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PATTERNS OF CORONAVIRUS DISEASE-19 IN SAUDI ARABIA COMPARED TO OTHER GULF COUNTRIES AND MOST INFECTED COUNTRIES IN THE WORLD DURING THE FIRST FIVE MONTHS OF THE PANDEMIC

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ABSTRACT

Variable Coronavirus disease-19 epidemic patterns were observed across the globe, the growth of the disease starts exponentially, then changes from a trend to another. This study aimed at analyzing and comparing growth, recovery, and death patterns of Coronavirus disease-19 among the selected countries.

Data from several websites and dashboards were collected. The numbers of new cases, cases/million population, doubling time, and case-fatality rates, and recovery rates from Saudi Ariba were compared to the remaining Gulf Countries and the most three infected countries in the world (United States, Brazil, and Russia).

Results showed that the total confirmed cases in Saudi Arabia were 201801, Qatar 98653, Bahrain 28410, while cases/million in Saudi Ariba were 5988, Qatar 35487, Bahrain 18212 cases. Regarding the growth doubling time in May in Saudi Arabia was 23.6 days, in the United Arab Emirates 35.6, Bahrain18.3, Qatar14.9, United States 46, Brazil 12.2, and Russia 28 days. Growth percentages and growth factors statistically showed no significant differences among the countries. In May, the case fatality rates were as follows: Saudi Arabia (0.59%), Bahrain (0.16%), Qatar (0.06%), United States (0.89%), Brazil (5.46%), and Russia (0.99%). In June, the reported recovery rates were as follows: Saudi Arabia (68.74%), United Arab Emirates (68%), Bahrain (72.66%), Oman (43.46%), Qatar (76.08%), United States (28.38%), Brazil (56.25%), and Russia (56.79%).

The study concluded that the pattern in Saudi Arabia is comparable to the other gulf countries in the growth percentage, growth factor, doubling time, and case fatality rate; the only found difference was the number of cases/million of populations. Upon excluding Saudi Arabia, Gulf countries have a higher number of cases/million population than the United States, Brazil, and Russia. Moreover, Saudi Arabia reported a lower case-fatality rate and doubling time compared to the United States and Brazil.

KEYWORD: ***COVID-19, epidemic curve, KSA Pattern, Gulf trend***

INTRODUCTION

In December 2019, an outbreak of pneumonia of unknown etiology was detected in Wuhan city, Hubei Province of China. Laboratory investigations proved that; it was caused by a newbie coronavirus later named Severe acute respiratory syndrome coronavirus 2 (SARS-COV-2).[1]

Coronaviruses are a group of viruses known to cause Severe Acute Respiratory Syndrome (SARS) and Middle Eastern Respiratory Syndrome (MERS).[2] This novel virus manifested itself in different clinical and epidemiological outcomes across the world. The global numbers hide the differences between the countries because it appears eventually as a total sum.[3] Thus the exact numbers per country are needed in the comparison.

Furthermore, the available data shows a considerable variation in trends of Coronavirus disease COVID-19 infection, which can be attributed to variation in age, sex, race, underline health condition, viral doses, viral strains, individual infectivity, and environmental factors. Therefore, the comparison of variations is a crucial step, in the way of exploring the natural history of any new infection.[2,4]

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COVID-19 epidemic curves continue as exponential, logarithmic, or as linear growth of the cases, however, a change from one trend to another was observed in the same curve. For this reason, epidemiologists tried to apply mathematical models to forecast the epidemic curves of this ailment.[5,6]

The epidemic curves are time-related plots of numbers of cases versus units of time (days, weeks, or months). On analyzing of an epidemic curve, a steep-up trend indicates a point-source infection in which infected cases have been exposed to one source within one incubation period.[7,8] On the other hand, irregular propagated curves reflect person to person spread, i.e., the first wave is a source that initiates the second wave of the infection.[8-9]

The methods used in monitoring the degree of acceleration/deceleration of growth in epidemic include the following parameters:

1) Growth rates (the amount of change within a unit of time).

2) Dispersity ratio (the factor by which a population multiplies itself over unites of time) mathematically known as Growth factors

4) Growth reproductive time R_o: (the number of secondary infected cases caused by the primary infectious ones)

3) Growth doubling time (the time needed for infected cases to double in size).[10,11]

The severity of epidemics could be estimated by finding the case-fatality rate (ratio of the total number of deaths to the total number of confirmed cases), besides, calculating the recovery rate (the ratio of total numbers of recovered cases to the total number of confirmed cases).[12,13]

OBJECTIVES OF THE STUDY

The aim of this study is 1). To analyze the epidemic growth curves, recoveries, and fatality patterns of COVID-19 in Saudi Arabia compared to neighboring Gulf countries and selected topmost infected countries in the world. 2). To monitor COVID-19 growth acceleration and deceleration, and percentages of changes over time in Saudi Arabia compared to the countries as mentioned earlier.

