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CORRELATION BETWEEN SOME CLIMATIC FACTORS AND COVID-19 EPIDEMIC IN TWO CITIES IN KINGDOM OF SAUDI ARABIA

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ABSTRACT: *The purpose of the current study is to explore the relations between coronavirus disease 2019 (COVID-19) case counts and meteorological factors in two capital cities of Kingdom of Saudi Arabia (K.S.A). Meteorological data on daily average (high, low and mean) barometer (atmospheric pressure) (hpa - hectoPascals), relative humidity (%), temperature (^{o}c), wind gust (km/h), wind speed (km/h) and drew point (^{o}c) during the study period, which was 35 days. The finding showed the person correlation coefficients between Daily number of infected cases of COVID-19 and weather factors in Al Riyad and Mecca cities in K.S.A. The results in Al Riayd and Mecca cities were: Daily number of infected cases of COVID-19 had obvious linear positive correlations significantly ($p<0.01$) with daily average temperature ($r = 0.72; 0.72$), daily average high temperature ($r = 0.70; 0.65$) and daily average low temperature ($r = 0.67; 0.71$); respectively, and significantly ($p<0.01$) negative correlations with daily average barometer ($r = - 0.72; - 0.50$), daily average high barometer ($r = - 0.63; - 0.53$), daily average low barometer ($r = - 0.67; - 0.52$); respectively. Also, in Al Riayd city the confirmed COVID-19 correlated significantly ($p<0.01$) with daily average humidity ($r = - 0.59$), daily average high humidity ($r = - 0.60$) and daily average low humidity ($r = - 0.52$) and in Mecca city was lower significant ($p<0.5$) with daily average humidity ($r = - 0.38$).*

KEYWORDS: Covid-19, Temperature, Humidity, Barometer, Wind Gust, Wind Speed

INTRODUCTION

World Health Organization (WHO) reported that there have been pneumonia cases in Wuhan City, Hubei Province, China (Zhu et al., 2019), but the etiology was unknown (Sohrabi et al., 2020). The case was developed very fast (Anderson et al., 2020), until January 7, 2020, the Chinese government said that pneumonia was a new type of coronavirus or COVID-19 (Li et al., 2020).

Common signs and symptoms of COVID-19 infection include symptoms of acute respiratory disorders such as fever, coughing and shortness of breath. The average incubation period is 5–6 days with the longest incubation period of 14 days. In severe cases, COVID-19 can cause pneumonia, acute respiratory syndrome, kidney failure, and even death. The clinical signs and symptoms reported in the majority of cases are fever, with some cases having difficulty breathing, and Xrays show extensive pneumonia infiltrates in both lungs (Holshue et al., 2020; Perlman, 2020). The clinical symptoms of severe and critical patients with COVID-19 are likely similar with the clinical symptoms of SARS and MERS (Wang et al., 2020).

Initial studies of disease rigorousness in early cases showed that COVID-19 had a 2.3% case fatality rate (She et al., 2020), much lower than in other diseases caused by other coronaviruses, such as Middle East Respiratory Syndrome (MERS, 34.4%) and Severe Acute Respiratory Syndrome (SARS, 9.2%) (Ceccarelli et al., 2020; Wu and McGoogan, 2020). However, Wu et al. reported that the number of COVID-19 cases doubled every 6.4 days from Dec. 2019 to Jan. 2020, indicating COVID-19 was much more infectious than SARS and MERS (Wu et al., 2020). In March 2020, the WHO declared that COVID-19 was a global pandemic.

Environmental factors can affect the epidemiological dynamics of many infectious diseases. In particular, several studies of climate and weather conditions found that these environmental factors affected the spatial distribution and timing of infections (Bedford et al., 2015; Sooryanarain and Elankumaran, 2015; Lemaitre et al., 2019). Based on analysis on climatic variables, there is evidence that temperature affect influenza epidemics in tropical regions (Tamerius et al., 2013). Temperate regions of the Northern and Southern Hemispheres experience highly synchronized annual influenza epidemics during their winter months (Tamerius et al., 2013; Bedford et al., 2015; Sooryanarain and Elankumaran, 2015). The seasonality of influenza in temperate monsoon climate regions may result from the meteorological factors that affect the environmental and physical stability of virus particles and human social behaviors, both of which contribute to virus epidemiological dynamics. SARS-CoV-2 can be transmitted through aerosols, large droplets, or direct contact with secretions or fomites, similar to the influenza virus (Li et al., 2005). However, the effects of different environmental factors on the incidence of COVID-19 remain to be elucidated.

Some studies have suggested that the climate change might have contributed to various infectious diseases emergence and spread (Lofgren et al., 2007; Gale et al., 2010; Stott, 2016), including the SARS and COVID-19. In Korea, researchers found that the risk of influenza incidence was significantly increased with low daily temperature and low/high relative humidity, but a positively correlated with diurnal temperature range (Park et al., 2020). Absolute humidity had significant correlations with influenza viral survival and transmission rates (Shaman et al., 2010; Shaman et al., 2011). One important feature of COVID-19 epidemic is that the countries presently suffering most from the disease are most located in the regions with low temperature. Therefore, climatological factors, such as ambient temperature and humidity, might play an important role in the spread of the disease. Many factors might influence the COVID-19 epidemic, including social and political factors, geographical factors, climatic factors, etc. (Casadevall, 2020; Wu et al., 2020). When only considering the temperature in single-factor model in the higher-temperature group, every 1 °C increase in the minimum temperature leads to a decrease of the cumulative number of COVID-19 cases by 0.86 (Wang et al., 2020). Luo etc. reported that weather was related to the spread of COVID-19, but the increase of temperature may not necessarily lead to declines in case counts without the implementation of extensive public health interventions (Luo et al., 2020). In another study, researchers estimated that the weather variables explain 18% of the variation in disease doubling time, and the remaining 82% may be related to containment measures, general health policies, population density, transportation or cultural aspects (Oliveiros et al., 2020). Because of the human to human transmission, the migration should be considered when evaluate the effects of weather factors over COVID-19 transmission. Viruses can be transmitted by being influenced by several factors, including climatic conditions, (Dalziel et al., 2018). So that to prevent the spread of covd-19 disease requires

evaluation of weather factors, such as (high, low and mean) barometer, relative humidity, temperature, wind gust, wind speed and drew point.

MATERIALS AND METHODS

Saudi Arabia

Saudi Arabia, officially the Kingdom of Saudi Arabia, is a country in Western Asia constituting the bulk of the Arabian Peninsula. With a land area of approximately 2,150,000 km^2 (830,000 sq mi). The Saudi population were 27,136,977 people on April 27, 2010 according to the preliminary results of the general census. Saudi Arabia has a diverse topography. The Tihama coastal plain which lies along the Red Sea, is 1,100 kilometers long, 60 kilometers wide in the south and gradually narrows to the north until it reaches the Aqaba Gulf. To the east of this plain, lies a chain of mountains called Sarawat. These mountains rise to 9,000 feet in the south and gradually fall to 3,000 feet in the north. Several large valleys slope eastward and westward from these mountains. They include Jazan valley, Najran valley, Tathleeth valley, Bisha valley, Himdh valley, Rumah valley, Yanbu valley and Fatima Valley. To the east of the chain stands the Najd Plateau which extends eastward to Samman Desert, Dahnaa Dunes and southward to Dwaser valley. This region is parallel to the Empty Quarter Desert and stretches northward to Najd plains, passing through Hail until it connects with the Great Nefud Desert, then to the borders of Iraq and Jordan. There are also some mountains in this plateau such as Twwaig, Al-Aridh, Aja and Salmah mountains. The Empty Quarter in the south-eastern part of the Kingdom occupies an estimated area of 640,000 square kilometers composed of sand hills and lava fields. The eastern coastal plain is 610 kilometers long and consists of large sand areas and Salinas (General Authority for statistic, 2015).

The climate of Saudi Arabia varies from one region to another because of its diverse topographical features. As a result of a subtropical high-pressure system, the Kingdom is generally hot in summer and cold in winter where rains fall often. Moderate climate is seen in the west and the southwestern part of the Kingdom; dry hot summer and cold winter in the interior parts; and high temperature and humidity in the coastal areas. Major parts of the Kingdom usually receive scanty amounts of rain in winter and spring. However, in the summer, rainfall is significant in the southwestern mountains. Humidity is high on the western coasts and mountains almost all year and it gets lower as we go inland (General Authority for statistic, 2015).

Al Riyad:- Riyadh is the capital of Saudi Arabia and the largest city on the Arabian Peninsula. With a population over 5 million people, Riyadh is the second-largest city in the Arab world and the 39th-largest in Asia. Riyadh is located on the eastern part of the Najd plateau at about 600 meters (2,000 ft) above sea level. Elevation: 611 meters Latitude: 24 43N Longitude: 046 43E (General Authority for statistic, 2015).

Mecca:- Mecca is a city in the Hejazi region of Saudi Arabia. The city is located 70 km (43 mi) inland from Jeddah, in a narrow valley 277 m (909 ft) above sea level and 340 kilometers (210 mi) south of Medina. Its population in 2010 was 4,534,731, according to the general census. although visitors more than triple this number every year during

the Ḥajj ("Pilgrimage"), held in the twelfth Muslim lunar month of Dhul-Ḥijjah. Elevation: 161 meters Latitude: 21 29N Longitude: 039 50E (General Authority for statistic, 2015).

Data Collection:

The period time of current study from 8 April to 12 May, 2020 (35 days) to set on covid-19 cases and survive features, as a measure of prevention the spread of the pandemic, the government prevent the migration between cities and decided to night curfew in cities in K.S.A. during this period time. The data of covid-19 cases were gathered from the official website of the Ministry of Health of the Kingdom of Saudi Arabia (https://covid19.moh.gov.sa/). Figure (1) presents the covid-19 position in Al Riyad and Mecca cities in K.S.A.

