Result for all four regions of confirmed corona virus cases from 10th March 2020 till 23rd April 2020. Variance is quite significant among some groups as F value is 50.08 with significant p value less than the 0.05.

Table 17

t-Test: Two-Sample Assuming Unequal Variances Lombardy_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.002403	1.99E-06
Variance	1.22E-06	6.48E-12
Observations	45	45
Hypothesized Mean Difference	0	
df	44	
t Stat	14.58851	
P(T<=t) one-tail	9.11E-19	
t Critical one-tail	1.68023	
P(T<=t) two-tail	1.82E-18	
t Critical two-tail	2.015368	

Table 18

t -Test: Two-Sample Assuming Unequal Variances NY_Maharashtra		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.00102	1.99E-06
Variance	1E-06	6.48E-12
Observations	45	45
Hypothesized Mean Difference	0	
df	44	
t Stat	6.815555	
P(T<=t) one-tail	1.07E-08	
t Critical one-tail	1.68023	
P(T<=t) two-tail	2.13E-08	
t Critical two-tail	2.015368	

```

Df Sum Sq Mean Sq F value Pr(>F)
Regions      3   11890      3963   481.3 <2e-16 ***
Residuals   180    1482         8
---
signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Figure 5 Analysis of Variance for mean temperature for the four regions with F-value 481.3 and p value less than significant level which is 0.05 thus it indicates that variance in group of means is present in the data and this is not random by chance.

ANOVA Result for mean Temperature

For significant difference for each region “*average temperature t-test*” being performed and results being attached below

Table 19

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Mean_tempNY</i>	<i>Mean_temp Maharashtra</i>
Mean	9.291395	29.40018
Variance	8.192638	2.78051
Observations	46	46
Hypothesized Mean Difference	0	
df	72	
t Stat	-41.1717	
P(T<=t) one-tail	4.39E-52	
t Critical one-tail	1.666294	
P(T<=t) two-tail	8.77E-52	
t Critical two-tail	1.993464	

Table 20

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Mean_temp Madrid</i>	<i>Mean_temp NY</i>
Mean	12.26495	9.291395
Variance	9.625608	8.192638
Observations	46	46
Hypothesized Mean Difference	0	
df	89	
t Stat	4.777732	
P(T<=t) one-tail	3.47E-06	
t Critical one-tail	1.662155	
P(T<=t) two-tail	6.95E-06	
t Critical two-tail	1.986979	

Table 21

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Mean_temp Lombardy</i>	<i>Mean_temp Madrid</i>
Mean	11.46205	12.26495
Variance	12.34137	9.625608
Observations	46	46
Hypothesized Mean Difference	0	
df	89	
t Stat	-1.16186	
P(T<=t) one-tail	0.124199	
t Critical one-tail	1.662155	
P(T<=t) two-tail	0.248398	
t Critical two-tail	1.986979	

Table 22

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Mean_temp Lombardy</i>	<i>Mean_temp_ Maharashtra</i>
Mean	11.46205	29.40018
Variance	12.34137	2.78051
Observations	46	46
Hypothesized Mean Difference	0	
df	64	
t Stat	-31.2862	
P(T<=t) one-tail	8.4E-41	
t Critical one-tail	1.669013	
P(T<=t) two-tail	1.68E-40	
t Critical two-tail	1.99773	

Table 23

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Mean_temp Madrid</i>	<i>Mean_temp_ Maharashtra</i>
Mean	12.26495	29.40018
Variance	9.625608	2.78051
Observations	46	46
Hypothesized Mean Difference	0	
df	69	
t Stat	-32.9952	
P(T<=t) one-tail	2.75E-44	
t Critical one-tail	1.667239	
P(T<=t) two-tail	5.5E-44	
t Critical two-tail	1.994945	

Table 24

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Mean_temp Lombardy</i>	<i>Mean_temp NY</i>
Mean	11.46205	9.291395
Variance	12.34137	8.192638
Observations	46	46
Hypothesized Mean Difference	0	
df	86	
t Stat	3.24887	
P(T<=t) one-tail	0.000827	
t Critical one-tail	1.662765	
P(T<=t) two-tail	0.001654	
t Critical two-tail	1.987934	

With all the above results we'll be able to conclude that maximum variance is seen for both the parameters, while comparing Maharashtra region with all three i.e. Lombardy, Madrid and New York City as f-value is larger than the f-critical value and p-value is smaller than the significance level which is 0.05 thus, we'll fail to accept the null hypothesis. But in case of Lombardy and New York number of variances for cumulative coronavirus confirmed cases is equal, as the f-value 1.212832 which is comparatively smaller to the f-critical value (1.650935) and p-value i.e. 0.262435 greater than significance value 0.05 in this case we'll fail to reject the null hypothesis and same conclusion goes for mean temperature variable where f-value is 1.50 which is lower than the f-critical range (1.64) and p-value is 0.086 which is way above higher than the significance level. Madrid and Lombardy do have a special case where we observe a slight variance between the values of cumulative confirmed cases as f-value (1.660731) is slightly more than the f-critical one (1.650) and p value (0.04805) i.e. approximately equal to 0.05 and equal variance is able to notice in the temperature parameter. Madrid and New York have unequal variance in number of confirmed cases but have equal variance for mean temperature.

Further, to determine whether the difference is significant t-test has been done, except for Madrid and Lombardy where the two tailed p-value (0.213353862) is higher than the 0.05 for the confirmed cases parameter and same goes for the mean temperature one (p-value 0.248398) the difference is not significant but for rest of the regions the difference is quite significant as p-value is smaller than the significance level for both i.e. cumulative confirmed COVID-19 cases and mean temperature.

Conclusion

Thus, we'll be able to infer that environmental factor "temperature" is playing quite a substantial role in daily rate of confirmed cases as the above statistical analysis that includes Pearson's correlation, f-statistics, ANOVA and t-test for unequal variances shows that daily rate of confirmed cases are higher in the areas with lower temperature even the correlation also gives a strong evidence that there is high negative correlation between mean temperature and cumulative number of confirmed cases.

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