METHODOLOGY

This study is an observational a trend-descriptive one, in which COVID-19 data from Saudi Arabia, other Gulf countries, and three of the most infected countries in the world were collected. By Gulf countries, we mean [Kingdom of Saudi Arabia (KSA), United Arab Emirate (UAE), Kuwait (KWT), Oman (OMN), Bahrain (BAH), Qatar (QAT)], and by the three most infected countries in the world, we mean countries revealed the highest numbers at the end of the study [United States of America (USA), Brazil (BRA) and Russia (RUS)]. This study started on the 1/2/2020 when the first cases COVID-19 appeared in the gulf region and continued for five months. During which a seven-day-rolling of data over twenty-two weeks was performed. After that, the retrieved data from the world health organization (WHO),[14] (Saudi Arabia, and UAE) ministry of health websites [15-16] were recorded in Excel sheets. The collected parameters include the following: a weekly absolute number of new cases, weekly numbers of cases per a million population, along with a weekly doubling time (in days), and monthly case fatality rates, and monthly recovery rates. Microsoft XLS, version 365, was used for saving the data and performing the statistical analysis. Epidemic curves were created, in which confirmed new cases were plotted against units of time (weeks) for easy comparison of patterns across the selected countries. After that, some of the data of the study was demonstrated in tables or figures.

Furthermore, a weekly growth percentage of the new cases, growth factors, and weekly doubling time were calculated. Then, the average of weekly doubling time in each month was obtained. A case fatality and recovery rates up to the latest point of each month were also calculated.

The following formulas were used for calculating the parameters of the study:

1. **Weekly percentage of growth** = (Number of new cases – Numbers of the previous week) /Numbers of the previous week. X 100.
2. **Weekly Dispersity ratio** (Growth Factor) = number of new cases /Numbers of the previous week. (i.e., less than one in decay, more than one in growth).
3. **Case Fatality Rate % (CFR)** = (Number of deaths due to COVID-19/ Number of confirmed cases of COVID-19) ×100.
4. **Recovery Rate % (RR)** = (Number of cases recovered from COVID-19/ Number of confirmed cases of COVID-19) ×100.
5. **Weekly growth doubling time** = (Counting the actual number of days in which confirmed cases of each week are doubled in their size).

Consequently, data from Saudi Ariba were compared to data of the remaining Gulf countries, and the most three infected countries in the world (USA, Brazil, and Russia). One-way ANOVA test in Excel is used to analyze the statistical differences in percentages of growth, and growth factors, and the doubling time of COVID-19 among these countries.

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RESULTS

The number of cases and the epidemic curves:

The COVID-19 epidemic curves of KSA and the other Gulf countries started on 1/2/2020 and going on for twenty-two weeks (five months), in which daily new cases were rolled as the weekly numbers. On examining the curves, a short lag phase in UAE curve started in February, after which growth accelerated exponentially in all the countries of the study in March, followed by a logarithmic to linear phase in (April, May, and June). in the last three weeks of June, however, there is slightly rising in KSA curve **(Fig. 1).**

