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A Statistical Analysis of the Relationship Between Meteorological Parameters and the Spread of COVID-19 Cases: Comparison Between Turkey and Italy

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Abstract

This study aims to statistically analyze the effects of meteorological parameters on the spread of coronavirus in Turkey and Italy. The multi-factor ANOVA for data analysis was used for the present study. The data of the COVID-19 active cases were handled covering 55 days between March 10, 2020 (the first case incident) and May 3, 2020 for Turkey and covering 69 days between February 25, 2020, and May 3, 2020 for Italy. The parameters of meteorology include average temperature (^{0}C), humidity (%), wind (mph) and pressure (Hg) in this study. The data of meteorological parameters were considered as the average of each factor's data for the highest populated cities of Turkey and the two most populous cities (Rome and Milan) in Italy. The analysis of variance was significantly analyzed with COVID-19 pandemic (R^2= 0.307; F-ratio=5.6581 prob > .0008 with 55 observations for Turkey, and R^2= 0.437; F-ratio=3.6581 prob > .0182 with 69 observations for Italy), with the highest level. Among the parameters of the weather, average temperature (°C) has a significant impact on COVID-19 pandemic (t-ratio=3.12; p<0.05) and humidity (%) provisionally affects COVID-19 pandemic (t-ratio=-1.186; p<0.10) for Turkey. In addition, both humidity (%) (t-ratio=-1,38; p<0.0172) and wind (mph) (t-ratio=-2,57; p<0.0125) parameters have been found to play an important role in the COVID-19 outbreak for Italy.

Keywords: COVID-19; Anova; Temperature; Humidity; Wind; Pressure

Özet

Bu çalışma, meteorolojik parametrelerin Türkiye ve İtalya ülkelerinde korona virüsün yayılmasına etkilerini istatistiksel olarak incelemeyi amaçlamaktadır. Veri analizi için çok faktörlü ANOVA testi bu çalışmada kullanılmıştır. Türkiye için COVID-19 aktif vakalarına ait veriler, 10 Mart 2020 (ilk vaka olayı) ile 3 Mayıs 2020 arasındaki 55 günlük ve İtalya için COVID-19 aktif vakalarına ait veriler, 25 Şubat 2020 ile 3 Mayıs 2020 arasındaki 69 günlük verileri kapsamaktadır. Bu çalışmada, meteoroloji parametreleri olarak ortalama sıcaklık (^{0}C), nem (%), rüzgâr (mph) ve basınç (Hg) faktörleri ele alınmıştır. Meteorolojik parametre verileri, Türkiye'nin en kalabalık şehirlerindeki her bir parametreye ait verilerin ortalaması ile İtalya'nın en kalabalık iki şehrine (Roma ve Milan) ait veriler dikkate alınmıştır. Varyans analizi kullanılarak COVID-19 vakalarına ait verileri (Türkiye için R^2 = 0.307; F-oranı = 5.6581 prob> .0008, 55 gözlem ve İtalya için R^2= 0.437; F-ratio=3.6581 prob> .0182, 69 gözlem) en yüksek düzeyde önemli ölçüde analiz edilmiştir. Meteoroloji parametreleri arasında yer alan ortalama sıcaklık (°C) (t-oranı = 3.12; p <0.05) önemli ölçüde ve nem (%) faktörü (t-oranı =-1.186; p <0.10) şartlı olarak Türkiye'deki COVID-19 salgınını etkilediği gözlemlenmiştir. Ayrıca, İtalya için hem nem (%) (t-ratio=-1,38; p<0.0172) hem de rüzgâr (mph) (t-ratio=-2,57; p<0.0125) parametrelerinin COVID-19 salgınında önemli rol oynadığı tespit edilmiştir.