Meteorological data on daily average by hours (high, low and mean) barometer (air pressure) (hpa), relative humidity (%), temperature (oc), wind gust (km/h), wind speed (km/h) and drew point (oc) during the study period were obtained from the official websites (www.weatherbase.com/ and www.wunderground.com/), which the source is the general authority of meteorology and environmental protection of Saudi Arabia. Figure (2 and 3) present daily average ambient in Al Riyad and Mecca cities in K.S.A. Dew point is the temperature at which the air is saturated and clouds are formed. In other words, it is the temperature to which the air needs to be cooled for the relative humidity to reach 100%. Wind gust is a brief increase in the speed of the wind, usually less than 20 seconds. It is of a more transient character than a squall, which lasts minutes, and is followed by a lull or slackening in the wind speed. Generally, winds are least gusty over large water surfaces and most gusty over rough land and near high buildings. In other words, it is a sudden, brief increase in speed of the wind. According to U.S. weather observing practice, gusts are reported when the peak wind speed reaches at least 16 knots and the variation in wind speed between the peaks and lulls is at least 9 knots. The duration of a gust is usually less than 20 seconds. A barometer is a device that measures atmospheric pressure. The word "barometer" comes from the Greek words for "weight" and "measure." Changes in atmospheric pressure recorded by barometers are most often used in meteorology for forecasting weather. Pressure is measured in hectoPascals (hPa), also called millibars. Standard pressure at sea level is defined as 1013hPa, but we can see large areas of either high or low pressure. As air warms, it ascends leading to low pressure at the surface (Strangeways, 2000).

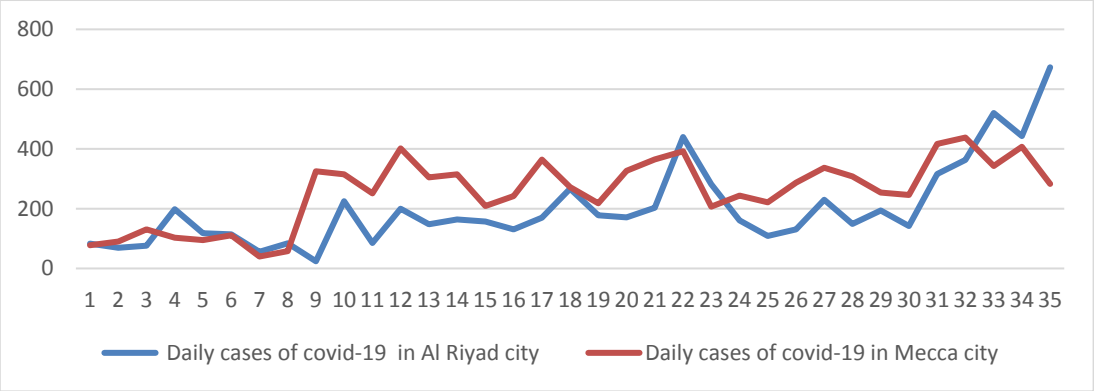

Figure (1): Daily infected cases of covid-19 in Al Riyad and Mecca cities in K.S.A in the period time from 8 April 2020 to 12 May 2020.

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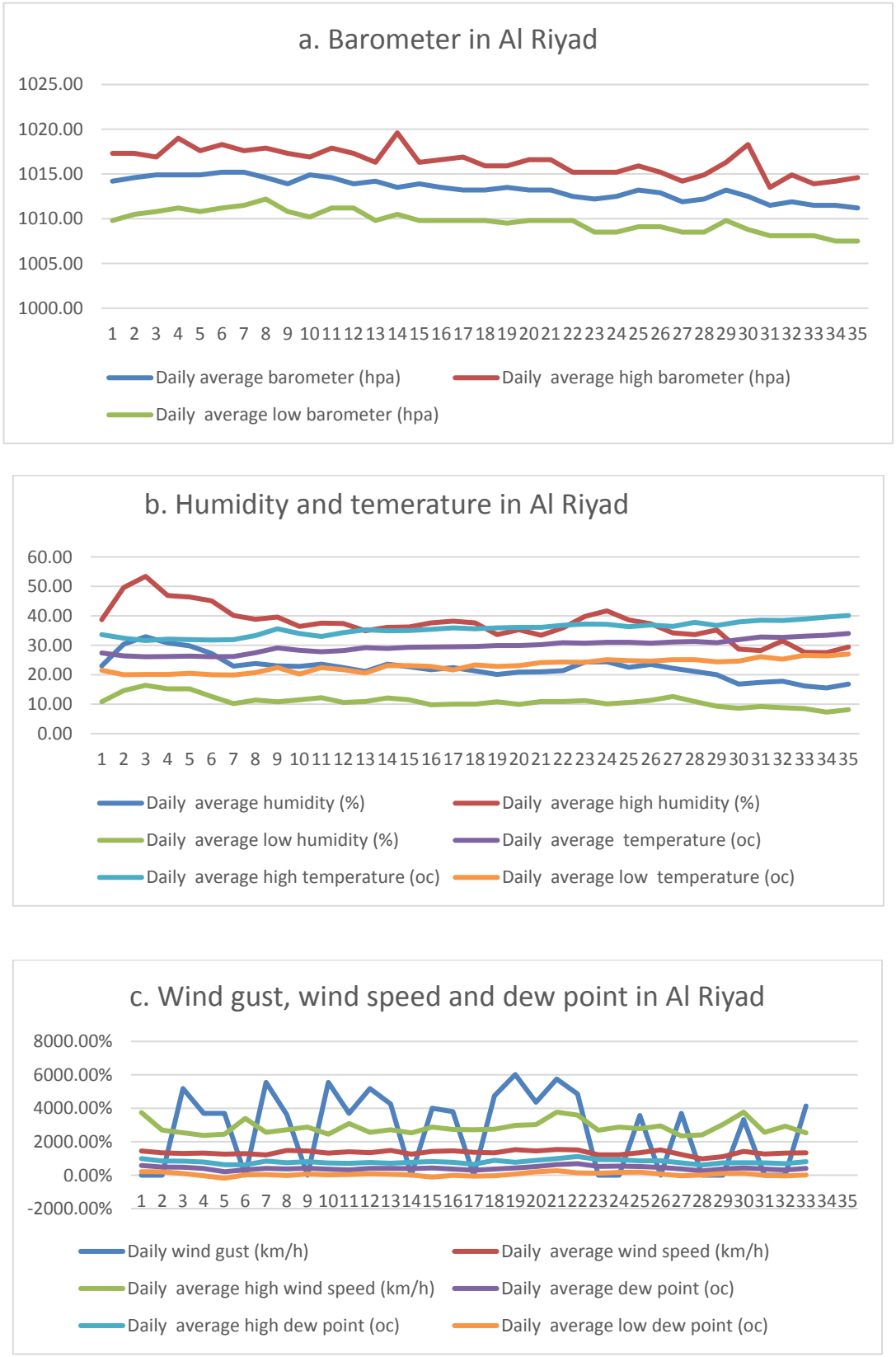

Figure (2): Daily average ambient factors (a. barometer b. humidity and temperature c. wind gust, wind speed and dew point) in Al Riyad city in K.S.A in the period time from 8 April 2020 to 12 May 2020.

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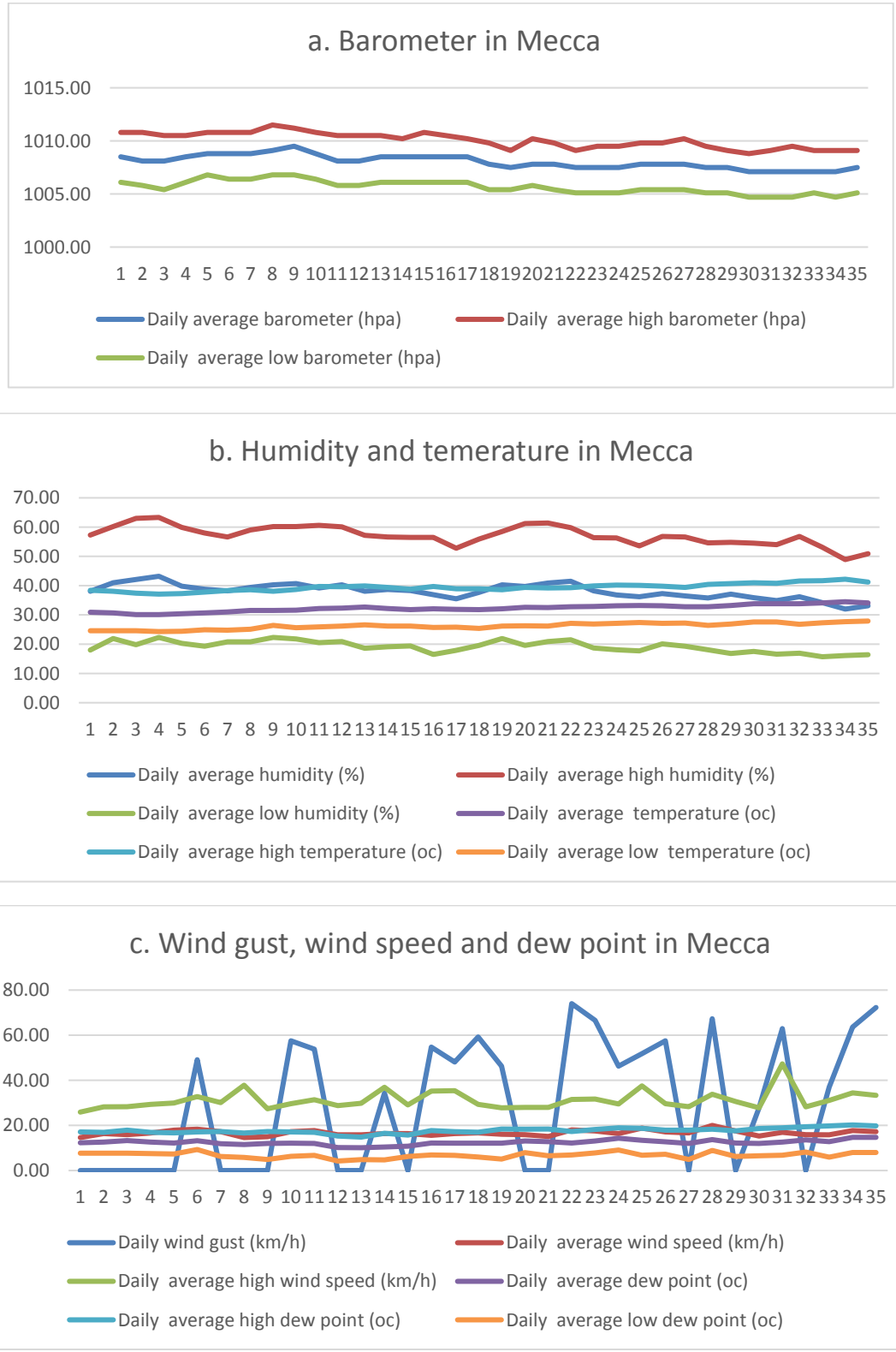