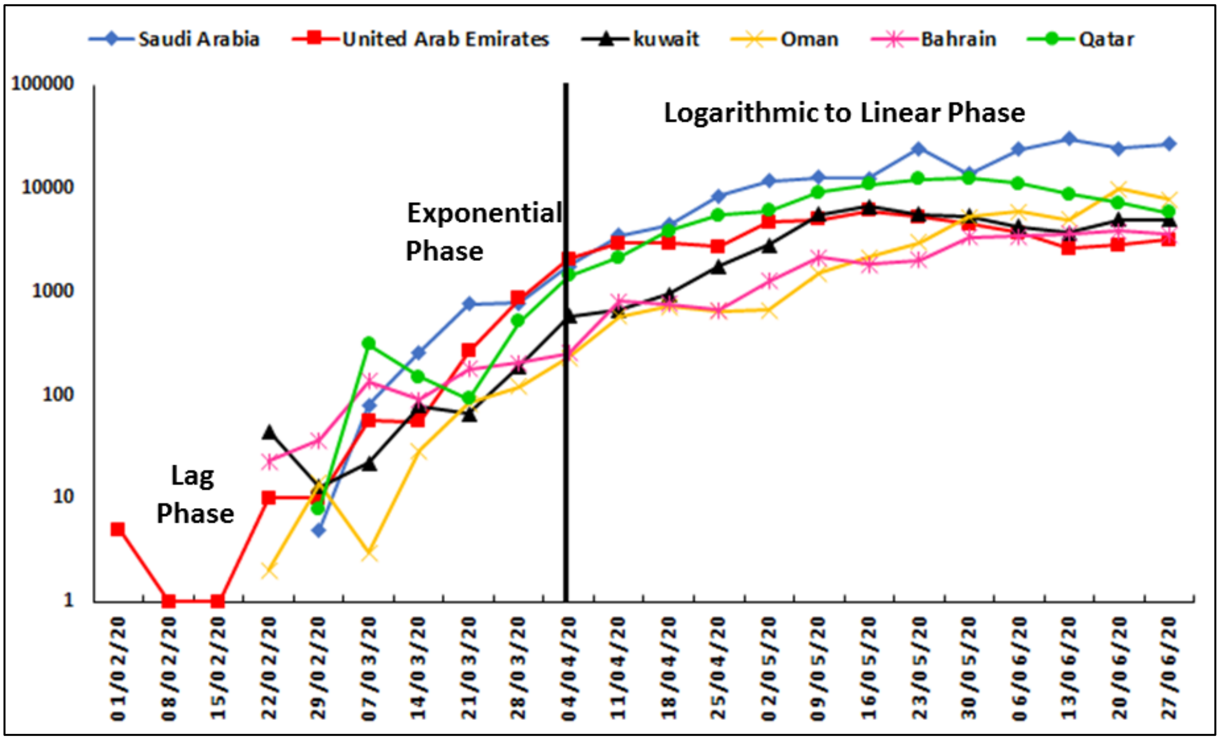

Fig. 1- New Cases of COVID-19/Week in the Gulf Countries (logarithmic scale)

On the other hand, the KSA curve is also compared to the USA, Brazil, and Russia. In February, the growth started as a short lag phase in the USA curve, followed by acceleration as an exponential growth phase in March in all these countries. After that in April, May, and the first two weeks of June, a logarithmic to a linear growth phase appears in the USA, brazil Russia and KSA curves, in the last two weeks of June, a slight rising in USA and brazil curves appears while the remaining countries curves continued on their previous patterns **(Fig. 2).**

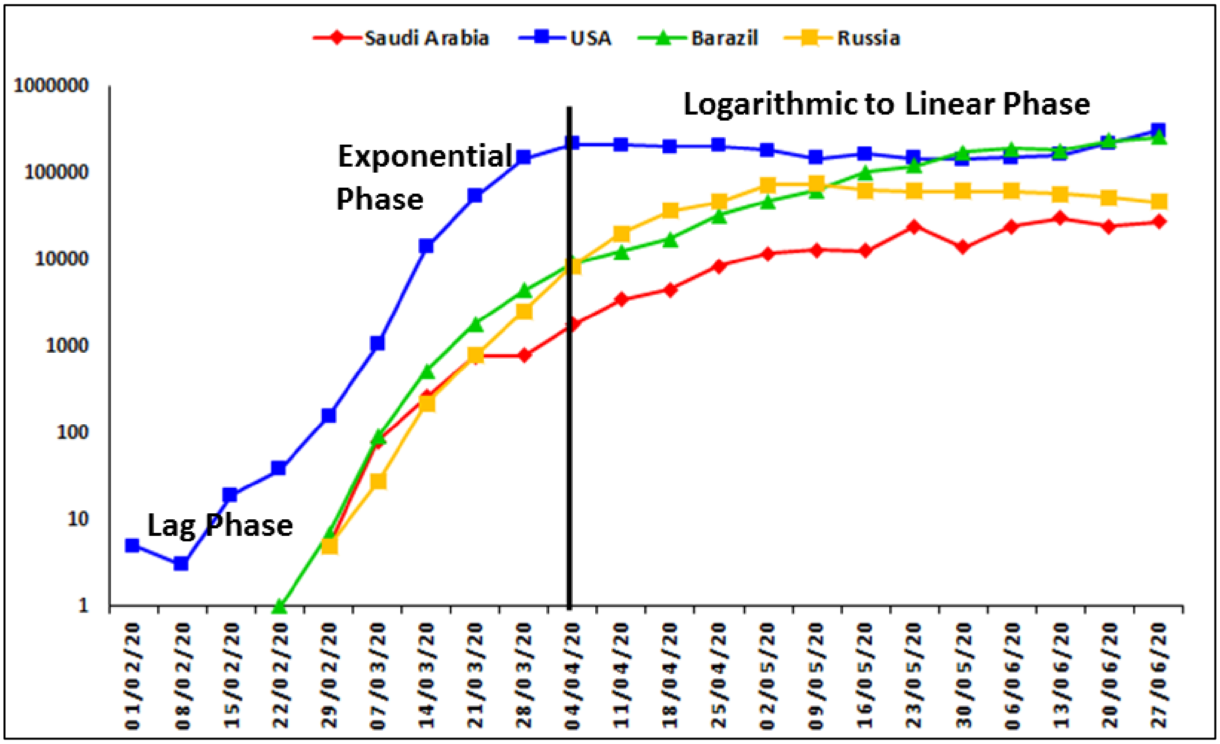

Fig. 2- The New Cases per Week in KSA, RUS, BRA, and USA (logarithmic scale)

