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Research Paper

Comparative study of COVID-19 situation between lower-middle-income countries in the eastern Mediterranean region

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ABSTRACT

Background and aims: The COVID-19 health crisis has created a disastrous situation worldwide. All nations are facing this pandemic, including eastern Mediterranean countries. The aim of this study is to assess and compare the impact of this devastating pandemic on lower-middle-income countries in the eastern Mediterranean region, identify the leading causes of its spread, examine the various risk factors associated with its virulence in each country, and provide effective intervention strategies to contain it.

Methods: Using the analysis of variance method, this research compares infection, case fatality, recovery, and positivity rates in seven countries, namely, Morocco, Tunisia, Egypt, Djibouti, Pakistan, Sudan, and Palestine. It focuses on their daily reported confirmed incidents, recoveries, deaths, and tests.

Results: The results highlight the significant differences in the effect of COVID-19 in these countries. Regarding the infection rate, Djibouti and Palestine have the highest rate, which could be related to the high poverty and the young population in these countries. However, it has been demonstrated that Tunisia, Djibouti, Egypt, and Sudan have the greatest case fatality rate in this comparison, which might be attributed to the relatively old population in Tunisia, the co-morbidity in Egypt, and the deficiency of the healthcare system in Djibouti and Sudan. Furthermore, the comparison of the recovery rate in these countries indicates that Djibouti has the highest recovery rate, which might be due to the young population.

Conclusion: This work allows us to come up with recommendations that could support policymakers to act efficiently in containing the pandemic flare-up.

1. Introduction

The novel Coronavirus pandemic COVID-19 is a potentially critical infectious disease that attacks the respiratory system. It is engendered by SARS-CoV-2 which is a severe acute respiratory syndrome. 1 In December 2019, the first reported case was discovered in the city of Wuhan, in China. Then, it has spread quickly all over the world. On March 11th, 2020, the World Health Organization declared this infection as a pandemic. 2 This disease has a variety of symptoms including coughs, sore throats, fever, headaches breathing problems which may sometimes lead to death. 3,4 Coronavirus can expand via respiratory drops, made from the sneeze or the cough of a sick person, containing the virus on it and touching a surface or a body. 5 The first confirmed cases of Covid-19 were reported on March 2nd, 2020 in Morocco and Tunisia. Besides, the first cases were identified on February 14th, February 26th, March 5th, March 13th, and March 17th, 2020 in Egypt, Pakistan, Palestine, Sudan, and Djibouti respectively. 6,9 The lockdown was started on March 20th, 2020 in Morocco and Tunisia. Whereas, containment was not imposed in Egypt. 7 Furthermore, the lockdown took place on March 23rd and March 24th in Djibouti and Pakistan respectively. 8,9 Besides, on March 5th, 2020, the same day when the first cases were detected, a state of emergency was declared in Palestine. 9 Moreover, a partial lockdown was announced on April 13th, 2020 in Sudan. 8

From the onset of the pandemic until September 11, 2020, the total number of COVID-19 positive cases reached around 79767 in Morocco, 5882 in Tunisia, 100557 in Egypt, 13437 in Sudan, 5394 in Djibouti, 300371 in Pakistan, and 37214 in Palestine. As for the total number of deaths, 1491 deaths were recorded in Morocco, 99 in Tunisia, 5590 in Egypt, 833 in Sudan, 61 in Djibouti, 6370 in Pakistan, and 224 in Palestine. Additionally, 64194 recoveries were reported in Morocco, 19788 in Palestine. However, data for the total...
number of tests were not available for all studied countries in the above-mentioned period. They were available only in four countries, namely, Morocco, Tunisia, Pakistan, and Palestine. Indeed, the total number of tests, up to September 11, 2020, reached around 2138164 in Morocco, 2879655 in Pakistan, and 77107 in Palestine. 

In the absence of effective treatment of this virus, many protective actions are taken by different countries to slow down the outbreak of the pandemic. For instance, wearing masks, staying away from infected individuals, cleaning hands frequently with soap or alcohol-based sanitizer which is made of 60% alcohol least and respecting social distancing. Besides, the identification of infected people, isolating and tracking them as well as environmental disinfection are fundamental measures to contain the spread of this morbidity. On the other hand, the infection spread is associated with several risk factors such as sex, age, and morbidity conditions like cardiovascular diseases (CVD), cancer as well as diabetes. Indeed, many low and middle-income countries have generally a young population. COVID-19 protective measures are expected to be equally difficult to respect among young people. This can be due to a personal fable, which is an aspect of adolescent egocentrism involving exclusivity and invincibility and leading probably to risky and careless behavior, like non-respect of lockdown situations. The personal conviction that one will not become sick is more expected to occur among young than old people in society. Therefore, people in Low- and Middle-income countries are more exposed to danger than the population of high-income countries. Furthermore, regular hand washing, which is a vital recommendation for alleviating infections, is a defy in several Low- and Middle-income countries as well as running water which is not available regularly in households.