Figure (3): Daily average ambient factors (a. barometer b. humidity and temperature c. wind gust, wind speed and dew point) in Mecca city in K.S.A in the period time from 8 April 2020 to 12 May 2020.

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RESULTS

Descriptive Analysis

Table (1) and table (2) summarize the descriptive statistics of daily number of infected cases of COVID-19 and ambient factors in Al Riyad and Mecca cities in Kingdom of Saudi Arabia (K.S.A). This study involved 35 days during the observation period (April 8, 2020 to May 12, 2020) and the low recorded cases of COVID-19 was 24 infection and maximum was 673 cases and average number was 202.11 with stander error mean 23.68 in Al Riyad city, while in Mecca city the number cases was 40 and maximum infection was 438 cases with average number was 257.14 with stander error mean 18.83. Daily minimum, maximum and mean value of daily average (average, high and low) barometer (hpa), humidity (%), temperature (0c), wind gust (km/h), wind speed (km/h) and dew point (oc) were recorded.

Person correlation coefficients Between infected cases of COVID-19 and ambient factors

Table (3) and figure (4.a) show the person correlation coefficients between Daily number of infected cases of COVID-19 and ambient factors in Al Riyad city in K.S.A. Daily number of infected cases of COVID-19 had significantly ($p<0.01$) positive correlations with daily average temperature ($r = 0.72$), daily average high temperature ($r = 0.70$) and daily average low temperature ($r = 0.67$), and significantly ($p<0.01$) negative correlations with daily average barometer ($r = - 0.72$), daily average high barometer ($r = - 0.63$), daily average low barometer ($r = - 0.67$), daily average humidity ($r = - 0.59$), daily average high humidity ($r = - 0.60$) and daily average low humidity ($r = - 0.52$). Among the metrological variables: daily average barometer had significantly ($p<0.01$) positive correlations with daily average humidity ($r = 0.74$) and significantly ($p<0.01$) negative correlations with daily average temperature ($r = - 0.96$). However, daily average humidity had significantly ($p<0.01$) positive correlations with daily average dew point ($r = 0.48$) and significantly ($p<0.01$) negative correlations with daily average temperature ($r = - 0.84$). Daily average speed wind correlated ($p< 0.05$) with dew point ($r = 0.41$).

Table (4) and figure (4.b) show the person correlation coefficients between Daily number of infected cases of COVID-19 and ambient factors in Mecca city in K.S.A. Daily number of infected cases of COVID-19 had significantly ($p<0.01$) positive correlations with daily average temperature ($r = 0.72$), daily average high temperature ($r = 0.65$) and daily average low temperature ($r = 0.71$), and significantly ($p<0.01$) negative correlations with daily average barometer ($r = - 0.50$), daily average high barometer ($r = - 0.53$), daily average low barometer ($r = - 0.52$) and lower significant ($p<0.5$) with daily average humidity ($r = - 0.38$). Among the metrological variables: daily average barometer had significantly ($p<0.01$) positive correlations with daily average humidity ($r = 0.52$) and significantly ($p<0.01$) negative correlations with daily average temperature ($r = - 0.77$) and average dew point ($r = - 0.49$). Also, in this study recorded negative correlation ($p<0.01$) between average humidity and Daily average temperature ($r = - 0.76$) and daily average high dew point ($r = - 0.59$) and high-speed wind ($r = - 0.42$, $p<0.05$). However, positive correlation had been seen between average temperature and daily average high dew point ($r = 0.60$, $p<0.05$). Moreover, positive correlation between daily wind gust and average speed wind ($r = 0.59$, $p<0.01$) and dew point ($r = 0.46$, $p<0.05$).

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Sensitivity Analysis

Based on results from table (3 and 4) linear correlation was graphed and suggest brief distribution characteristics between daily number of COVID-19 confirmed cases and climatic factors, recorded an obvious trend positive association between COVID-19 and temperature, it seemed that the confirmed case number increased with temperature increasing in the range of 19.9 °C – 42.20 °C. Moreover, a current study found that there was inverse linear regression for the negative relationship between confirmed cases counts and barometer, in the range of 1004.7 hpa – 1019.6 hpa. However, the regression model showed that the infected cases of COVID-19 counts declined with the increase of humidity in rang of 7.30 % - 53.40 %. Figures (5,6,7,8 and 9), revealed the correlation ship between daily number of infected cases of COVID-19 and daily average barometer measurements (a. average, b. high and c. low) in Al Riyad and Mecca cities in K.S.A.

Table (1): Descriptive statistic of daily number of infected cases of covid-19 and ambient factors in Al Riyad city in K.S.A.

Parameter	Number of days	Minimum value	Maximum value	Mean		
				Statistic	Stander error mean	Stander Deviation
Daily number of infected cases of covid-19	35	24.00	673.00	202.11	23.68	140.12
Daily average barometer (hpa)	35	1011.20	1015.20	1013.37	0.20	1.19
Daily average high barometer (hpa)	35	1013.50	1019.60	1016.39	0.25	1.48
Daily average low barometer (hpa)	35	1007.50	1012.20	1009.71	0.20	1.19
Daily average humidity (%)	35	15.50	32.90	22.49	0.68	4.03
Daily average high humidity (%)	35	27.50	53.40	37.20	1.01	5.96
Daily average low humidity (%)	35	7.30	16.40	10.99	0.34	2.01
Daily average temperature (^{o}c)	35	26.10	34.00	29.63	0.38	2.25
Daily average high temperature (^{o}c)	35	31.60	40.10	35.55	0.40	2.34
Daily average low temperature (^{o}c)	35	19.90	27.00	23.07	0.37	2.17
Daily wind gust in mecca (km/h)	22	33.30	60.20	44.62	1.75	8.22
Daily average speed wind (km/h)	35	9.80	15.40	13.56	0.21	1.25
Daily average high speed wind (km/h)	35	23.50	37.70	28.55	0.66	3.92

Daily average dew point (^{o}c)	35	2.10	6.90	4.21	0.17	1.03
Daily average high dew point (^{o}c)	35	6.10	11.20	7.99	0.19	1.13
Daily average low dew point (^{o}c)	35	-1.80	2.70	0.53	0.17	0.99

Table (2): Descriptive statistic of daily number of infected cases of covid-19 and ambient factors in Mecca city in K.S.A.

Parameter	Number of days	Minimum value	Maximum value	Mean		
				Statistic	Stander error mean	Stander Deviation
Daily number of infected cases of covid-19	35	40.00	438.00	257.14	18.83	111.40
Daily average barometer (hpa)	35	1007.10	1009.50	1008.01	0.11	0.64
Daily average high barometer (hpa)	35	1008.80	1011.50	1010.05	0.12	0.73
Daily average low barometer (hpa)	35	1004.70	1006.80	1005.65	0.11	0.63
Daily average humidity (%)	35	32.00	43.20	38.08	0.43	2.54
Daily average high humidity (%)	35	48.90	63.30	57.20	0.55	3.27
Daily average low humidity (%)	35	15.70	22.30	19.19	0.33	1.94
Daily average temperature (^{o}c)	35	30.10	34.50	32.31	0.20	1.18
Daily average high temperature (^{o}c)	35	37.10	42.20	39.43	0.21	1.27
Daily average low temperature (^{o}c)	35	24.30	27.90	26.20	0.18	1.05
Daily wind gust in mecca (km/h)	19	27.80	74.00	54.22	2.88	12.56
Daily average speed wind (km/h)	35	14.60	20.00	16.64	0.20	1.18
Daily average high speed wind (km/h)	35	25.90	47.30	31.25	0.70	4.15
Daily average dew point (^{o}c)	35	10.10	14.70	12.45	0.18	1.09
Daily average high dew point (^{o}c)	35	14.80	20.20	17.67	0.21	1.22
Daily average low dew point (^{o}c)	35	4.20	9.30	6.78	0.22	1.28

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Table(3): Person correlation coefficients between Daily number of infected cases of covid-19 and ambient factors in Al Riyad city in K.S.A.