At the end of the twenty-second week of the study, the reported numbers of COVID-19 cases in the selected countries were as follows: KSA 201801 cases, UAE 50141, Qatar 98653, Bahrain 28410, Oman 43929, USA 2788395, Brazil 1539081, and Russia 666941 cases. Also, the number of case/million of the population were recorded at the end of the study which was as following: KSA 5988 cases, UAE 5207, Qatar 35487, Bahrain 18212, Oman 9114, USA 8496, Brazil 7346, and Russia 4616 cases **(Table 1).**

Table 1- Number of Case/Million of the Population at the End of the Study

Country	*Population*/Million (2018) *	*Number* of Total Cases	*Number of Case/Million*
Kingdom of Saudi Arabia	33.7	201801	5988
United Arab of Emirates	9.63	50141	5207
Kuwait	4.13	48672	11785
Bahrain	1.56	28410	18212
Oman	4.82	43929	9114
Qatar	2.78	98653	35487
United States of America	328.2	2788395	8496
Brazil	209.5	1539081	7346
Russia	144.5	666941	4616

*Adopted from world meter web site.[17]

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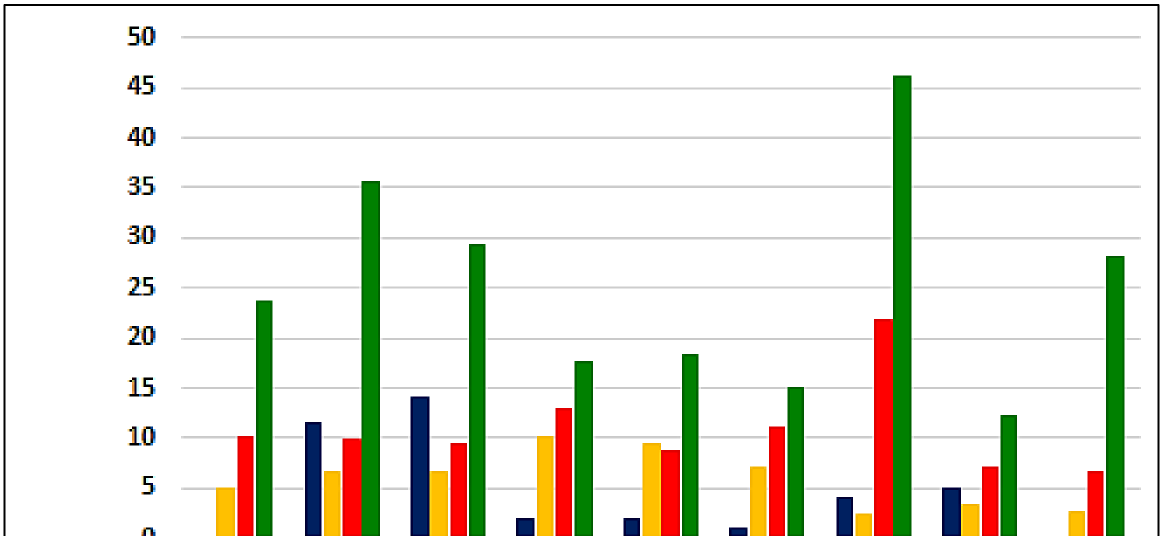
Doubling time

The average weekly doubling times of cases (in days) in February to May was as follows. In February, no recorded cases in KSA and Russia, hence no doubling time. However, in UAE, the doubling time was 11.5 days, Kuwait 14, Oman 2, Bahrain 2, Qatar 1, USA 4, and Brazil 5 days. In March, the doubling time in KSA was five days, UAE 6.5, Kuwait 6.7, Oman 10, Bahrain 9.3, Qatar 7, USA 2.5, Brazil 3.3, and Russia 2.6 days. In April, KSA doubling time was 10.1, UAE 9.8, Kuwait 9.4, Oman 12.9, Bahrain 8.8, Qatar 11.1, USA 21.8, Brazil 7, and Russia 6.6 days. Lastly, in May, the KSA doubling time was 23.6 days, in UAE 35.6, Kuwait 29.3, Oman 17.6, Bahrain18.3, Qatar14.9, USA 46, Brazil 12.2, and Russia 28 days. The number of cases in June has not finished its doubling yet (**Fig. 3).**