Furthermore, precautionary measures vary from a country to another making the propagation of the virus and its virulence different between countries. Therefore, a pandemic situation comparison and the impact of the risk factors in each country play an essential role in identifying the similarities and the differences between countries. Consequently, this could assist policymakers in taking the right decisions and actions to contain this pandemic. In this context, several researches were conducted to compare the COVID-19 situation between different countries. Khan et al. analyzed the impact of the pandemic on the most affected countries in the world. Ouchetto et al. compared and assessed the effectiveness of preventive measures taken in North African countries. Boufkhed et al. assessed the level of readiness and ability to react to the COVID-19 pandemic in the Middle-East and North African countries in terms of palliative care services. Musa et al. reviewed the pandemic situation in Africa and proposed potential explanations behind the present trends, such as the wide experience of African countries with infectious diseases and their youth population along with presenting recommendations to avoid a quick expansion in Covid-19 number of cases later on. Likewise Chitungu et al. presented some explanations of the low number of Covid-19 infections in Africa. Moreover Alanezi et al. examined and compared the control policies implemented to curb the pandemic in the Gulf Cooperation Council and European Union countries. Alshammari et al. evaluated and appraised the early preventive measures and patterns adopted by 175 countries across six continents to tackle the pandemic spillover. Piovani et al. investigated how early social distancing measures affected Covid-19 cumulative mortality over the first wave of the pandemic in the 37 states that make up the Organization for Economic Cooperation and Development. Further studies forecasted COVID-19 trends. For instance, Takele et al. focused on predicting COVID-19 infection spread in some East African Countries using the Autoregressive Moving Average modeling. Similarly ArunKumar et al. predicted the epidemiological patterns of COVID-19 pandemic in the top-16 countries which accounts for 70%-80% of total cumulative number of cases and consequently, assisted these countries in developing health care strategies to tackle the current pandemic.

The present study focuses on analyzing and comparing the situation of Covid-19 in lower-middle-income countries in the eastern Mediterranean region, namely, Morocco, Tunisia, Egypt, Djibouti, Pakistan, Sudan, and Palestine. In order to determine the similarities and the differences between these countries, a statistical method, called the Analysis of variance (ANOVA), was used for comparing the means between the above-mentioned countries.

2. Data & methods

The “Our World in Data” dataset was used to calculate the infection, case fatality and positivity rates. This dataset is updated day by day from the World Health Organization situation reports. More information concerning this dataset can be found at https://ourworldindata.org/coronavirus-source-data. Daily data of new cases, new deaths, new tests, and the population of each country were utilized to compute infection, case fatality, and positivity rates. On the other hand, recovery rate was calculated using data of new recovered and new cases taken from the dataset found on the following website: https://ourworldindata.org/coronavirus-source-data. The current work deals with daily data from seven lower-middle-income countries in the eastern Mediterranean region, specifically, Morocco, Tunisia, Egypt, Djibouti, Pakistan, Sudan, and Palestine. Infection, case fatality, and recovery rates were calculated for all the above-mentioned countries. However, since the data of new tests were not available for Egypt, Djibouti, and Sudan, the positivity rate was computed only for Morocco, Tunisia, Pakistan, and Palestine. The data covered the period from the first appearance of the pandemic in each country till September 11, 2020.

The Analysis of variance (ANOVA) was used to identify the similarities and the differences between the countries. Actually, the analysis of variance is a statistical test commonly used in statistics. It is applied to examine the differences between at least three groups. There are three main assumptions in ANOVA; the populations, from which the samples are taken, are normally distributed, they have the same variances and the samples are selected randomly and independently from each other. Although ANOVA is applied to test the null hypothesis, which is all sampled populations have the same mean, against the alternative hypothesis which is, at least one population has a different mean compared to the others. The fundamental matter in the implementation of the ANOVA tests is that when the null hypothesis is rejected, it does not indicate between which pair of the population the means are different. To solve this matter, the post hoc multiple comparison tests are used to determine between which pair of populations the means are different.

In the present study, three assumptions were tested before the application of the Analysis of Variance (ANOVA). In particular, Independence of samples, normality, and homogeneity of variances. For the Independence of samples, it is assumed that the data were collected independently from a country to another. However, the other two assumptions were checked. Actually, the normality and the homogeneity of variance were not satisfied. The normality was checked using Kolmogorov-Smirnov and Shapiro-Wilk tests. As to the homogeneity of variance, Levene’s test was utilized to verify it. In order to get normally distributed data, a two-step transformation to normality was applied. This approach comprises two steps; the first one consists in changing the variable into rank of percentile resulting in uniformly distributed probabilities. The second step aims to create a new variable made up of normally distributed z-scores using the inverse-normal transformation of the first step’s resulting variable. Regarding the homogeneity of variance assumption, ANOVA is robust to the violation of homogeneity of variances. Therefore, due to the heterogeneity of variances between the groups and unequal sample sizes, robust tests of equality of means, namely Welch test and Brown-Forsythe test, were used for the ANOVA instead of the ANOVA F test (Fig. 1). All the above-mentioned tests and analysis were performed using IBM SPSS Statistics 22 software.
3. Results