Parameters	Daily number of infected cases of covid-19	Daily average barometer (hpa)	Daily average high barometer (hpa)	Daily average low barometer (hpa)	Daily average humidity (%)	Daily average high humidity (%)	Daily average low humidity (%)	Daily average temperature (°c)	Daily average high temperature (°c)	Daily average low temperature (°c)	Daily wind gust (km/h)	Daily average speed wind (km/h)	Daily average high speed wind (km/h)	Daily average dew point (°c)	Daily average high dew point (°c)	Daily average low dew point (°c)
Daily number of infected cases of covid-19	1.00															
Daily average barometer (hpa)	-0.72**	1.00														
Daily average high barometer (hpa)	-0.63**	0.80**	1.00													
Daily average low barometer (hpa)	-0.67**	0.91**	0.82**	1.00												
Daily average humidity (%)	-0.59**	0.74**	0.55**	0.66**	1.00											
Daily average high humidity (%)	-0.60**	0.74**	0.54**	0.66**	0.97**	1.00										
Daiy average low humidity (%)	-0.52**	0.68**	0.50**	0.61**	0.94**	0.85**	1.00									
Daily average temperature (°c)	0.72**	-0.96**	-0.78**	-0.90**	-0.84**	-0.84**	-0.78**	1.00								
Daily average high temperature (°c)	0.70**	-0.96**	-0.76**	-0.90**	-0.84**	-0.83**	-0.79**	0.99**	1.00							
Daily average low temperature (°c)	0.67**	-0.95**	-0.76**	-0.87**	-0.74**	-0.75**	-0.68**	0.95**	0.93**	1.00						

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Daily wind gust (km/h)	-0.19	-0.01	0.26	0.14	0.23	0.16	0.18	-0.10	-0.02	0.06	1.00					
Daily average wind speed (km/h)	0.03	0.13	-0.07	0.04	0.31	0.29	0.29	-0.20	-0.17	-0.18	0.13	1.00				
Daily average high wind speed (km/h)	0.04	-0.17	-0.30	-0.20	0.16	0.17	0.13	0.09	0.10	0.08	0.10	0.50**	1.00			
Daily average dew point (°c)	0.00	-0.14	-0.22	-0.17	0.48**	0.45**	0.43**	0.02	0.02	0.14	0.27	0.41*	0.51**	1.00		
Daily average high dew point (°c)	-0.04	-0.12	-0.21	-0.16	0.46**	0.46**	0.36*	0.01	0.02	0.12	0.29	0.37*	0.42*	0.94**	1.00	
Daily average low dew point (oc)	0.05	-0.16	-0.17	-0.14	.41*	0.31	0.49**	0.05	0.03	0.15	0.29	0.2	0.52**	0.82**	0.68**	1.00

*** correlation is significant at P<0.01*
** correlation is significant at P<0.05*

Table(4): Person correlation coefficients between Daily number of infected cases of covid-19 and ambient factors in Mecca city in K.S.A.

Parameters	Daily number of infected cases of covid-19	Daily average barometer (hpa)	Daily average high barometer (hpa)	Daily average low barometer (hpa)	Daily average humidity (%)	Daily average high humidity (%)	Daily average low humidity (%)	Daily average temperature (oc)	Daily average high temperature (oc)	Daily average low temperature (oc)	Daily wind gust (km/h)	Daily average speed wind (km/h)	Daily average high speed wind (km/h)	Daily average dew point (oc)	Daily average high dew point (oc)	Daily average low dew point (oc)
Daily number of infected cases of covid-19	1.00															
Daily average barometer (hpa)	-0.50**	1.00														
Daily average high barometer (hpa)	-0.53**	0.92**	1.00													
Daily average low barometer (hpa)	-0.52**	0.97**	0.91**	1.00												

Daily average humidity (%)	-0.38*	0.52**	0.54**	0.51**	1.00											
Daily average high humidity (%)	-0.32	0.47**	0.56**	0.48**	0.95**	1.00										
Daily average low humidity (%)	-0.32	0.55**	0.54**	0.55**	.87**0	0.81**	1.00									
Daily average temperature (oc)	0.72**	-0.77**	-0.79**	-0.76**	-0.76**	-0.70**	-0.67**	1.00								
Daily average high temperature (oc)	0.65**	-0.76**	-0.74**	-0.75**	-0.80**	-0.74**	-0.77**	0.96**	1.00							
Daily average low temperature (oc)	0.71**	-0.70**	-0.75**	-0.71**	-0.66**	-0.63**	-0.55**	0.95**	0.86**	1.00						
Daily wind gust (km/h)	0.26	-0.12	-0.08	-0.20	-0.02	-0.04	0.09	0.10	0.05	0.13	1.00					
Daily average wind speed (km/h)	0.04	-0.22	-0.27	-0.22	-0.21	-0.28	-0.11	0.13	0.13	0.16	0.59**	1.00				
Daily average high wind speed (km/h)	0.18	-0.11	-0.17	-0.12	-0.42*	-0.45**	-0.40*	0.29	0.29	0.27	0.20	0.30	1.00			
Daily average dew point (oc)	0.05	-0.49**	-0.45**	-0.51**	-0.41*	-0.33	-0.38*	0.32	0.34*	0.27	0.46*	0.36*	0.08	1.00		
Daily average high dew point (oc)	0.31	-0.70**	-0.70**	-0.69**	-0.59**	-0.51**	-0.55**	0.62**	0.61**	0.56**	0.11	0.16	0.18	0.84**	1.00	
Daily average low dew point (oc)	-0.21	-0.26	-0.18	-0.27	-0.18	-0.11	-0.28	0.01	0.08	-0.07	0.42	0.40*	0.04	0.80**	0.46**	1.00

*** correlation is significant at P<0.01*
** correlation is significant at P<0.05*

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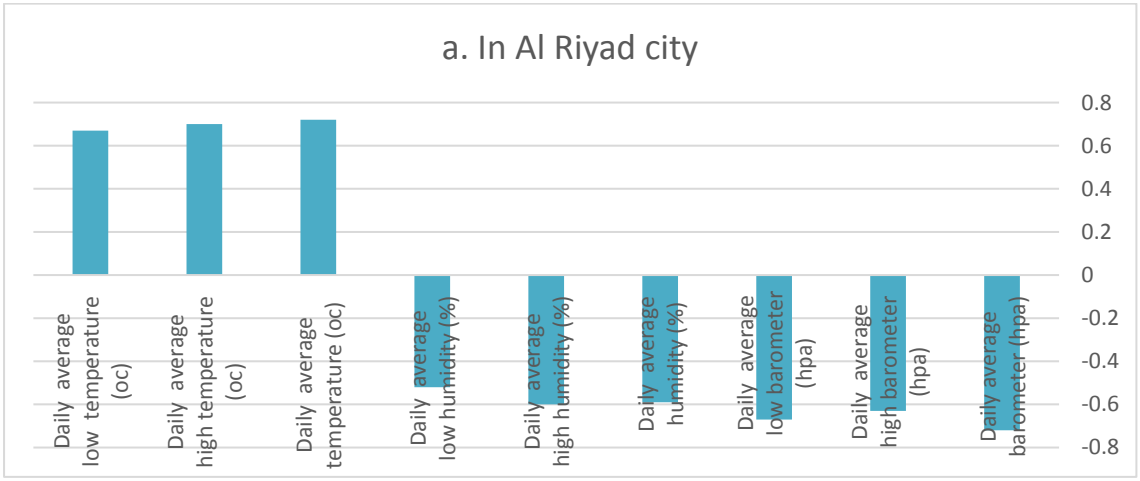

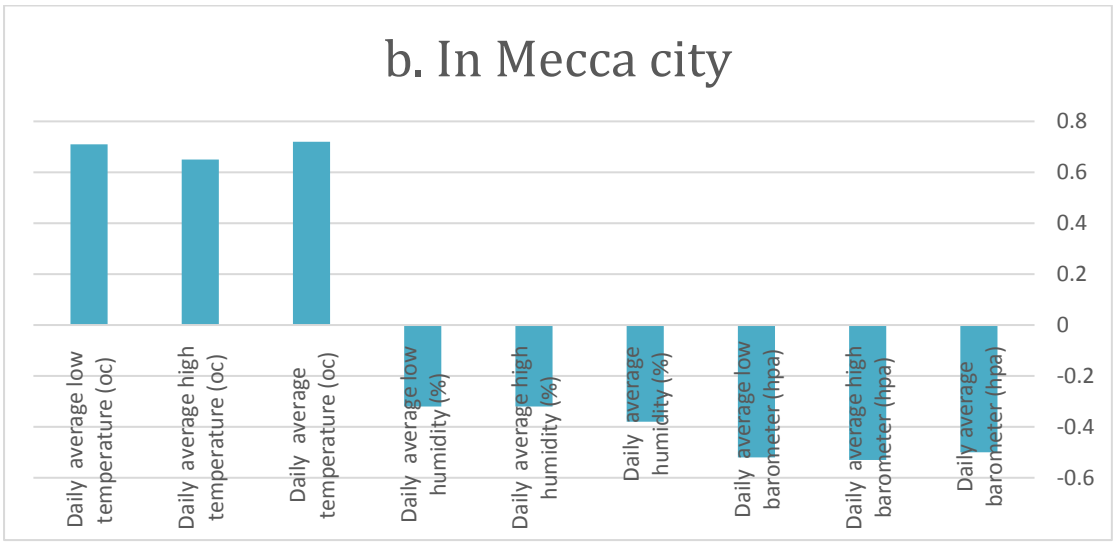

Figure (4): The comparison of Pearson correlation coefficients between daily infected cases of covid-19 and ambient factors in (a. Al Riyad and b. Mecca) cities in K.S.A in the period time from 8 April 2020 to 12 May 2020.