	KSA	UAE	KWT	OMN	BAH	QAT	USA	BRA	RUS
February	0	11.5	14	2	2	1	4	5	0
March	5	6.5	6.7	10	9.3	7	2.5	3.3	2.6
April	10.1	9.8	9.4	12.9	8.8	11.1	21.8	7	6.6
May	23.6	35.6	29.3	17.6	18.3	14.9	46	12.2	28

Fig. 3- Weekly Doubling Time (in days), Rolled as Average in (February-May)

Percentages of growth and growth factors

A weekly percentage of new growth and growth factor (ratio of dispersity, i.e., new week: previous week growth), both the parameters are recorded over weeks, i.e., week 1 to week 22. The positive value in the table represents growth acceleration, and the negative value represents growth deceleration growth trends, the growth factor values were calculated and displayed in the next column **(Table 2).**

A weekly growth percentages in KSA pattern shows a deceleration in weeks 17th, and 21st with a growth factor of 0.85, and 0.98, respectively, in UAE, the trend of growth percentage shows a deceleration in weeks 2, 7, 13, 17, 18, 19 and 20, with growth factors of 0.20, 0.98, 0.92, 0.87, 0.86, 0.82, 0.70 consecutively. Regarding Kuwait pattern, growth percentage shows deceleration in weeks 5, 8, 17, 18, 19, 20 and 22, and a growth factor of 0.29, 0.84, 0.84, 0.97, 0.79, 0.86, 0.99, consecutively. Concerning Bahrain pattern, growth percentages shows deceleration in weeks 7, 11, 12, 13, 16 and 22, with a growth factor of 0.67, 0.94, 0.87, 0.86, 0.93 consecutively. In Oman pattern, there is deceleration in weeks 7, 11, 12, 13, 16 and 22, with a growth factor of 0.21, 0.91, 0.84, 0.79, respectively. Qatar shows deceleration in weeks 7, 8, 19, 20, 21 and 22, and a growth factor of 0.5, 0.6, 0.9, 0.8, 0.8, 0.8 consecutively. In USA, the pattern revealed deceleration in weeks 2, 11, 12, 14, 15, 17, and 18, with a growth factor of 0.6, 0.97, 0.95, 0.87, 0.80, 0.89, 0.97, respectively. Brazil pattern reported a deceleration only in the 20th week with a growth factor of 0.97. As regards to Russia, the trend shows a deceleration in weeks 16, 17, 19, 20, 21, and 22, with a growth factor of 0.84, 0.96, 0.99, 0.93, 0.89, 0.89 consecutively. We performed a one-way ANOVA test to analyze the statistical differences in the weekly growth percentages and growth factors. To synchronize the starting point of the pandemic, we have excluded the first six-week from the analysis. The statistical results showed no significant differences among the countries (**Table 2).**