This section presents the findings of our analysis. Infection, case fatality, recovery and positivity rates are compared in the studied countries. Before applying the One way ANOVA, normality and homogeneity of variances assumptions were checked for each rate considering that the independent observations assumption was met. First, the distribution of each rate was not normal. In order to meet the normality assumption, a two step transformation was done. The variable after the first step of the transformation was not normal. Whereas, after the...
second step of the transformation the variable had a normal distribution.
Therefore, the normality assumption is accomplished. As for the ho-
mogeneity of variances assumption, it is violated (p-value < 0.05).
Consequently, the one way ANOVA is applied using Welch and Brown-
Forsythe tests, since they are robust to the non-homogeneity of vari-
ances. As the one way ANOVA shows only whether there is a difference
of the means between at least one country and the others, Games-Howell
Post hoc test is used to determine the differences between which coun-
tries is occurred.

4. Infection rate

The infection rate is the proportion of infected individuals to the
overall population. It is calculated using the following formula:
\[
\text{Infection Rate} = 100 \times \left( \frac{\text{New Cases}}{\text{Population of the Country}} \right)
\]

4.1. Testing normality of data

Hypothesis

- Null hypothesis
- Alternative hypothesis

Based on Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 1):

- The “infection_rate” variable, which is the variable before the transformation, and “Fractional Rank of infection_rate”, which is the variable after the first step of the transformation, have statistically significant results (p-value < 0.05). Therefore, the null hypothesis is rejected which implies that both of these two distributions are not normal.
- The normalized infection rate variable “norm_infection_rate” has a non statistically significant result (p-value > 0.05). So, the null hypothesis is accepted which means that the distribution is normal.

4.2. Testing homogeneity of variances

4.2.1. Levene’s test

Hypothesis

- Null hypothesis H0: The infection rate in the countries we are comparing has equal variances.
- Alternative hypothesis H1: The infection rate in the countries we are comparing has different variances.

According to Levene’s test, the p-value is 0 which is less than 0.05.

4.3. One way ANOVA

In order to apply the Analysis Of Variance (ANOVA), Welch and Brown-Forsythe tests, which are robust to the non-homogeneity of variances assumption, were used for comparing the means. In both tests, the significance is 0 (p-value < 0.05). Hence, the null hypothesis is rejected. This means that at least the mean of the infection rate in one country is different from that in the other countries (Table 3).

4.4. Post hoc test for infection rate

In order to detect between which countries the differences occurred regarding the infection rate, a Games-Howell Post hoc test was used for multiple comparisons. According to the results of multiple comparisons, it is shown that (Table 4):

- Pakistan is very similar in the infection rate to Morocco, because of the insignificant p-value which is equal to 0.901. Also, it is relatively close to Egypt with a p-value equals to 0.259.
- Tunisia and Sudan have moderately similar infection rates due to the p-value which is equal to 0.259.
- Djibouti and Palestine are slightly similar with a p-value equals to 0.151
- Djibouti and Palestine have relatively a higher infection rate, followed by Morocco, Pakistan, and Egypt, and then Sudan and Tunisia have a relatively very small infection rate (Fig. 2).

5. Case fatality rate

The case fatality rate is a measure used to assess the impact of
COVID-19 on humans by calculating the percentage of the dead in
dividuals to the total number of infected ones.\(^\text{30}\) It is calculated using the following formula:
\[
\text{Case fatality Rate} = \left( \frac{\text{New Deaths}}{\text{New Cases}} \right)
\]

5.1. Testing normality

Hypothesis

- Null hypothesis H0: The data are normally distributed.
- Alternative hypothesis H1: The data are not normally distributed.

According to Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 5):
- The "case_fatality_rate" variable, which is the variable before the transformation, and "Fractional Rank of case_fatality_rate", which is the variable after the first step of the transformation, have statistically significant results (p-value < 0.05). Therefore, the null hypothesis is rejected which implies that both of these two distributions are not normal.

- The normalized case fatality rate variable "norm_fatality_rate" has a non statistically significant result (p-value > 0.05). So, the null hypothesis is accepted which means that the distribution is normal.

5.2. Testing homogeneity of variances

5.2.1. Levene’s test

Hypothesis
- Null hypothesis \( H_0 \): The case fatality rate in the countries we are comparing has equal variances.
- Alternative hypothesis \( H_1 \): The case fatality rate in the countries we are comparing has different variances.

According to Levene’s test, the p-value is 0 which is less than 0.05. Thus, the null hypothesis is rejected. This means that the case fatality rate in the countries we are comparing has different variances and the assumption of homogeneity of variances is violated (Table 6).

5.3. One way ANOVA

Hypothesis
- Null hypothesis \( H_0 \): The means of the case fatality rate in all countries are equal.
- Alternative hypothesis \( H_1 \): At least one mean is different.