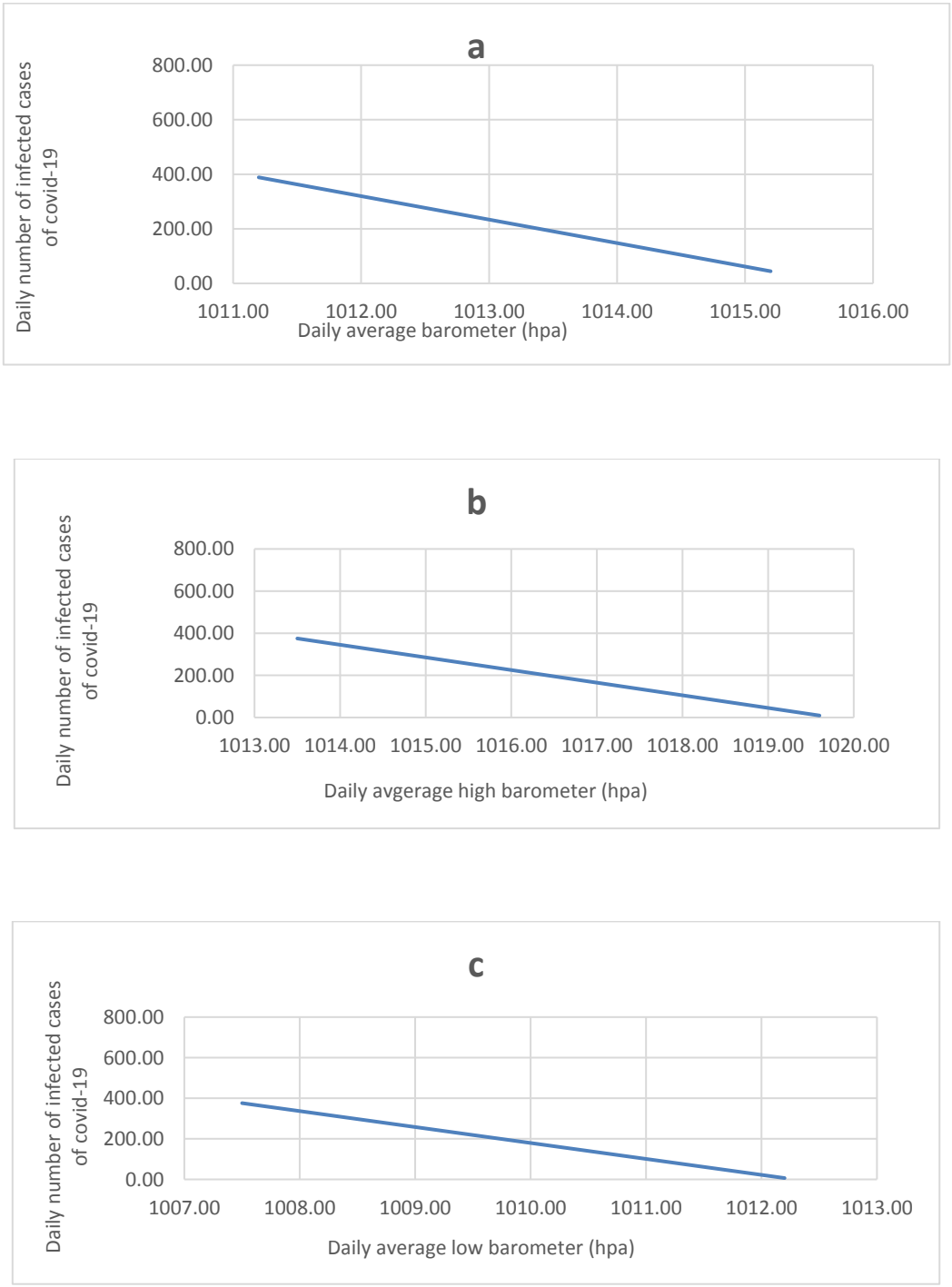

Figure (5): Correlation ship between Daily number of infected cases of covid-19 and daily average barometer measurements (a. average, b. high and c. low) in Al Riyad city in K.S.A.

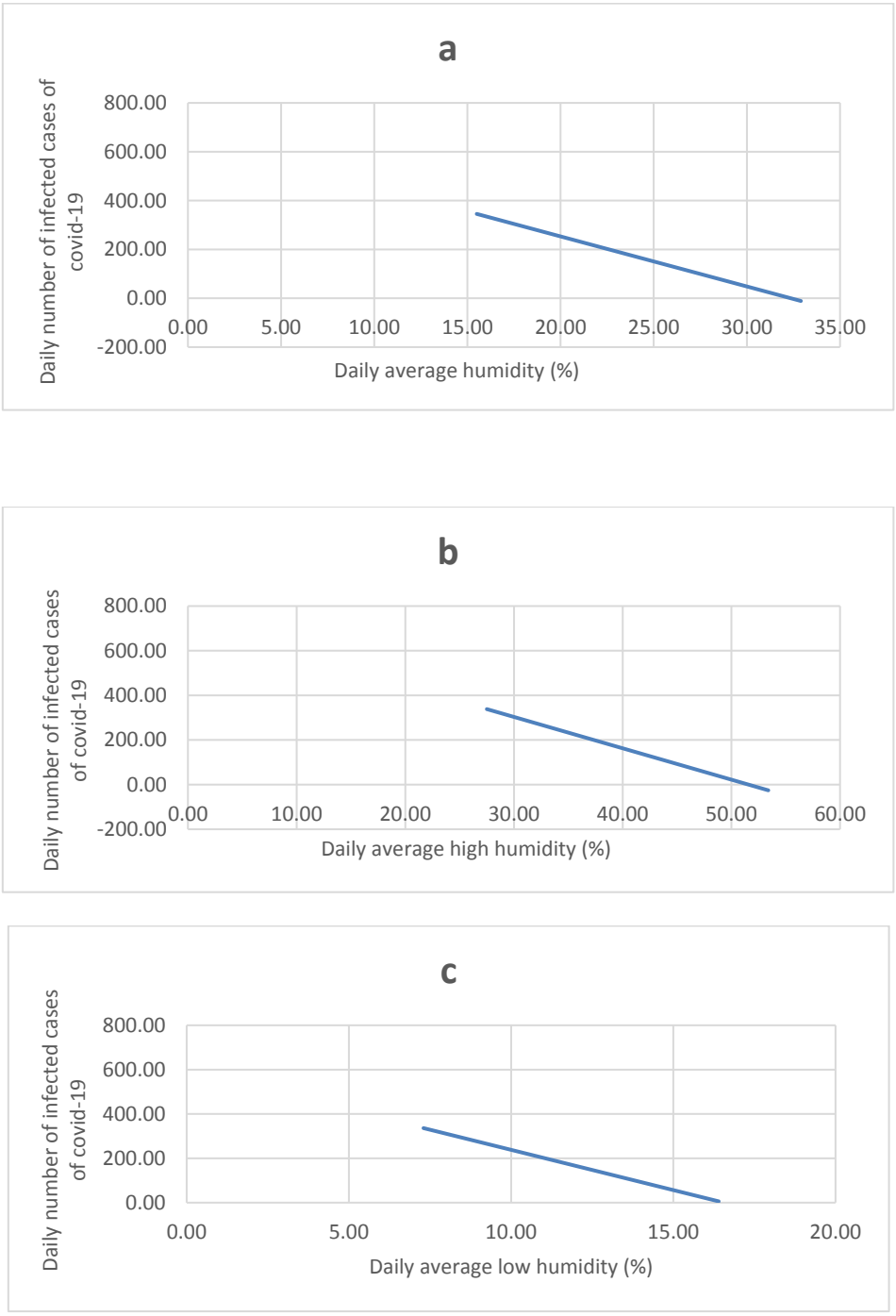

Figure (6): Correlation ship between Daily number of infected cases of covid-19 and daily average humidity measurements (a. average, b. high and c. low) in Al Riyad city in K.S.A.