Anahtar Kelimeler: COVID-19; Anova; Sıcaklık; Nem; Rüzgar; Basınç

1. INTRODUCTION

Described as a disease similar to pneumonia cases, the C0VID-19 virus first appeared in Wuhan City, Hubei Province, China, in December 2019 (Atalan 2020a; Nghiem et al. 2020; Saglietto et al. 2020; Tobías et al. 2020). With the rapid increase in the number of cases, research showed that there is a new type of coronavirus that has not been identified before. This virus has been named Coronavirus-2019, SARS nCoV-2 or COVID-19 by health organizations with its emergence in December 2019 (Paital, Das, and Parida 2020). Although there are many reasons for the transmission of this virus from person to person, the main reason is transmitted by air (weather) (Ministry of Health 2020). Furthermore, meteorological factors play an important role in the rapid spread of this virus (Atalan 2020b; Chen et al. 2020; Liu et al. 2020; Shi et al. 2020; Tosepu et al. 2020). However, there is no clearly proven (still a controversial situation) study on whether meteorological factors have a direct or indirect effect on the spread of COVID-19.

Factors such as temperature, humidity, pressure, wind speed, the amount of rainfall density that are thought to be effective on coronavirus are widely discussed in the studies. Different statistical methods were used for these factors in the literature (Cássaro and Pires 2020; Liu et al. 2020). Tosepu et al. determined that temperature has an important effect on COVID-19 by using spearman's correlation method by considering temperature (^{0}C), humidity (%) and the amount of rainfall (mm) (Tosepu et al. 2020). Shi et al. Measured the effect of temperature and humidity on COVID-19 using the modified susceptible-exposed-infectious-recovered method (M-SEIR) (Shi et al. 2020). They concluded that only temperature can have an effect on COVID-19 with this method. Wang et al. found that high temperature and high humidity significantly reduced COVID-19 pandemic with the linear regression analysis (Wang et al. 2020). Tobias et al. have found a slowdown in spread of COVID-19 pandemic during rainy days (Tobías et al. 2020). These studies show that meteorological factors have been emphasized to have a direct or indirect effect on COVID-19.

Most studies have focused on the correlation between factors (Atalan 2018; Ayaz Atalan et al. 2020). Calculating the correlation coefficients does not mean that a factor exerts its effect on a response variable. A second analysis in statistics is needed to see the effect of factors on responses (Dönmez and Atalan 2019). In this study, Anova was performed besides the correlation test to measure the effect of temperature (^{0}C), humidity (%), wind (mph) and pressure (Hg) factors on COVID-19 for Turkey and Italy. Turkey has announced the first COVID-19 case on 10 March 2020. The total number of COVID-19 cases is 126,045 until May 3, 2020 (Ministry of Health 2020). The number of people who died due to COVID-19 is 3397 until May 3, 2020 (Ministry of Health 2020). The data of the COVID-19 active cases are handled for 69 days of data covering between February 25, 2020 (The first day of the announcement of the COVID-19 case) and May 3, 2020 in Italy. In this study, deaths for both countries were not included in the statistical analysis.

This study includes four sections. The first section deals with the literature review of studies related to COVID-19 pandemic. The second part gives detailed information about the methodology of the study. The results obtained from the method mentioned in the methodology section were discussed in the third section. In the last section, conclusion about the study has been provided.

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2. METHODOLOGY

In this study, the most populous in terms of density cities in Turkey and Italy of the COVID-19 cases and the meteorological parameters data were discussed. The data used in this study were handled as 55 days of data covering between March 10, 2020 (the first case incident) and May 3, 2020 for Turkey. The number of data collected is a sufficient rate for statistical analysis. In this study, the correlation test was employed with the multi-factor Anova to measure the effect of factors on the number of the COVID-19 cases. COVID-19 cases were defined as the output (or response) factor in the Anova analysis. Data of the regions covered Turkey has a population of 83.15 million (Turkish Statitical Institute 2020). Turkey consists of 81 cities and 7 geographic regions which are Marmara, Aegean, Central Anatolia, Black Sea, Mediterranean, Southeast Anatolia, and Eastern Anatolia. Turkey is also perceived as a bridge between Asia and Europe so the rate of population permeability (being a transfer point especially in air transportation change) is too much. Therefore, Turkey is considered as an autonomous region for COVID-19 studies.