	KSA		UAE		KWT		BAH		OMN		QAT		USA		BRA		RUS	
	%	GF	%	GF	%	GF	%	GF	%	GF	%	GF	%	GF	%	GF	%	GF
W1	0	0.00	0	0.0	0	0.00	0	0.00	0	0.00	0	0.00	0	5.00	0	0.00	0	0.00
W2	0	0.00	-80	**0.20**	0	0.00	0	0.00	0	0.00	0	0.00	-40	**0.60**	0	0.00	0	0.00
W3	0	0.00	0	1.00	0	0.00	0	0.00	0	0.00	0	0.00	533	6.33	0	0.00	0	0.00
W4	0	0.00	900	10.0	0	0.00	0	0.00	0	0.00	0	0.00	100	2.00	0	0.00	0	0.00
W5	0	0.00	0%	1.00	-71	**0.29**	61	1.61	600	7.00	0	0.00	308	4.07	600	7.00	0	0.00
W6	1600	17	460	5.60	69	1.69	265	3.65	-79	**0.21**	3800	39.0	578	6.78	1186	12.85	440	5.40
W7	295	3.95	-2	**0.98**	259	3.59	-33	**0.67**	867	9.67	-52	**0.48**	1228	13.27	481	5.81	711	8.11
W8	217	3.17	382	4.81	-16	**0.84**	101	2.01	186	2.86	-39	**0.61**	281	3.80	246	3.46	258	3.57
W9	44	1.44	224	3.24	191	2.91	14	1.14	46	1.46	458	5.57	173	2.73	143	2.42	221	3.20
W10	90	1.90	144	2.44	200	3.00	23	1.23	92	1.92	180	2.80	46	1.46	106	2.06	233	3.33
W11	106	2.05	40	1.40	15	1.15	222	3.22	152	2.52	50	1.49	-3	**0.97**	36	1.36	140	2.40
W12	65	1.64	1	1.01	44	1.44	-6	**0.94**	23	1.23	80	1.79	-5	**0.95**	41	1.40	82	1.82
W13	73	1.73	-7	**0.92**	84	1.84	-13	**0.87**	-9	**0.91**	44	1.44	4	1.04	86	1.85	25	1.25
W14	46	1.45	72	1.72	61	1.61	92	1.92	1	1.01	10	1.09	-12	**0.87**	45	1.45	60	1.60
W15	8	1.07	6	1.05	100	2.00	68	1.68	128	2.27	51	1.51	-19	**0.80**	35	1.35	2	1.02
W16	5	1.04	20	1.20	19	1.19	-14	**0.86**	43	1.43	20	1.19	12	1.12	61	1.60	-15	**0.84**
W17	-14	**0.85**	-13	**0.87**	-16	**0.84**	11	1.11	40	1.39	12	1.12	-10	0.89	17	1.17	-4	**0.96**
W18	1	1.01	-13	**0.86**	-3	**0.97**	66	1.66	74	1.74	1	1.01	-3	0.97	43	1.43	2	1.01
W19	55	1.55	-18	**0.82**	-21	**0.79**	1	1.01	14	1.13	-12	**0.88**	6	1.05	9	1.09	-1	**0.99**
W20	40	1.40	-30	**0.70**	-14	**0.86**	6	1.06	-16	0.83	-20	**0.79**	6	1.06	-3	**0.97**	-6	**0.93**
W21	-1	**0.98**	7	1.06	35%	1.35	7	1.07	99	1.98	-17	**0.82**	36	1.30	27	1.27	-10	**0.89**
W22	13	1.12	12	1.12	-1	**0.99**	-7	**0.93**	-21	0.79	-20	**0.79**	40	1.39	12	1.11	-11	**0.89**

Table 2- Weekly Percentages (%) of Growth Rates and Growth Factors (GF)

ANOVA test for percentage: P-value: 0.8340

ANOVA test for GF: P-value: 0.841

*Yellow and red digits mean deceleration from the previous week

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Case fatality and Recovery rates

Table 3 displays the monthly case fatality rates for the five months of the study. In February, no reported deaths. In March, the case fatality rates per countries were as follows: KSA (0.27%), UAE (0.27%), Kuwait (0.0%), Bahrain (0.61%), Oman (0.0%), Qatar (0.0%), USA (1.85%), Brazil (1.49%), and Russia (0.3%). In April, the case fatality rates per countries were as follows: KSA (1.06%), UAE (0.67%), Kuwait (0.33%), Bahrain (0.44%), Oman (0.51%), Qatar (0.1%), USA (1.86%), Brazil (5.46%), and (0.88%) in Russia. In May, the case fatality rates per countries was as follows: KSA (0.59%), UAE (0.91%), Kuwait (0.72%), Bahrain (0.16%), Oman (0.46%), Qatar (0.06%), USA (0.89%), Brazil (5.46%), and Russia (0.99%). in June, the case fatality rates were as follows: KSA (0.78%), UAE (0.67%), Kuwait (0.79%), Bahrain (0.25%), Oman (0.44%), Qatar (0.17%), USA (0.36%), Brazil (4.86%), and Russia (1.36%).

Table 3 displays the monthly recovery rates of COVID-19 across the countries of the study. In February, the recorded recovery rates were as follows: UAE (35.38%), USA (22.26%). In March, the reported recovery rates were as follows: KSA (1.66%), UAE (18.24%), Kuwait (10.72%), Bahrain (28.25%), Oman (25.6%), Qatar (2.44%), USA (1.36%), Brazil (0.142%), and Russia (14.33%). In April, the recorded recovery rates were as the following: KSA (15.76%), UAE (15.98%), Kuwait (21.32%), BAH (28.25%), Oman (19.99%), Qatar (9.46%), USA (9.58%), Brazil (31.84%), and Russia (8.46%). In May, the recorded recovery rates were as follows: KSA (45.1%), UAE (39.35%), Kuwait (31.88%), Bahrain (47.24%), Oman (28.33%), Qatar (2055%), USA (19.66%), Brazil (44.59%), and Russia (26.99%). Moreover, in June, the reported recovery rates were as follows: KSA (68.74%), UAE (68%), Kuwait (73.55%), Bahrain (72.66%), Oman (43.46%), Qatar (76.08%), USA (28.38%), Brazil (56.25%), and Russia (56.79%).