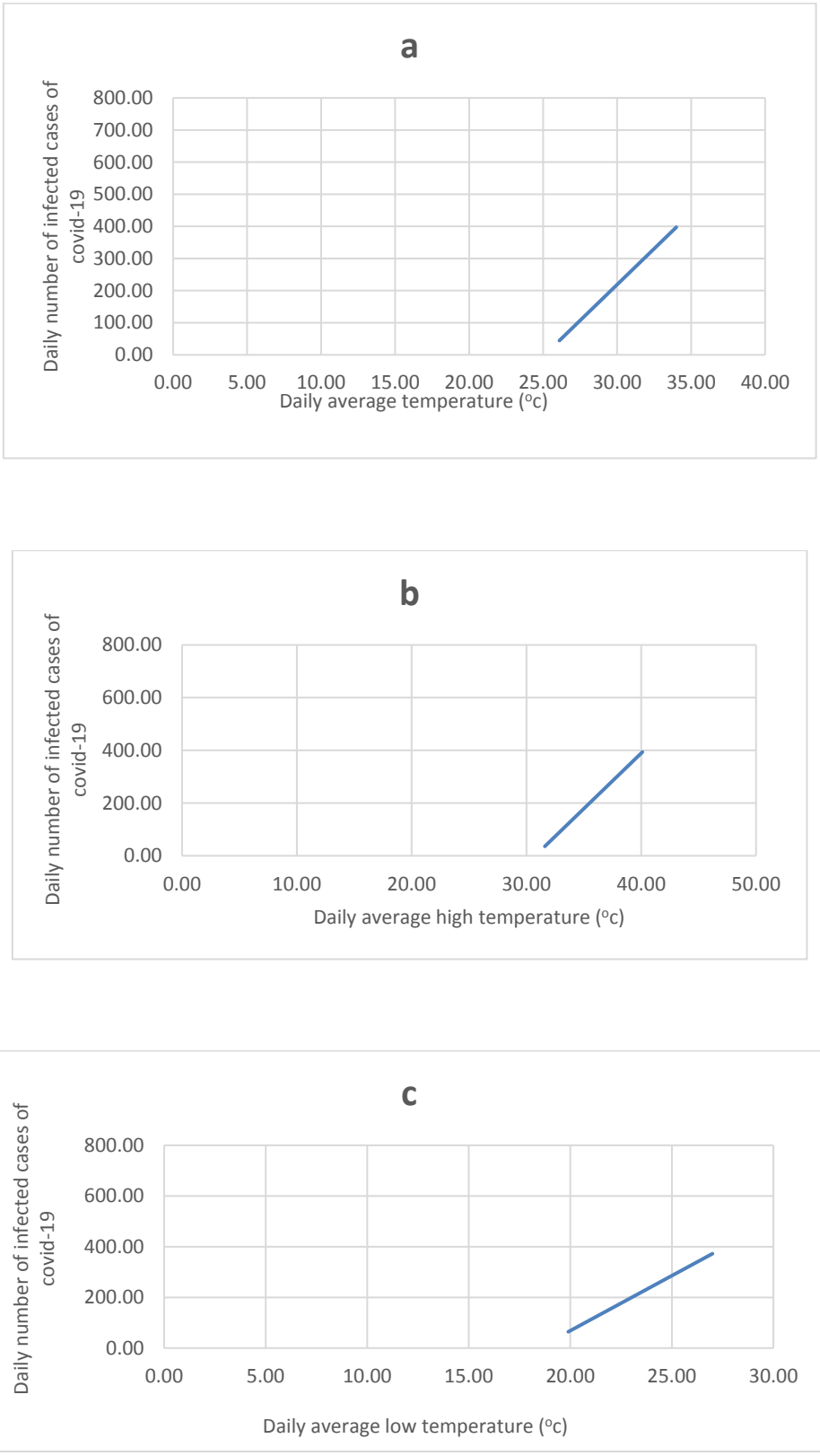

Figure (7): Correlation ship between Daily number of infected cases of covid-19 and daily average temperature measurements (a. average, b. high and c. low) in Al Riyad city in K.S.A.

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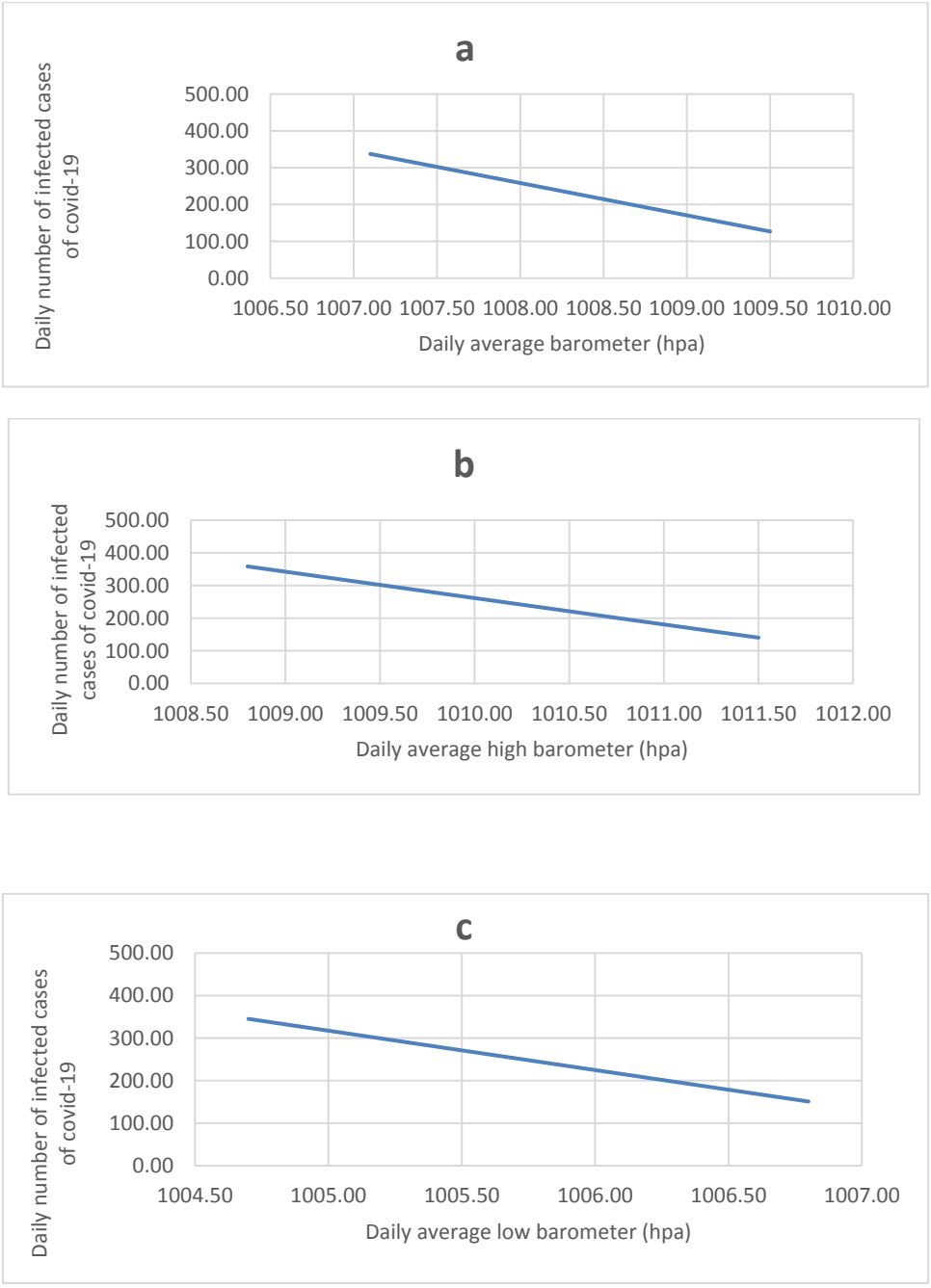


Figure (8): Correlation ship between Daily number of infected cases of covid-19 and daily average barometer measurements (a. average, b. high and c. low) in Mecca city in K.S.A.

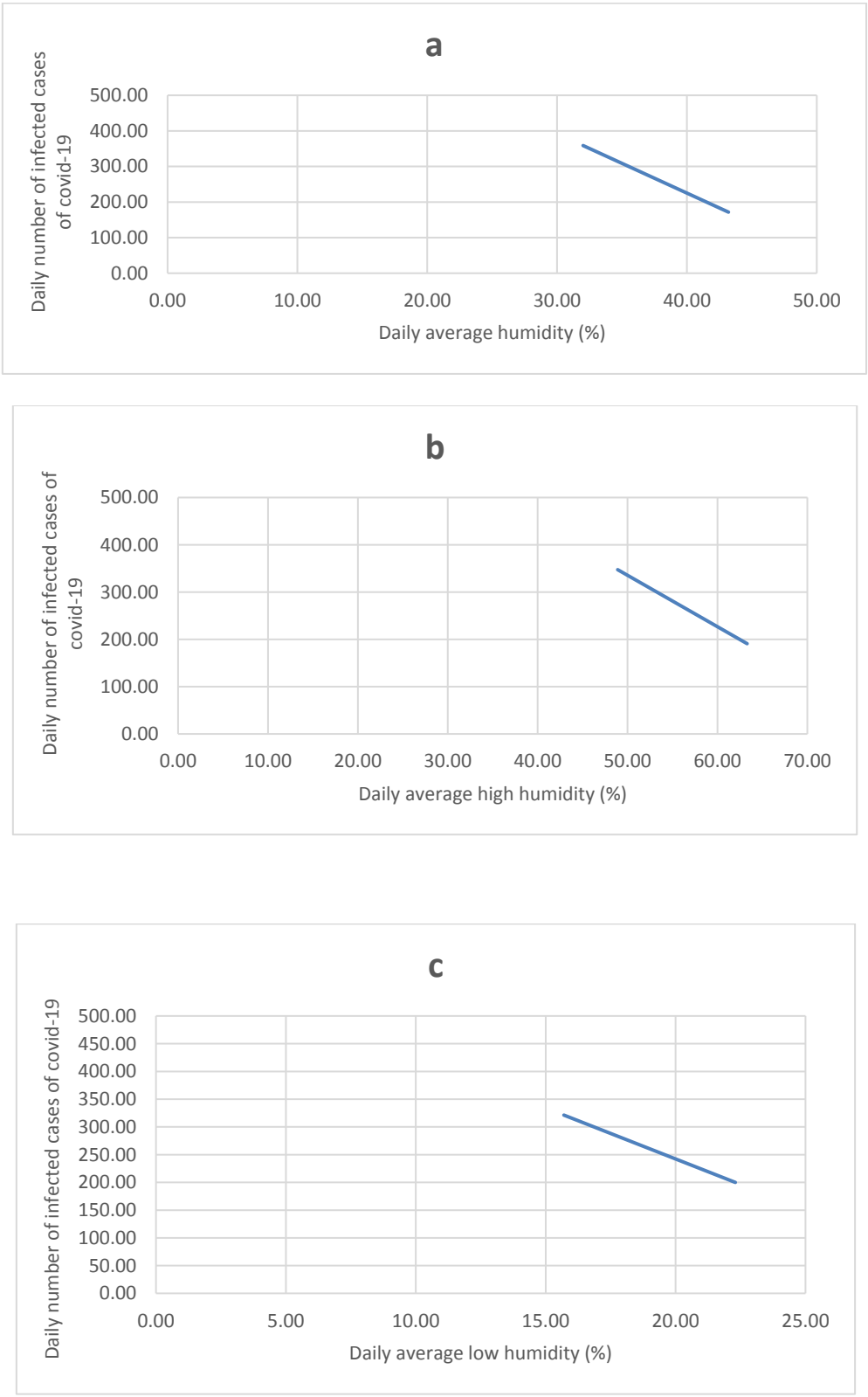
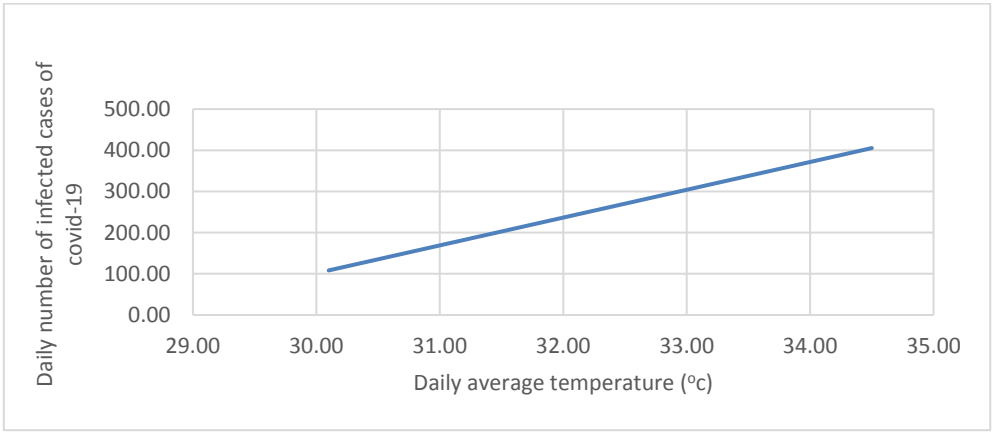
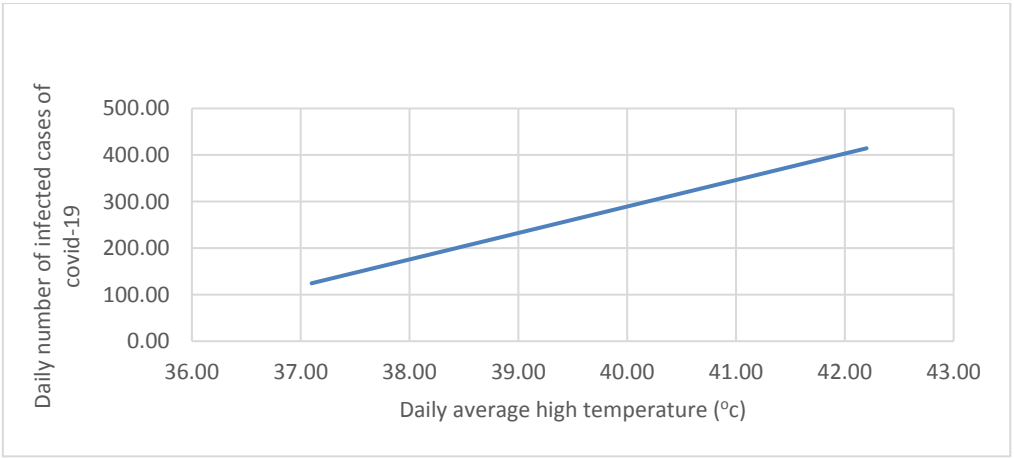