The 55-day COVID-19 case data are shown in figure 1 (Worldometer 2020). According to **Fig.1**., the number of COVID-19 cases should be examined in two parts. While the number of COVID-19 cases increased daily before the 33rd day, the number of COVID-19 cases decreased after that date. The peak point of COVID-19 cases was recorded as 5138 on 11 April 2020 (temperature, 11.83 ^{0}C; humidity, 61.10%; wind, 7.07mph; pressure, 28.30Hg in Turkey. The average number of cases was calculated as 2292.

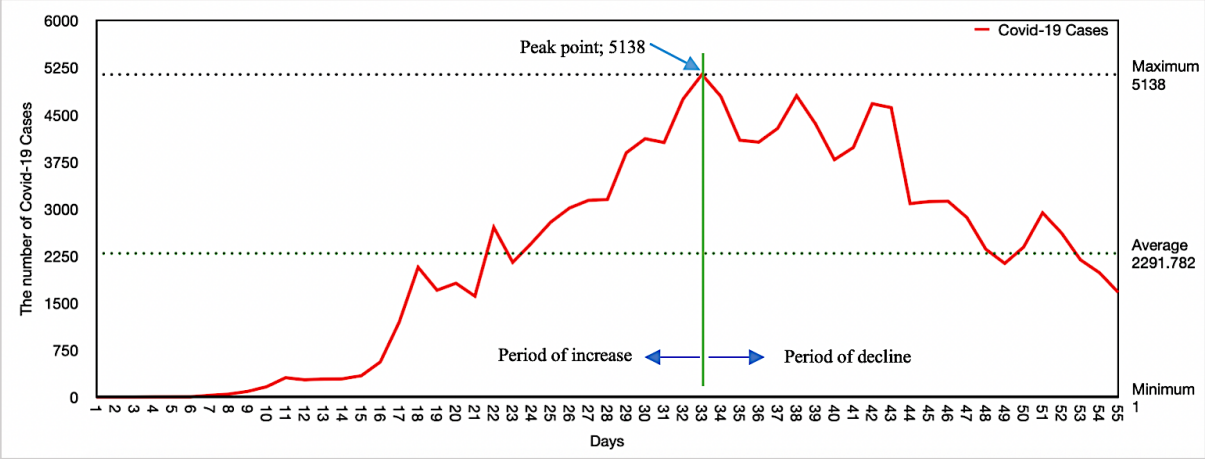

Fig. 1. COVID-19 case numbers by days

The cases of COVID-19 pandemic data are used as 69 days of data covering between February 25, 2020, and May 3, 2020, in Milan and Rome, Italy (Lab24 2020; Worldometer 2020) The daily cases of COVID-19 data for Rome and Milan are shown in **fig. 2.** (Worldometer 2020). The city of Rome is located in the Lazio region in Italy. The most populated city in Italy is Rome. Rome has an area of 5,363 km^2 and a population of 4.35 million (World Population Review 2020b). The city of Milan is located in the Lombardy region in the north of Italy. The second most populated city in Italy is Milan. Milan has an area of 1,575 km^2 and a population of 3.25 million (World Population Review 2020a) (See **fig.3**.).