Table 4
Multiple comparisons for the infection rate. Dependent Variable: norm_infection_rate, Games-Howell.

| (I) country_code | (J) country_code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |
|------------------|------------------|-----------------------|------------|------|------------------------|
| Morocco          | Tunisia          | ,00273^a             | ,00030     | ,000 | ,0019                  |
| Egypt            | Tunisia          | ,00102^a             | ,00029     | ,008 | ,0002                  |
| Pakistan         | Tunisia          | ,00036^a             | ,00030     | ,901 | ,0005                  |
| Djibouti         | Tunisia          | ,00238^a             | ,00033     | ,000 | ,0033                  |
| Sudan            | Tunisia          | ,00200^a             | ,00032     | ,000 | ,011                   |
| Palestine        | Tunisia          | ,00130^a             | ,00040     | ,021 | ,0025                  |

Table 5
Tests of Normality for the case fatality rate.

|                     | Kolmogorov-Smirnov^a | Shapiro-Wilk               |
|---------------------|-----------------------|----------------------------|
|                     | Statistic   df Sig.  | Statistic   df Sig.       |
| case_fatality_rate  | ,292 722 .000       | ,415 722 .000             |
| Fractional Rank of  |                       |                           |
| case_fatality_rate  | ,059 722 .000       | ,955 722 .000             |
| norm_fatality_rate  | ,005 722 ,200^a     | ,999 722 ,968             |

df: degree of freedom, Sig: significance.

^a The mean difference is significant at the 0.05 level.

- The "case_fatality_rate" variable, which is the variable before the transformation, and "Fractional Rank of case_fatality_rate", which is the variable after the first step of the transformation, have statistically significant results (p-value < 0.05). Therefore, the null hypothesis is rejected which implies that both of these two distributions are not normal.

- The normalized case fatality rate variable "norm_fatality_rate" has a non statistically significant result (p-value > 0.05). So, the null hypothesis is accepted which means that the distribution is normal.
To apply the Analysis Of Variance (ANOVA), Welch and Brown-Forsythe tests, which are robust to the non-homogeneity of variances assumption, were used for comparing the means. In both tests, the significance is 0 (p-value < 0.05). Hence, the null hypothesis is rejected. This means that at least the mean of the case fatality rate in one country is different from that in the other countries (Table 7).

### 5.4. Post hoc test for the case fatality rate

A Games-Howell Post hoc test was used for multiple comparisons of the case fatality rate to detect between which countries the differences occurred. According to the results of multiple comparisons (Table 8), it is revealed that:

- Morocco is very similar to Pakistan, because of the insignificant p-value which is equal to 0.992. Moreover, it is slightly close to Djibouti with a p-value equals to 0.052.

#### Table 6

Test of Homogeneity of Variances for the case fatality rate.

| norm_fatality_rate | Levene Statistic | df1 | df2 | Sig. |
|-------------------|-----------------|-----|-----|------|
|                   | 22,007          | 6   | 715 | .000 |

df: degree of freedom, Sig: significance.

#### Table 7

Robust Tests of Equality of Means for the case fatality rate.

| norm_fatality_rate | Statistic | df1 | df2 | Sig. |
|-------------------|-----------|-----|-----|------|
|                   |           |     |     |      |
|                   | Welch     | 127,717 | 6 | 191,642 | .000 |
|                   | Brown-Forsythe | 71,115 | 6 | 179,298 | .000 |

df: degree of freedom, Sig: significance.

Asymptotically F distributed.

#### Table 8

Multiple comparisons for the case fatality rate.

| (I) country_code | (J) country_code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |
|------------------|------------------|-----------------------|------------|------|------------------------|
|                  |                  |                       | Lower Bound | Upper Bound |
| Morocco | Tunisia | -1,11249 |
|         | Egypt | -1,4529 |
|         | Pakistan | -0.00720 |
|         | Djibouti | -0.99579 |
|         | Sudan | -1,14147 |
|         | Palestine | 0.00787 |
| Tunisia | Morocco | 1,11249 |
|         | Egypt | 0.00720 |
|         | Pakistan | 0.99579 |
|         | Djibouti | 1.14147 |
|         | Sudan | 1.01657 |
|         | Palestine | 0.00787 |
| Egypt | Morocco | 1.4529 |
|         | Tunisia | 0.03405 |
|         | Pakistan | 1.38097 |
|         | Djibouti | 0.04949 |
|         | Sudan | 0.00382 |
|         | Palestine | 0.23288 |
| Pakistan | Morocco | 0.00720 |
|         | Tunisia | 1.10404 |
|         | Egypt | 1.38097 |
|         | Djibouti | -0.88859 |
|         | Sudan | -1.13427 |
|         | Palestine | 0.00787 |
| Djibouti | Morocco | 0.09579 |
|         | Tunisia | 0.01544 |
|         | Egypt | 0.04949 |
|         | Pakistan | 0.08859 |
|         | Sudan | 0.04567 |
|         | Palestine | 0.22667 |
| Sudan | Morocco | 1.14147 |
|         | Tunisia | 0.03023 |
|         | Egypt | 0.00382 |
|         | Pakistan | 0.13427 |
|         | Djibouti | 0.04567 |
|         | Palestine | 0.27234 |
| Palestine | Morocco | -1.03087 |
|         | Tunisia | -0.91518 |
|         | Egypt | -0.91518 |
|         | Pakistan | -0.76761 |
|         | Djibouti | -0.04675 |
|         | Sudan | -0.27234 |

Std. Error: Standard Error.
Sig: Significance.