Figure (9): Correlation ship between Daily number of infected cases of covid-19 and daily average humidity measurements (a. average, b. high and c. low) in Mecca city in K.S.A.





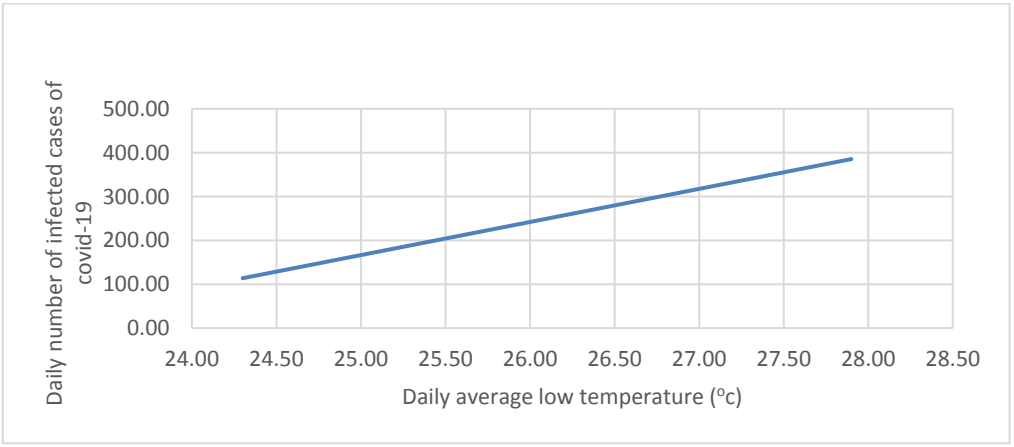


Figure (10): Correlation ship between Daily number of infected cases of covid-19 and daily average temperature measurements (a. average, b. high and c. low) in Mecca city in K.S.A.

DISCUSSION

In current study, the pattern of ecological features change provides a picture of the occurrence of COVID-19 in K.S.A. The exposure -response relationship was positive linear with temperature and negatively with barometer and humidity. In previous researches similar response was founded with temperature; Tosepeu et al. (2020) reported that temperature average was significantly correlated with COVID-19 pandemic in Jakarta; Indonesia, also the results of Jingui, et al.; 2020 in china designated that mean temperature has a positive linear relationship with the number of COVID-19 cases with a threshold of 3 °C. The results of this study had been compared to other studies in the existence and spread of other coronaviruses, like SARS-CoV and MERS-CoV (Bi et al., 2007; Casanova et al., 2010; Chan et al., 2011; Tan et al., 2005 and Van Doremalen et al., 2013) and Tan et al. (2005) found that the optimum environmental temperature related to SARS cases, therefore the current findings of this study compared with results in these studies. Besides that, Bi et al. (2007) stated that temperature had a negative relationship with SARS transmission in Hong Kong and Beijing in 2003. Also, there was a laboratory study using surrogate viruses to investigate the effect of temperature on coronavirus survival on surfaces (Casanova et al., 2010), and Van Doremalen et al. (2013) also said that MERS-CoV was less stable at high temperature. As well, previous researches that shows the relationship between weather transmission and Syncytial Virus Respiration (Vandini et al., 2013), SARS (Tan et al., 2005), temperature is also the environmental driver of the COVID-19 outbreak in China (Shi et al., 2020). Concisely the correlation coefficient is higher (r =0.70) in this study compared with that in the study by Tosepeu et al. (2020) in which the coefficient value (r = 0.39). Most studies showed that there was an optimum temperature for coronavirus and high temperature was destructive to its viability.

The decrease in humidity and barometer (air pressure) in this study increases the confirmed cases of COVID-19 in Saudi Arabia, however, both factors correlate with a higher positive (r = 0.74 and 0.52 in two cities). In previous studies we found that Tosepeu et al. (2020) did not record any statistically significant association between humidity and prevalence of covid-19, while Jaakkola et al. 2014 reported that high humidity, which is associated with low temperatures is an important factor in influenza virus transmission. In this study, regard to low humidity and air pressure leading to the spread of the epidemic, the reason may be due to the interaction of different environmental factors; as we stated before in correlations among variables; such as dew point with humidity (r = 0.48), wind speed with dew point (r = 0.41) and wind gust with dew point (r = 0.46) etc, meteorological factors such as humidity, visibility, and wind speed can affect environmental stability, or affect the survival of viruses, as well as air temperature have an impact on the transmission of the epidemic, besides, it was noted that the air temperature and humidity significantly affected the transmission of COVID-19 (Chen et al., 2020), as Ma et al., 2020, said that temperature and humidity differences may be important factors influencing the mortality rate of covid-19, also Poole, (2020) reported a correlation between the prevalence of COVID-19 on temperature and climate latitude.

The effects of different environmental factors on the incidence of COVID-19 remain to be explicated. Based on dynamical equalities, previous researchers developed susceptible exposed infectious recovered (SEIR) modeling to estimate key epidemic parameters to better characterize the mechanisms underlying the dynamics of epidemics (Chanprasopchai et al., 2017; Liu et al., 2017; Niakan et al., 2019). Current study observed the association of the

daily confirmed cases rate of COVID-19 with temperature, humidity and barometer using linear correlation and scatterplot, thus on line of recent published researches to prevent spread of COVID-19 as possible.

CONCLUSIONS

This study implicates that meteorological factors play important role in the COVID-19 transmission. The findings showed Daily number of infected cases of COVID-19 had obvious linear positive correlations with daily (average, high and low temperature) and negative correlations with daily (average, high and low) barometer and daily (average, high and low) humidity. Also, there were correlations among the metrological variables, daily average barometer had positive correlations with daily average humidity and negative correlations with daily average temperature. However, daily average humidity had positive correlations with daily average dew point and negative correlations with daily average temperature. Daily average speed wind correlated with dew point. Moreover, positive correlation between daily wind gust and average speed wind and dew point. This study indicates that the epidemic might gradually ease as a result of guidance for national and international prevention and intervention measures that target COVID-19 as well as the implementation of public health control measures.

Availability of data and materials

The data collections used and analyzed through the current study are available from the websites.

Declaration of competing interest

Ethics approval and consent to participate All data were freely available, no patient contact was made, and no individual identifiers were required. Therefore, ethical approval for the study was not required.

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REFERENCES

Anderson, R.M., Heesterbeek, H., Klinkenberg, D., Hollingsworth, T.D., 2020. How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet 395, 931–934.

Bedford, T., Riley, S., Barr, I.G., et al., 2015. Global circulation patterns of seasonal influenza viruses vary with antigenic drift. NATURE 523, 217–220. https://doi.org/10.1038/ nature14460.