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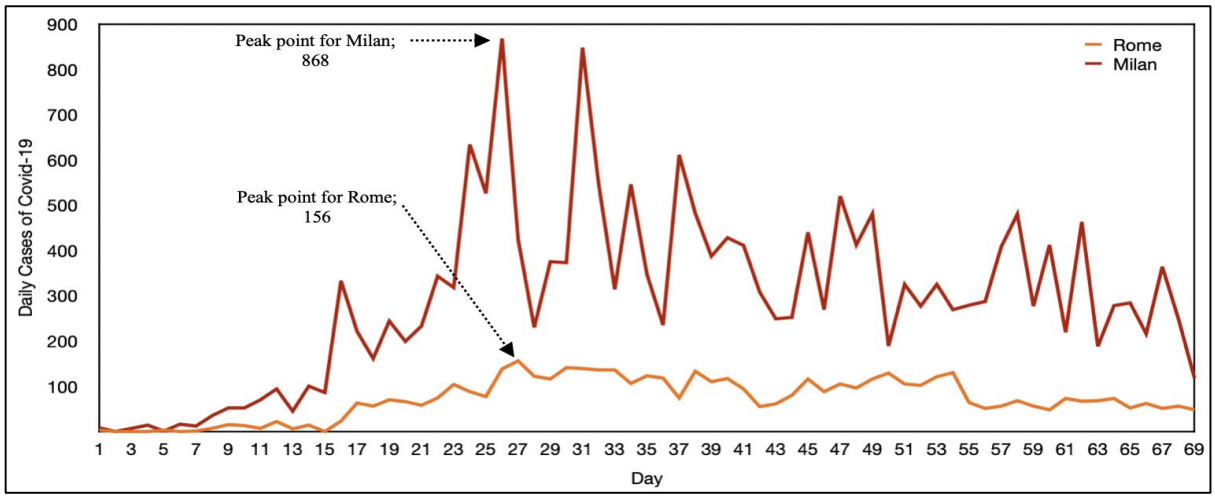