* The mean difference is significant at the 0.05 level.
- Tunisia is identical to Djibouti as the p-value is equal to 1, followed by Sudan with a p-value equals to 0.835, and Egypt with a p-value equals to 0.699.
- Egypt is identical to Sudan, quite similar to Tunisia and Djibouti.
- Pakistan is very similar to Morocco and marginally similar to Djibouti.
- Djibouti and Sudan are remarkably similar.
- Palestine is different from all the other compared countries.

It is shown that Tunisia, Djibouti, Egypt, and Sudan have the highest case fatality rates in this comparison, followed by Morocco and Pakistan with a relatively smaller rate. However, Palestine has the lowest rate (Fig. 3).

6. Recovery rate

Recovery rate is the proportion of recovered patients to the total infected individuals. It is calculated using this formula:

\[ \text{Recovery Rate} = \frac{\text{New recovered}}{\text{New cases}} \]

6.1. Testing normality

Hypothesis

- Null hypothesis \( H_0: \) The data are normally distributed.
- Alternative hypothesis \( H_1: \) The data are not normally distributed.

According to Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 9):

- The “Recovery rate” variable, which is the variable before the transformation, and “Fractional Rank of Recovery_rate”, which is the variable after the first step of the transformation, have statistically significant results (p-value < 0.05). Therefore, the null hypothesis is rejected which implies that both of these two distributions are not normal.
- The normalized recovery rate variable “norm_recovery_rate” has a non statistically significant result (p-value > 0.05). So, the null hypothesis is accepted which means that the distribution is normal.

6.2. Testing homogeneity of variances

6.2.1. Levene’s test

Hypothesis

- Null hypothesis \( H_0: \) The recovery rate in the countries we are comparing has equal variances.
- Alternative hypothesis \( H_1: \) The recovery rate in the countries we are comparing has different variances.

According to Levene’s test, the p-value is 0 which is less than 0.05. Thus, the null hypothesis is rejected. This means that the recovery rate in the countries we are comparing has different variances and the assumption of homogeneity of variances is violated (Table 10).

6.3. One way ANOVA

Hypothesis

- Null hypothesis \( H_0: \) The means of the recovery rate in all countries are equal.
- Alternative hypothesis \( H_1: \) At least one mean is different.

Table 10

| Test of Homogeneity of Variances for the recovery rate. |
|--------------------------------------------------------|
| norm_recovery_rate                                    |
| Levene Statistic                                      | df1 | df2 | Sig   |
| 5.406                                                 | 6   | 932 | .000  |

df: degree of freedom, Sig: significance.

Fig. 3. The mean of the case fatality rate in the studied countries.
To apply the Analysis Of Variance (ANOVA), Welch and Brown-Forsythe tests, which are robust to the non-homogeneity of variances assumption, were used for comparing the means. In both tests, the significance is 0 (p-value < 0.05). Hence, the null hypothesis is rejected. This means that at least the mean of the recovery rate in one country is different from that in the other countries (Table 11).

### 6.4. Post hoc test for the recovery rate

A Games-Howell Post hoc test was used for multiple comparisons, for the sake of identifying the similarities and the differences between the countries regarding the recovery rate. The results of this test (Table 12) illustrate that:

- Morocco is identical to Pakistan, very similar to Tunisia with a p-value equals to 0.999, very close to Palestine with a p-value equals to 0.992 as well as Egypt with a p-value equals to 0.972.
- Tunisia is identical to Pakistan and Palestine and very similar to Morocco and Egypt with a p-value equals to 0.999 and 0.920 respectively.
- Egypt is very similar to Morocco, Pakistan, Tunisia, and Palestine with a p-value equals to 0.972, 0.964, 0.920, and 0.830 respectively.
- Pakistan is identical to Morocco and Tunisia (p-value = 1) and very close to Palestine and Egypt with a p-value equals to 0.995 and 0.964 respectively.

### Table 11

| norm_recovery_rate | Welch | Brown-Forsythe |
|--------------------|-------|----------------|
| Statistic          | df1   | df2    | Sig.    |
| 11,230             | 6     | 382,309 | 0,000  |
| 10,504             | 6     | 760,084 | 0,000  |

df: degree of freedom, Sig: significance.

a. Asymptotically F distributed.

