



Statistical and spatial analysis of the impact of COVID-19 mortality on some demographic factors in Kuwait in 2020

Nayef F. Alghais⁽¹⁾
Barrak A .Alkharaz⁽²⁾

Abstract

Objectives: The COVID-19 pandemic was directly responsible for a large number of death cases worldwide and Kuwait was no exception. This article attempted to analyze and understand any impacts of demographic factors on COVID-19 mortality in Kuwait over 2020. Specifically, age, nationality status, gender and population density of the deceased were considered. **Method:** Statistical and spatial analysis utilized ArcGIS and hypothesis testing to obtain the results. **Results:** Based on the results, it was found that all three demographic factors (age, nationality and gender) had significant statistical impact on COVID-19 mortality. As the elderly, males and citizens were the groups at highest risk of dying from COVID-19. Furthermore, a spatial analysis has shown that population density of Kuwait's governorates did not have any significant impact on mortality due to COVID-19. **Conclusion:** The findings suggested that any policies and public health campaigns for future pandemics or COVID-19 waves should be designed in a way to mitigate the impacts on the most vulnerable groups.

Keywords: mortality, COVID-19, population geography, Kuwait

(1) Associate Professor, Geography Department, Kuwait University. Email: nayef.alghais@ku.edu.kw

(2) Employee, Ministry of Defense, Kuwait. Email: balkharraz@gmail.com

- Submitted: 22/11/2023, Revised: 16/4/2023, Accepted: 27/4/2023.

التحليل الإحصائي والمكاني لبعض العوامل الديموغرافية لوفيات كوفيد-19 في دولة الكويت في 2020

نايف فهد الغيص⁽¹⁾

براك عبدالمحسن الخزان⁽²⁾

ملخص

الأهداف: كانت جائحة كوفيد-19 مسؤولة بشكل مباشر عن عدد كبير من الوفيات في جميع أنحاء العالم ودولة الكويت لا تعد استثناءً لذلك. تحاول هذه الدراسة تحليل وفهم أي تأثير للعوامل الديموغرافية-السكانية على وفيات كوفيد-19 في دولة الكويت خلال عام 2020. على وجه التحديد، تم البحث والتحقق من تأثير العوامل التالية: العمر والنوع والجنسية والكثافة السكانية. **المنهج:** تم استخدام تحليل احصائي ومكاني بمساعدة ArcGIS للتحقق من فرضيات تم وضعها للحصول على **النتائج:** كشفت النتائج أن العوامل الديموغرافية (العمر، النوع والجنسية) لها تأثير احصائي واضح على وفيات كوفيد-19. فكلبار السن والذكور والمواطنين هم الفئات الأكثر عرضة للوفاة من كوفيد-19. علاوة على ذلك، أظهرت النتائج أن الكثافة السكانية حسب محافظات دولة الكويت ليس لها تأثير عالي على وفيات كوفيد-19. **الخاتمة:** توصي الدراسة على أن أي سياسات وحملات صحية عامة للأوبئة المستقبلية أو موجات كوفيد-19 جديدة يجب أن تُصمم بطريقة تخفف من الآثار على الفئات الأكثر عرضة للوفاة.

الكلمات المفتاحية: الوفيات، كوفيد 19، جغرافية السكان،

الكويت

(1) أستاذ مشارك، قسم الجغرافيا، جامعة الكويت. الإيميل: nayef.alghais@ku.edu.kw

(2) موظف، وزارة الدفاع، الكويت. الإيميل: balkharraz@gmail.com

- تُسَلَّم البحث في: 2023/1/22، عُذِّل في: 2023/4/16، أُجيز للنشر في: 2023/4/27.