Fig. 2. Daily COVID-19 cases in Italy's most crowded cities Rome and Milan

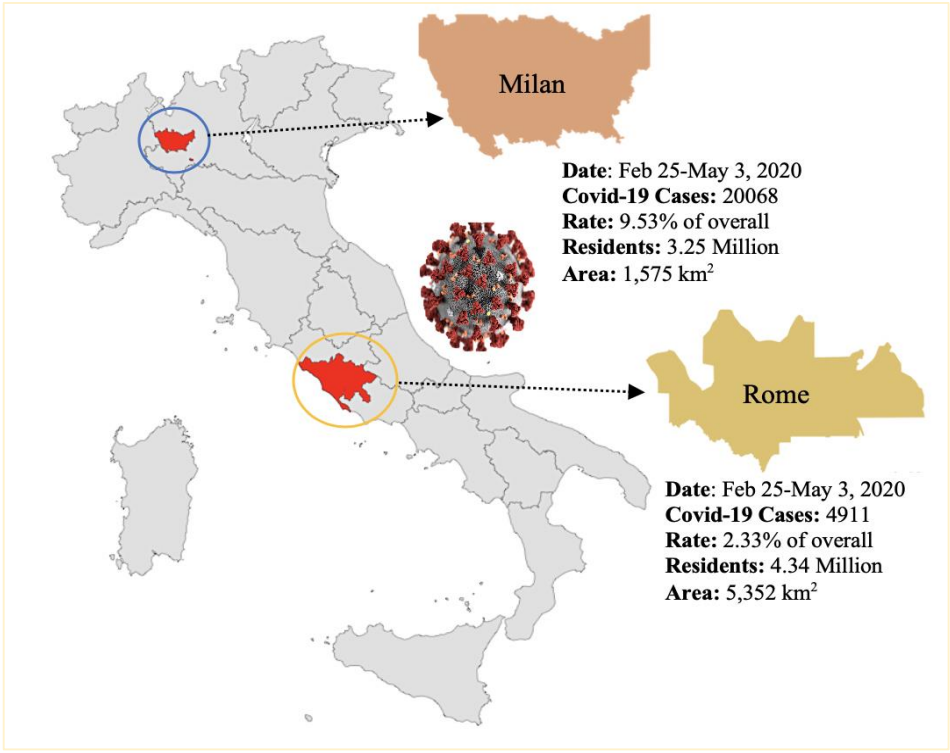
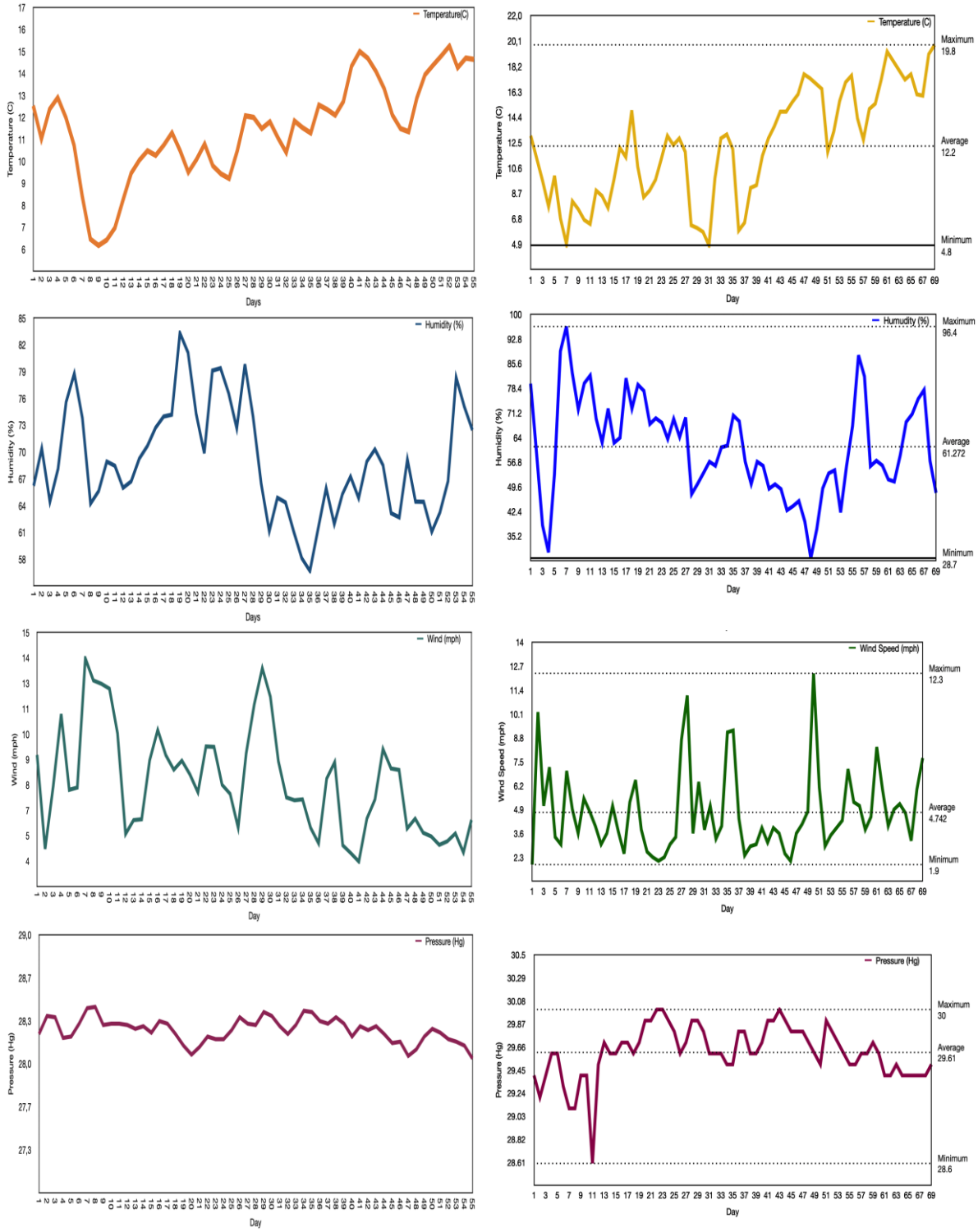


Fig. 3. The descriptive data of the cities in Italy

Meteorological parameters affecting the environmental balance can also be effective in the spread of the COVID-19 virus. Four different weather factors, namely temperature (^{0}C) humidity (%), wind (mph), and pressure (Hg) were considered that we think are effective on COVID-19 case data. The data of the weather parameters were calculated as the average value between the dates determined for the study. The average value of daily weather data on the largest cities located in seven regions of Turkey were collected to represent the entire region of Turkey. The reason for using this method is that countries with large borders do not have daily average weather data. The cities of Istanbul for the Marmara Region, Ankara for the Central Anatolia region, Izmir for Aegean region, Adana for Mediterranean region, Samsun for Black Sea region, Van for Eastern Anatolia region and Diyarbakir for Southeast Anatolia region were determined to calculate the weather data for Turkey. The total population in these cities account for 38.48% of Turkey's population. Istanbul (15.52 million) is the most

crowded city in Turkey and approximately 60% of COVID-19 cases is observed in this city. **Fig. 4.** shows the average value of the weather parameters of Turkey. Temperature(^{0}C) and humidity (%) rates are increased day by day, but wind speed (mph) and pressure (Hg) values are stable.