### Table 12

| Dependent Variable: norm_recovery_rate |
|----------------------------------------|
| Games-Howell                           |
| (I) Country_Code (J) Country_Code Mean Difference(I-J) Std. Error Sig. 95% Confidence Interval |
| Lower Bound Upper Bound                  |
|-----------------------------------------|
| Morocco                                  | Tunisia | .20003 | .43037 | .999 | −1.0823 | 1.4824 |
| Morocco                                  | Egypt   | −.30649 | .3926 | .972 | −1.3128 | .6998 |
| Morocco                                  | Pakistan | .02263 | .32071 | 1.000 | −.9289 | .9741 |
| Morocco                                  | Djibouti | −1.95655a | .42453 | .000 | −3.2213 | .6918 |
| Tunisia                                  | Egypt   | −.50652 | .45073 | .920 | −1.8479 | .8349 |
| Tunisia                                  | Pakistan | −.17740 | .43694 | 1.000 | −1.4789 | 1.1241 |
| Tunisia                                  | Djibouti | −2.15658a | .51796 | .001 | −3.6974 | .6157 |
| Sudan                                    | Morocco | 1.40106a | .65343 | .036 | .5055  | 2.7516 |
| Sudan                                    | Tunisia | .61025 | .52975 | 1.000 | −1.4669 | 1.6874 |
| Sudan                                    | Egypt   | .30649 | .3926 | .972 | −.6998 | 1.3128 |
| Egypt                                    | Tunisia | .50652 | .45073 | .920 | −.8349 | 1.8479 |
| Egypt                                    | Pakistan | .32912 | .34755 | .964 | −.7019 | 1.3602 |
| Egypt                                    | Djibouti | −1.65006a | .44515 | .005 | −.2974 | .3254 |
| Sudan                                    | Morocco | 1.90757a | .36807 | .000 | .8136  | 3.0015 |
| Sudan                                    | Tunisia | .61677 | .45882 | .830 | −.7508 | 1.9844 |
| Sudan                                    | Egypt   | .222648 | .52501 | .000 | .7037  | 3.8300 |
| Pakistan                                 | Morocco | −.02263 | .32071 | 1.000 | −.9741 | .9289 |
| Pakistan                                 | Tunisia | −.17740 | .43694 | 1.000 | −1.1241 | 1.4789 |
| Pakistan                                 | Egypt   | −.32912 | .34755 | .964 | −.3602 | .7019 |
| Pakistan                                 | Djibouti | −1.97918a | .43118 | .000 | −3.3633 | .6950 |
| Sudan                                    | Morocco | 1.57845a | .35105 | .000 | .5343  | 2.6226 |
| Sudan                                    | Tunisia | .2875 | .44528 | .995 | −1.0410 | 1.6163 |
| Djibouti                                 | Morocco | 1.95655a | .42453 | .000 | .6918  | 3.2213 |
| Djibouti                                 | Tunisia | 2.15658a | .51796 | .001 | .6157  | 3.6794 |
| Djibouti                                 | Egypt   | 1.65006a | .44515 | .005 | .3254  | 2.9747 |
| Djibouti                                 | Pakistan | 1.97918a | .43118 | .000 | .6950  | 3.2633 |
| Djibouti                                 | Sudan   | 3.55764a | .44789 | .000 | 2.2237 | 4.8915 |
| Djibouti                                 | Palestine | 2.26683a | .52501 | .000 | .7037  | 3.8300 |
| Sudan                                    | Morocco | −1.40106a | .45343 | .036 | −2.7516 | .0505 |
| Sudan                                    | Tunisia | −1.90757a | .36807 | .000 | −.3005 | .8136 |
| Sudan                                    | Pakistan | −1.57845a | .35105 | .000 | −.6226 | .5343 |
| Sudan                                    | Djibouti | −3.55764a | .44789 | .000 | −4.8915 | 2.2237 |
| Palestine                                | Morocco | −3.1028 | .43884 | .992 | −1.6203 | .9997 |
| Palestine                                | Tunisia | −1.1025 | .52975 | 1.000 | −1.6874 | 1.4669 |
| Palestine                                | Egypt   | −.61677 | .45882 | .830 | −1.9844 | .7508 |
| Palestine                                | Pakistan | −.28765 | .44528 | .995 | −1.6163 | 1.0410 |
| Palestine                                | Djibouti | −2.26683a | .52501 | .000 | −3.8300 | 2.7037 |
| Palestine                                | Sudan   | 1.29081 | .61417 | .082 | −.8575 | 2.6673 |

Std. Error: Standard Error.  
Sig: Significance.  
a The mean difference is significant at the 0.05 level.
- Palestine is analogous to Tunisia (p-value = 1), very similar to Pakistan, Morocco, and Egypt with a p-value equals to 0.995, 0.992, and 0.830 respectively.
- Sudan and Palestine are slightly similar with a p-value equals to 0.082.

According to Fig. 4, it is illustrated that Djibouti has the highest recovery rate, followed by Tunisia, Egypt, Palestine, Morocco, and Pakistan with a relatively high recovery rate, and finally, Sudan with the lowest recovery rate in this comparison (Fig. 4).

7. Positivity rate

The positivity rate is the ratio of infected individuals to the number of tests done. It is calculated using this formula:

\[
\text{Positivity Rate} = 100 \times \left(\frac{\text{New cases}}{\text{New tests}}\right)
\]

7.1. Testing normality

Hypothesis.