Table 3- Monthly Case Fatality and Recovery Rates in the Study

Country	RR/Month CFR/Month	February	March	April	May	June
KSA	**RR**	0.0%	1.66%	15.76%	45.1%	68.74%
	CFR	0.0	0.27%	1.06%	0.59%	0.78%
UAE	**RR**	35.38%	18.24%	15.98%	39.35%	68%
	CFR	0.0%	0.27%	0.67%	0.91%	0.67%
KWT	**RR**	0.0%	10.72%	21.32%	31.88%	73.55%
	CFR	0.0%	0.00%	0.33%	0.72%	0.79%
BAH	**RR**	0.0%	28.25%	50 %	47.24%	72.66%
	CFR	0.0%	0.61%	0.44%	0.16%	0.25%
OMN	**RR**	0.0%	25.60%	19.99%	28.33%	43.46%
	CFR	0.0%	0.00%	0.51%	0.46%	0.44%
QAT	**RR**	0.0%	2.44%	09.46%	20.55%	76.08%
	CFR	0.0%	0.00%	0.10%	0.06%	0.17%
USA	**RR**	22.26%	1.36%	9.58%	19.66%	28.38%
	CFR	0.0%	1.85%	1.86%	0.89%	0.36%
BRA	**RR**	0.0%	0.14%	31.84%	44.59%	56.25%
	CFR	0.0%	1.49%	5.60%	6.62%	4.86%
RUS	**RR**	0.0%	14.33%	8.46%	26.99%	56.79%
	CFR	0.0%	0.30%	0.88%	0.99%	1.36%

RR: Recovery rat, CFR: case fatality rate

DISCUSSION

Comparing data of COVID-19 among affected countries is a hectic and a complicated process, not only because of variations in population size, but also variations in the density of infection, and the different starting dates of the epidemic.[18] Data approximation and rolling approach is an appropriate method for comparing data among the countries. Thus, a weekly and monthly rolling approach is performed in this study.[19]

Curve patterns and numbers

In the Kingdom of Saudi Arabia, the epidemic curve pattern is comparable to the curves in the remaining Gulf countries and the most affected countries of the world. COVID-19 curve started as exponential growth in March, but in April, May, and June, it changed to a logarithmic and linear phase with few variations among the countries see (Fig. 1&2). Using daily absolute numbers for comparison reflects only a visible part of the picture, but for the full scene, the population size should be considered.[18] At the end of

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this study, 201801 cases were reported in the KSA, which is the highest absolute number in the Gulf region. Surprisingly, this number makes 5207 cases/million, which is the lowest number per million of the population in the region. The number/million of cases in each of the USA, Brazil, and Russia are far below the numbers reported in the Gulf countries, except in KSA. Qatar, an example of the Gulf countries that recorded 35487 case/million, far exceeds the numbers reported in the most affected countries of the world (USA, Brazil, and Russia), which recorded 8496, 7346, and 4616 case/million, respectively. KSA, unlike the other gulf countries, revealed a comparable figure of case/million to the USA, Brazil, and Russia (**Table 1).** It seems that KSA has a different profile from the remaining gulf countries regarding this point.[20] This finding is an unexplainable, but one plausible reason may be the less density of population/kilometer of KSA in comparison to the other Gulf countries.[17]

Growth percentages and Growth Factors

For comparing trends of growth in this study, we have calculated both the percentages of growth and the growth factors. These two parameters provide us with a simple comparison tool and a quick method of measuring the dispersity of the epidemy.[19,21] However, there are several limitations when using both the parameters mentioned above, e.g., variation in host infectivity, transmissibility, and the presence of undetected sources of transmission, …etc. Therefore, to increase the reliability of comparison, we need to add the reproductive number (R_0).[1,4] Unfortunately, the design of our study cannot permit the estimation of the reproductive number (R_0). This is another limitation of the study.

A glance at **(Table 2)**, reveals that acceleration of growth appears as positive numbers and deceleration as negative ones. Moreover, a growth factor that appears above the value of (1) is an acceleration growth, and less than (1) is a deceleration of growth. A detailed analysis in the table showed the numbers in the first six weeks, which indicates that the disease had not started yet or not established itself in some of the countries. Therefore, the numbers in this period (1st six weeks) appear as outlier numbers and have been excluded from the analysis. This finding is consistent with what has been written by Middelburg *et al* [2]. weeks 7 to 10 of the study revealed an acceleration in all the countries of the study with increasing numbers of both the growth percentages and the growth factors; this goes with the exponential growth reported in the epidemic curves (Table 2, Fig.1). In weeks 11 to 17, there is mild acceleration in the weekly percentages, which is consistent with the period of lockdown and restriction measures. It also fits the period of the logarithmic to the linear phase in the epidemic curves see (**Fig. 1&2)**.