(a) Turkey (b) Italy

Fig. 4. Average values of meteorological parameters for Turkey (a) and Italy (b)

The peak of COVID-19 cases for Milan was observed as 868 COVID-19 cases on March 21, 2020 (with temperature, 12.8 ^{0}C; humidity, 64.1 %; wind, 3.4 mph; pressure, 29.6 Hg on the date of the peak point in Milan). The number of cases in Italy was recorded as 6557 daily new cases and 53578 total cases at the peak date for Milan. The average number of daily new cases was calculated as 291. The peak of COVID-19 cases for Milan was observed as 868 COVID-19 cases on March 22, 2020 (with temperature, 14.6 ^{0}C; humidity, 58.5 %; wind, 6.1 mph; pressure, 29.5 Hg on the date of the peak point in Rome). The number of cases was recorded as 5560 daily new cases and 46638 total cases at the peak date for Rome in Italy. The average number of daily new COVID-19 cases was calculated as 71 in Rome. Although Rome has a crowded population, the number of COVID-19 cases is less than the number of COVID-19 cases occurring in Milan.

The data of weather for Italy showed temperature minimum of 6.16 °C (with the cases of COVID-19, 93), the maximum temperature of 15.24 °C (with the cases of COVID-19, 2615), the lowest humidity of 56.67% (with the cases of COVID-19, 4093), the maximum humidity of 83.30% (with the cases of COVID-19, 1704), the lowest wind of 4.17 mph (with the cases of COVID-19, 3977), the maximum wind speed of 13.77 mph (with the cases of COVID-19, 31), and the minimum pressure of 28.04 Hg (with the cases of COVID-19, 1670), the maximum pressure of 28.44 Hg (with the cases of COVID-19, 49).

3. RESULTS AND DISCUSSIONS

The data set used is not suitable for normal distribution according to Anderson-Darling (0.9160) and Shapiro-Wilk (1.3412) tests. Therefore, ANOVA test was performed for this study, since many data sets that were not significantly normal would yield perfectly suitable results for an ANOVA. The lognormal and Weibull distributions provide a good fit for the cases of COVID-19 data for Turkey and Italy.

Table 1 shows the correlation values of weather parameters with each other. The correlation value varies between -1.00 and +1.00. The correlation value of a factor indicates that it has a negative relationship as it approaches -1.00, and a positive relationship as it approaches +1.00. Anova model has a positive relationship only with the wind (0.2125), while the model has a negative relationship with temperature (-0.2509), humidity (-0.4969), and pressure (-0.9992) for Turkey and a positive relationship only with the temperature (0.2430), while the model has a negative relationship with humidity (-0.5783), wind (-0.3973), and pressure (-0.9994) for Italy. The strongest relationship with cases of COVID-19 number negatively is with pressure for Turkey and Italy.

Table 1. Correlation values of meteorological parameters for Turkey and Italy

Country	Correlation	Model	Temp (^{0}C)	Humidity (%)	Wind (mph)	Pressure (Hg)
Turkey	Model	1,0000	-0,2509	-0,4969	0,2125	-0,9992
	Temp (C)	-0,2509	1,0000	0,2061	0,4816	0,2256
	Humidity (%)	-0,4969	0,2061	1,0000	-0,1423	0,4691
	Wind (mph)	0,2125	0,4816	-0,1423	1,0000	-0,2308
	Pressure (Hg)	-0,9992	0,2256	0,4691	-0,2308	1,0000
Italy	Model	1,0000	0,2430	-0,5783	-0,3973	-0,9994
	Temp (C)	0,2430	1,0000	-0,2788	0,1116	-0,2632
	Humidity (%)	-0,5783	-0,2788	1,0000	0,3058	0,5600
	Wind (mph)	-0,3973	0,1116	0,3058	1,0000	0,3791
	Pressure (Hg)	-0,9994	-0,2632	0,5600	0,3791	1,0000