- Null hypothesis
- Alternative hypothesis

According to Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 13):

- The “positivity_rate” variable, which is the variable before the transformation, and “Fractional Rank of positivity_rate”, which is the variable after the first step of the transformation, have statistically significant results (p-value < 0.05). Therefore, the null hypothesis is rejected which implies that both of these two distributions are not normal
- The normalized positivity rate variable “norm_positivity_rate” has a non statistically significant result (p-value > 0.05). So, the null hypothesis is accepted which means that the distribution is normal.

7.2. Testing homogeneity of variances

7.2.1. Levene’s test

Hypothesis

- Null hypothesis
- Alternative hypothesis

According to Levene’s test, the p-value is 0 which is less than 0.05. Thus, the null hypothesis is rejected. This means that the positivity rate in the countries we are comparing has different variances and the assumption of homogeneity of variances is violated (Table 14).

7.3. One way ANOVA

Hypothesis

- Null hypothesis
- Alternative hypothesis

To apply the Analysis Of Variance (ANOVA), Welch and Brown-Fig. 4. The mean of the recovery rate in the studied countries.
Palestine has a higher population density and young population suffering from poverty, hand washing and sanitation rate and a relatively slight number of tests comparing with Pakistan and Morocco (Table 17) and (Fig. 5).

Pakistan has the greatest positivity rate and the highest number of tests in the studied period. However, Tunisia has the lowest positivity rate and a relatively slight number of tests comparing with Pakistan and Morocco (Table 15) and (Fig. 5).

### 7.4. Post hoc test for positivity rate

Data for the number of tests, in the studied period, are found only in four countries. Explicitly, Morocco, Tunisia, Pakistan, and Palestine. A Games-Howell Post hoc test is used for multiple comparisons for the sake of identifying the differences between the countries. Based on the results of multiple comparisons, it is indicated that each country has a different positivity rate from the others (Table 16).

Pakistan has the greatest positivity rate and the number of tests in the studied period. However, Tunisia has the lowest positivity rate and a relatively slight number of tests comparing with Pakistan and Morocco (Table 17) and (Fig. 5).

### 8. Discussion

Regarding the infection rate, Djibouti and Palestine have a relatively higher infection rate. Palestine has a higher population density and young population suffering from poverty, hand washing and sanitation guidelines seem to be very difficult or even impossible to be applied. Likewise, the young population in Djibouti could explain its higher infection rate. Actually, as indicated by the newest Statistical Yearbook 2019 of Djibouti, the median age of the population is 20 years old and 86.5% of the population under 49 years old. This population structure could explain the increase of confirmed cases since the majority of habitants is active and vulnerable to be infected by the virus in their daily life. On the other hand, the greatest percentage of extreme poverty (22.5%) in Djibouti could explain its high infection rate comparing to the other studied countries (Table 18). However, the low infection rate in Tunisia might be attributed to its relatively old population compared to the other studied countries. Actually, the median age is 32.7 years old, the share of the population that is 65 years and older is equal to 8.001% and the share of the population that is 70 years and older is equal to 5.075% (Table 18). This could explain the low infection rate because old people are more confined to their homes and have less contact with others or they could be more stringent regarding the preventive measures. Furthermore, In Sudan, the lack of testing laboratories induces a smaller number of reported infections and the partial respect of the precautionary measures might be the reasons for the low infection rate.

The case fatality rate is relatively high in Tunisia, Djibouti, Egypt, and Sudan compared with the other countries. However, the lowest rate is in Palestine. The high case fatality rate in Tunisia could be due to the old population compared with the other countries, as mentioned before. In Djibouti, the lack of medical resources which is reported in Takele et al., the greatest percentage of extreme poverty as well as the lowest human development index (0.476) might raise the case fatality rate (Table 18). Moreover, the high case fatality rate in Egypt could depend on the co-morbidity that influences Covid-19 infection. Actually, the highest death rate from cardiovascular diseases (525.432) and the highest diabetes prevalence (17.31%) could explain this highest rate in Egypt (Table 18). On the other hand, the precautionary measures in Egypt were less stringent. This could spread the virus to more people, especially the elderly and people suffering from obesity, diabetes, or cardiovascular diseases. Additionally, the co-morbidity risk factor could be present in Sudan, which comes after Egypt with a death rate from cardiovascular diseases equal to 431.388 and a diabetes prevalence (17.31%) could explain this relatively high rate (Table 18). However, Palestine has the lower case fatality rate, which might be attributed to the young population.