Bi, P., Wang, J., Hiller, J.E., 2007. Weather: driving force behind the transmission of severe acute respiratory syndrome in China? Intern. Med. J., 37 (8) (2007), pp. 550-554, 10.1111/j.1445-5994.2007.01358.x.

Casadevall, A., 2020. Climate change brings the specter of new infectious diseases. J. Clin. Invest.J Clin Invest 130 (2), 553–555. https://doi.org/10.1172/jci135003.

Casanova, S. Jeon, W.A. Rutala, D.J. Weber, Sobsey, M.D., 2010. Effects of air temperature and relative humidity on coronavirus survival on surfaces Appl. Environ. Microbiol., 76 (2010), pp. 2712 2717, 10.1128/AEM.02291-09.

Ceccarelli, M., Berretta, M., Venanzi, R.E., et al., 2020. Differences and similarities between severe acute respiratory syndrome (SARS)-corona virus (CoV) and SARS-CoV-2. Would a rose by another name smell as sweet? Eur. Rev. Med. Pharmacol. Sci. 24, 2781–2783. https://doi.org/10.26355/eurrev_202003_20551.

Chan, J. Peiris, S. Lam, L. Poon, K. Yuen, W. Seto., 2011. The effects of temperature and relative humidity on the viability of the SARS coronavirus Adv. Virol., 2011 (2011), 10.1155/2011/734690.

Chanprasopchai, P., Pongsumpun, P., Tang, I.M., 2017. Effect of rainfall for the dynamical transmission model of the dengue disease in Thailand. Comput. Math Methods Med. 2017, 2541862. https://doi.org/10.1155/2017/2541862.

Chen, J. Guo, C. Wang, F. Luo, X. Yu, W. Zhang, J. Li, D. Zhao, D. Xu, Q. Gong., 2020. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records Lancet, 395 (2020), pp. 809-815, 10.1016/S0140-6736(20)30360-3.

Dalziel, B.D., Kissler, S., Gog, J.R., Viboud, C., Bjørnstad, O.N., Metcalf, C.J.E., et al., 2018. Urbanization and hu.

Davis, R.E., McGregor, G.R., Enfield, K.B., 2016. Humidity: A review and primer on atmospheric moisture and human health. Environ. Res.Environ Res 144 (Pt A), 106–116. https://doi.org/10.1016/j.envres.2015.10.014.

Gale, P., Brouwer, A., Ramnial, V., et al., 2010. Assessing the impact of climate change on vector-borne viruses in the EU through the elicitation of expert opinion. Epidemiol. Infect.Epidemiol Infect 138 (2), 214–225. https://doi.org/10.1017/ s0950268809990367.

Holshue, M.L., DeBolt, C., Lindquist, S., Lofy, K.H., Wiesman, J., Bruce, H., et al., 2020. First case of 2019 novel coronavirus in the United States. N. Engl. J. Med.

Jaakkola, K., Saukkoriipi, A., Jokelainen, J., Juvonen, R., Kauppila, J., Vainio, O., Ikäheimo, T.M., 2014. Decline in temperature and humidity increases the occurrence of influenza in cold climate. Environ. Health 13 (1), 22.

Jingui Xie and Yongjian Zhu., 2020. Association between ambient temperature and COVID-19 infection in122 cities from China. Science of the Total Environment 724(2020) 138201.

Lemaitre, J., Pasetto, D., Perez-Saez, J., et al., 2019. Rainfall as a driver of epidemic cholera: comparative model assessments of the effect of intra seasonal precipitation events. Acta Trop. 190, 235–243. https://doi.org/10.1016/j.actatropica.2018.11.013.

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., et al., 2020. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. N. Engl. J. Med.

Li, Y., Huang, X., Yu, I.T., et al., 2005. Role of air distribution in SARS transmission during the largest nosocomial outbreak in Hong Kong. Indoor Air 15, 83–95. https://doi.org/10.1111/j.1600-0668.2004.00317.x.

Liu, T., Zhu, G., He, J., et al., 2017. Early rigorous control interventions can largely reduce dengue outbreak magnitude: experience from Chaozhou, China. BMC Public Health 18, 90. https://doi.org/10.1186/s12889-017-4616-x.

Lofgren, E., Fefferman, N.H., Naumov, Y.N., et al., 2007. Influenza seasonality: underlying causes and modeling theories. J. Virol.J Virol 81 (11), 5429–5436. https://doi.org/ 10.1128/jvi.01680-06.

Luo, W., Majumder, M.S., Liu, D., et al., 2020. The role of absolute humidity on transmission rates of the COVID-19 outbreak. medRxiv, 2020.2002.2012.20022467 https://doi.org/10.1101/2020.02.12.20022467.

Ma, Y. Zhao, J. Liu, X. He, B. Wang, S. Fu, B. Luo., 2020. Effects of temperature variation and humidity on the death of COVID-19 in Wuhan, China Sci. Total Environ. (2020), Article 138226, 10.1016/j.scitotenv.2020.138226.

Niakan, K.S., Ghazisaeedi, M., Azizi, R., et al., 2019. Studying the influence of mass media and environmental factors on influenza virus transmission in the US Midwest. Public Health 170, 17–22. https://doi.org/10.1016/j.puhe.2019.02.006.

Oliveiros, B., Caramelo, L., Ferreira, N.C., et al., 2020. Role of Temperature and hUmidity in the mOdulation of the Doubling Time of COVID-19 Cases. medRxiv. https://doi.org/ 10.1101/2020.03.05.20031872 2020.2003.2005.20031872.

Park, J.E., Son, W.S., Ryu, Y., et al., 2020. Effects of temperature, humidity, and diurnal temperature range on influenza incidence in a temperate region. Influenza Other Respir. VirusesInfluenza Other Respir Viruses 14 (1), 11–18. https://doi.org/10.1111/irv.12682.

Perlman, S., 2020. Another decade, another coronavirus. Mass Medical Soc.

Poole, L., 2020. Seasonal Influences on the Spread of SARS-CoV-2 (COVID19), Causality, and Forecastabililty (3-15-2020). Causality, and Forecastabililty (3-15-2020). (March 15, 2020)

Shaman, J., Goldstein, E., Lipsitch, M., 2011. Absolute humidity and pandemic versus epidemic influenza. Am. J. Epidemiol.Am J Epidemiol 173 (2), 127–135. https://doi.org/ 10.1093/aje/kwq347.

Shaman, J., Pitzer, V.E., Viboud, C., et al., 2010. Absolute humidity and the seasonal onset of influenza in the continental United States. PLoS Biol.PLoS Biol 8 (2), e1000316. https://doi.org/10.1371/journal.pbio.1000316.

She, J., Jiang, J., Ye, L., et al., 2020. 2019 novel coronavirus of pneumonia in Wuhan, China: emerging attack and management strategies. Clin. Transl. Med. 9, 19. https://doi.org/ 10.1186/s40169-020-00271-z.

Shi, P., Dong, Y., Yan, H., Li, X., Zhao, C., Liu, W., et al., 2020. The Impact of Temperature and Absolute Humidity on the Coronavirus Disease 2019 (COVID-19) Outbreak-Evidence from China. medRxiv

Sohrabi, C., Alsafi, Z., O'Neill, N., Khan, M., Kerwan, A., Al-Jabir, A., et al., 2020. World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19). Int. J. Surg.

Sooryanarain, H., Elankumaran, S., 2015. Environmental role in influenzavirus outbreaks. Annu. Rev. Anim. Biosci. 3, 347–373. https://doi.org/10.1146/annurev-animal- 022114-111017.

Stott, P., 2016. CLIMATE CHANGE. How climate change affects extreme weather events. Science 352 (6293), 1517–1518. https://doi.org/10.1126/science.aaf7271.

Strangeways, Ian (2000). Measuring the Natural Environment. Cambridge University Press, p. 92.

Tamerius, J.D., Shaman, J., Alonso, W.J., et al., 2013. Environmental predictors of seasonal influenza epidemics across temperate and tropical climates. PLoS Pathog. 9, e1003194. https://doi.org/10.1371/journal.ppat.1003194.

Tan, L. Mu, J. Huang, S. Yu, B. Chen, J. Yin., 2005. An initial investigation of the association between the SARS outbreak and weather: with the view of the environmental temperature and its variation J. Epidemiol. Community Health, 59 (2005), pp. 186-192, 10.1136/jech.2004.020180 CrossRefView Record in ScopusGoogle Scholar

Tosepu, J. Gunawan, D.S. Effendy, L.O.A.I. Ahmad, H. Lestari, H. Bahar., Asfian, P., 2020. Correlation between weather and COVID-19 pandemic in Jakarta, Indonesia Sci. Total Environ. (2020), Article 138436, 10.1016/j.scitotenv.2020.138436.

Van Doremalen, T. Bushmaker, V., 2013. Munster Stability of Middle East respiratory syndrome coronavirus (MERS-CoV) under different environmental conditions Eurosurveillance, 18 (2013), Article 20590 http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=20590.

Vandini, S., Corvaglia, L., Alessandroni, R., Aquilano, G., Marsico, C., Spinelli, M., et al., 2013. Respiratory syncytial virus infection in infants and correlation with meteorological factors and air pollutants. Ital. J. Pediatr. 39 (1).

Wang, Y., Wang, Y., Chen, Y., Qin, Q., 2020. Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. J. Med. Virol.

Wu, J.T., Leung, K., Leung, G.M., 2020. Now casting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. LANCET 395, 689–697. https://doi.org/10.1016/S0140-6736(20) 30260-9.

Wu, Z., McGoogan, J.M., 2020. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72,314 cases from the Chinese Center for Disease Control and Prevention. JAMA https://doi.org/ 10.1001/jama.2020.2648.

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., et al., 2019. A novel coronavirus from patients with pneumonia in China. N. Engl. J. Med. 2020.