In weeks 18 to 22, swinging records from mild acceleration to mild deceleration of growth was observed in all the countries of the study except KSA, USA, and Brazil. In which a steady-state or acceleration in the last two weeks of the study has been registered. ANOVA test was performed and showed no significant differences in growth percentages and growth factors among these countries.
Our study showed a slow pattern of growth in April and May in comparison to March, and this might be attributed to the restriction measures and lockdown instituted by these countries. In contrast, an increment in growth was noticed gradually over the last two weeks of June in some countries. However, this pattern attributed to the ease of lockdown policies and restrictions. This finding is parallel to what was reported by Henrik *et al* about the decreasing velocity of infection transmission after a lockdown in France.[22] Eventually, the study revealed that percentages and growth factors have been evolved and changed over time, which is consistent with Biao Tang *et al* study.[23] Moreover, Hiroshi *et al* reported that the ratio of dispersity (synonym of growth factor) is linked to the reproductive number (R_0).[21] Therefore, the growth factor might be a rough measurement of infectivity, just like(R0).

Doubling time

Calculating the doubling time (in days) provides an additional tool for comparison in this study. The monthly average for February to May was calculated to make the data demonstrated clearly.[19] These results show a comparable doubling time among KSA, Gulf countries, and Russia. A more extended period of doubling time was noticed in the USA (46 days), and a shorter in brazil (12 days) in the same month. ANOVA statistical test was performed, and it showed no significant differences in the doubling time among these countries. A result contradicting with a study by Kundapur *et al*. The latterly mentioned study reported a significant difference in doubling time among India, Japan, and China.[1] Over time we noticed an increase in the doubling time in all countries included in the study, which is consistent with a study by Rick *et al* see **Fig 3.**

Case fatality rates and recovery rates

The case fatality rate is a crucial parameter for characterizing the new epidemy. However, it carries potential biases and limitations. Such as 1) asymptomatic carriers are not involved in the calculation 2) deaths may be due to associated chronic diseases.[24] The reported case-fatality rates in KSA, which is fluctuating around a rate of 1%, is comparable to the remaining Gulf countries. This ratio is considered as one of the lowest ratios all over the world. As regard, Qatar has the highest cases/million ratio, also recorded the lowest case fatality rate that is 0.16%, compared to 6%, 1.8% in Brazil, and the USA respectively see **(Table 1& 3)**. In contrast, some European countries like France, Belgium, and United Kingdom recorded a higher case fatality rate of 18%, 16%, and 14%, respectively.[14] This is attributed to the higher average of age in the old continent compare to younger communities of the gulf region.[1,9] Even though the excellent health system in the Gulf countries contributes to low case fatality rates. It is believed that the

younger age average of the population is the main controlling factor. In India and several African countries although they do not have advanced health system yet have a relatively low case fatality rate .[25,26]
The recovery rate is an evolving parameter over time. A high recovery rate reflects a sign of flattening of the epidemic curve. The recovery rates of the countries included in the study are increasing month by month, and this is consistent with what was reported by Unisa *et al*.[27] In June, the recovery rate increase in KSA to 68.74% compared to only 43.46% in Oman, 28.38 % in the USA. Even though a comparable case fatality rate is detected among the gulf countries, they also showed unexplainable variations in recovery rates see **(Table 3)**.

CONCLUSION

COVID-19 pattern in KSA is comparable to the remaining other gulf countries in the percentage of change, growth factor, doubling time, and case fatality rate. The only difference that was found is in the numbers of cases/million populations. Although KSA pattern has a comparable number of these parameters compared to the USA and Brazil, it has a lower case-fatality rate and doubling time compared to them. Excluding KSA, Gulf countries have a higher number of cases/million population than the three most infected countries in the world. At the end of the study, there was no decline in the epidemic curves of countries of the study. However, the patterns are evolving and changing every day. We concluded that an increase in the doubling time, and decrease of growth over time, which both considered as being signs of flattening in the epidemic curves.

Recommendations

We recommended using the weekly percentage of change, growth factor, doubling time, the number of case/million population for the comparison of COVID-19 data instead of the usage of absolute numbers. A more extended period and more elaborated epidemiolocal studies are needed in the future to see the full picture of the patterns of this pandemic.

Ethical Approval

Not applicable in this study

Conflicts of interest

The authors of this paper declare no conflicts of interest

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