Regarding recovery, Djibouti recorded the highest rate. This might be due to the young population and the stringent strategy of isolating patients, including testing suspected people who could be infected by the virus and contact tracing of the patients. However, Sudan represents the lowest recovery rate. This could be attributed to the

### Table 16

Multiple Comparisons for the positivity rate.

| (I) Country Code | (J) Country Code | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |
|------------------|------------------|-----------------------|------------|-----|------------------------|
|                  |                  | Lower Bound           | Upper Bound |
| Morocco          | Tunisia          | 22,54950*             | 4,40581    | .000 | 11,1725                | 33,9264 |
|                  | Pakistan         | −26,72501*            | 4,23907    | .000 | −37,6498               | −15,8002 |
|                  | Palestine        | −40,14388*            | 4,20692    | .000 | −51,1901               | −29,9977 |
| Tunisia          | Morocco          | −22,54950*            | 4,40581    | .000 | −33,9265               | −11,1725 |
|                  | Pakistan         | −49,27451*            | 3,95914    | .000 | −59,5006               | −39,0484 |
|                  | Palestine        | −62,69338*            | 3,93342    | .000 | −73,0784               | −52,3083 |
| Pakistan         | Morocco          | 26,72501*             | 4,23907    | .000 | −15,8002               | 37,6498  |
|                  | Tunisia          | 49,27451*             | 3,95914    | .000 | 39,0484                | 59,5006  |
|                  | Palestine        | 62,69338*             | 3,93342    | .000 | 52,3083                | 73,0784  |
| Palestine        | Morocco          | 40,14388*             | 4,20692    | .000 | 29,0977                | 51,1901  |
|                  | Tunisia          | 62,69338*             | 3,93342    | .000 | 52,3083                | 73,0784  |

The mean difference is significant at the 0.05 level.

Std. Error: Standard Error.

Sig: Significance.
co-morbidity risk factor and the lowest life expectancy of its population (Table 18).

This study has some limitations that must be noted. The data about the number of tests are not available in some countries and relatively few in others. This could affect the accuracy of the positivity rate comparison. On the other hand, since the number of tests is a key factor to determine the number of cases, the new infections could not be accurately identified. Therefore, the situation of the pandemic might not be appraised effectively in each country.

9. Conclusion

The Coronavirus pandemic has presented a threat to the whole world since it has not only affected the fundamental aspects of our life, such as the health security, psychological and social well-being of people, but also the world economy. Statistical analysis of Covid-19 carried out in various countries are based on the official data of each country. The studied countries have taken different precautionary measures to control the pandemic and, in this manner, contain the spread of the virus, reduce the burden on the health system and minimize the number of deaths. This study allows us to find out the relationships in the lower-middle-income countries in the eastern Mediterranean region, between controlling the spread of the virus and different factors, such as preventive measures, demographic aspects, poverty, health system, and co-morbidity like diabetes, cardiovascular diseases, and cancer. Since the precautionary measures are the most effective factors to contain the infection and alleviate its impact, people need to be aware of the importance of respecting social distancing, avoiding gatherings, wearing masks, and washing hands frequently. Moreover, the number of tests is a key factor to determine the number of cases. Hence, more efforts should be made to create more testing facilities in order to be more accurate in identifying the new infections and effectively appraise the situation of the pandemic in each country. On the other hand, the old population and co-morbidity conditions can increase the fatality rate. For this reason, old people and those suffering from other chronic diseases, such as cardiovascular diseases, diabetes and cancer should keep their distance from people and apply all the strict sanitary precautions. Additionally, countries should increase their hospital capacities, the efficiency of their healthcare system as well as reduce poverty.

In this context, further studies can be done. The notion of time can be introduced in the investigation and conduct an exploratory panel data analysis. Other studies can focus on comparing the precautionary measures and their economic effects as well as the direct demographic effects of Covid-19 on the population.

Table 18
Demographic and economic data of lower-middle-income countries in the eastern Mediterranean region.

| Country     | Djibouti | Egypt   | Morocco | Pakistan | Palestine | Sudan | Tunisia |
|-------------|----------|---------|---------|----------|-----------|-------|---------|
| population_density | 41.285   | 97.999  | 80.08   | 255.573  | 778.202   | 23.258| 74.228  |
| median_age   | 20a      | 25.3    | 29.6    | 23.5     | 20.4      | 19.7  | 32.7    |
| aged_65_older| 4.213    | 5.159   | 6.769   | 4.495    | 3.043     | 3.548 | 8.001   |
| aged_70_older| 2.38     | 2.891   | 4.209   | 2.78     | 1.726     | 2.034 | 5.075   |
| extreme_poverty | 22.5     | 1.3     | 1.0     | 4.0      | 1.0       | –     | 2.0     |
| cardiovasc_death_rate | 258.037  | 525.432 | 419.146 | 423.031  | 265.91    | 431.388| 318.991 |
| diabetes_prevalence  | 6.05     | 17.31   | 7.14    | 8.25     | 10.59     | 15.67 | 8.52    |
| hospital_beds_per_thousand | 1.4      | 1.6     | 1.1     | 0.6      | –         | 0.8   | 2.3     |
| life_expectancy    | 67.11    | 71.99   | 76.68   | 67.27    | 74.05     | 65.31 | 76.7    |
| human_development_index | 0.476    | 0.696   | 0.667   | 0.562    | 0.686     | 0.502 | 0.735   |

All other data are taken from “Our World in Data” dataset).

* This data is taken from Statistical Yearbook 2019 of Djibouti.

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