The correlation between parameters does not mean that these parameters have an effect on COVID-19. Therefore, more than one analysis should be made in statistics. **Table 2** shows that, the analysis of variance was significantly analyzed with COVID-19 pandemic (R^2= 0.307; F-ratio=5.6581 prob > .0008 with 55 observations for Turkey, and R^2= 0.437; F-ratio=3.6581 prob > .0182 with 69 observations for Italy), with high level.

Among the parameters, temperature (^{0}C) has the most important effect on COVID-19 cases based on F-ratio and t-ratio (p=0.0037) for Turkey. We also can say that the humidity rate has a significant effect in terms of significance for Turkey. Since significance of humidity (%) is less than the value of p=0.1, its effect on COVID-19 is high. Tosepu et al. (2020) expressed the humidity (%) was insignificant correlated (Tosepu et al. 2020). This is because the data they use in their studies are statistically insufficient. Wind (mph) and pressure (Hg) parameters did not show a significant effect on COVID-19. Another study shows that temperature and humidity have an important and consistent distribution in the spread of the virus (Chen et al. 2020). Both Humidity (%) (t-ratio=-1,38; p<0.0172) and Wind (mph) (t-ratio=-2,57; p<0.0125) parameters have been found to play an important role in the COVID-19 outbreak for Italy.

Table 2. ANOVA data of the parameters for COVID-19

Country	Source	Std Error	Sum of Squares	t-Ratio	F-Ratio	Prob > F Prob > |t|
Turkey	Temperature (C)	72899.42	19001496	3.04	9.2659	0.0037
	Humidity (%)	109.5994	6933250	-1.84	3.3809	0.0719
	Wind (mph)	36.26466	6016.00	-0.05	0.0029	0.9570
	Pressure (Hg)	98.15116	735691.0	0.60	0.3588	0.5519
Italy	Temperature (C)	1.882879	0.182000	-0,01	0,0001	0.9920
	Humidity (%)	0.515344	3444.845	-1,38	1,9026	0.0172
	Wind (mph)	2.055759	11974.693	-2,57	6,6137	0.0125
	Pressure (Hg)	37.80559	412.66600	0,48	0,2279	0.6347

According to Prediction Profiler, the number of COVID-19 cases in the coming days will range from 2.2 to 4373.4. Temperature, humidity, wind, pressure values should be 15.24, 83.3, 13.77 and 28.001, respectively, within these limits.

4. CONCLUSION

In this study, the effects of meteorological parameters on the spread of coronavirus have been analyzed statistically in Turkey and Italy. The multi-factor ANOVA for data analysis was used for the present study. The data of the COVID-19 active cases were handled covering 55 days between March 10, 2020 (the first case incident) and May 3, 2020 for Turkey and covering 69 days between February 25, 2020, and May 3, 2020 for Italy.

The parameters of meteorology include average temperature (^{0}C), humidity (%), wind (mph) and pressure (Hg) in this study. The data of meteorological parameters were considered as the average of each factor's data for the highest populated cities of Turkey and the two most populous cities (Rome and Milan) in Italy. The analysis of variance was significantly analyzed with COVID-19 pandemic (R^2= 0.307; F-ratio=5.6581 prob > .0008 with 55 observations for Turkey, and R^2= 0.437; F-ratio=3.6581 prob > .0182 with 69 observations for Italy), with the highest level.

Among the parameters of the weather, average temperature (°C) has a significant impact on COVID-19 pandemic (t-ratio=3.12; p<0.05) and humidity (%) provisionally affects COVID-19 pandemic (t-ratio=-1.186; p<0.10) for Turkey. In addition, both humidity (%) (t-ratio=-1,38; p<0.0172) and wind (mph) (t-ratio=-2,57; p<0.0125) parameters have been found to play an important role in the COVID-19 outbreak for Italy.

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