Introduction

Research in the field of population geography studies population in the context of space, place and distance, analyzes theories and relevant policies, and develops models for quantifying and predicting population growth, distribution as well as migration, fertility and mortality (Newbold, 2017). The topic of mortality is a demographic directly used in research besides population geography, such as in healthcare and economics. Naturally, disease epidemics and pandemics have been dominant factors of mortality throughout history. As of 2023, the latest disease outbreak with global impacts was the Novel Coronavirus (COVID-19). It appears to have originated in Wuhan, China, on December 2019, by the 11th of March 2020, it was declared a “global pandemic” by the World Health Organization [WHO] (Airhihenbuwa et al., 2020). As a result of the pandemic, the Chinese government enforced a lockdown in the city of Wuhan in January 2020, hoping to contain and delay the spread of COVID-19; since then, multiple authorities around the world followed suit with lockdowns and other public health mandates (Fang et al., 2020).

Since 2020, the literature has investigated the demographic factors of COVID-19 in various cities and regions using numerous statistical methods. It has been suggested that among others, age, population density and gender appear to be demographic factors that affect the mortality rates due to COVID-19.

For instance, Bhadra et al. (2021) studied the impact of population density on COVID-19 incidence and mortality in India with the help of linear regression. They found that districts with the highest population density had higher Covid-related mortality rate. Urban and Nakada (2021) presented five spatial regression models and analyses of disease distribution in Brazil. A Spearman correlation test confirmed an existing relationship between COVID-19 deaths and sociopolitical factors such as population density and poverty/level of disadvantage: COVID-19 deaths were more common among groups living in poorer and more densely populated parts of Brazil.

Furthermore, a study in the United States examined demographic factors that might affect COVID-19 mortality in six different large cities. These factors were basically on racial and ethnic; in addition to housing, socioeconomic status, occupation, transportation modes, health care access, long-run opportunity, human mobility, and underlying population health. The research found that Black and Hispanic communities have higher COVID-19 mortality cases (Benitez et al., 2020). Similarly, Karmakar et al. (2021) examined sociodemographic risk factors on COVID-19 incidence and mortality in the US as well. These factors include household composition and disability, racial/ethnic minority, environmental factors, English language proficiency status, housing and transportation. The findings illustrated that these factors had significant impacts on COVID-19 incidences.

Mohamed et al. (2020) analyzed the mortality of COVID-19 in England and Wales by gender and age (adults of 18 years old and above). The study established two points by producing a linear relationship between the Age-Standardized Mortality Rate [ASMR] and age. Firstly, males were consistently more likely to pass away across all age groups, and secondly, mortality increased with age. Caramelo et al. (2020) quantified various risk factors for COVID-19 mortality based on data collected by the Chinese Center for Disease Control and Prevention [CDC] from late December 2019 to 11th of February 2020. They established that age was the factor associated with the highest risk of mortality from COVID-19.

In the Arabian Gulf region, a recent study compared the case fatality rates [CFR] between Gulf countries and Europe. This research found that the CFRs in Gulf region were significantly lower than those in Europe due to the difference in age groups between the two regions as the Gulf region has younger population and smaller elderly demographic. They highlighted the need for further research into other demographic factors (Rimawi & Rimawi, 2021).

In addition, a study in UAE which is similar to Kuwait in its high foreign labors and non-citizens population ratio. The study founded that the most effected by COVID-19 cases were the Asian population with more than 70%. Besides, elderly and kidney diseases increased the COVID-19 mortality rates in UAE (Nair et al., 2021).

Besides, multiple studies pertinent to the COVID-19 pandemic utilized Geographical Information Systems [GIS] as a means of visualization and pattern identification. GIS is a commonly used tool for decision making in the field of population geography; mortality and COVID-19 are not exception. GIS models proved significant in identifying transmission patterns and associating incidence and mortality with geospatial and demographic factors. Arguably, the data derived from GIS models contributed to developing methods on how to tackle this virus and establish strategies for future pandemics.

For instance, Wu et al. (2020) associated particle pollution to the risk of death due to COVID-19 in the United States. The basis of this assumption was that the risk of death is greater for those with certain health conditions who are also infected by the virus. Such health conditions tend to be particularly prevalent in groups exposed to air pollution for the long term. To determine the relationship of COVID-19 deaths and the exposure to particle pollution, a negative binomial mixed model was applied using COVID-19 deaths as the outcome and the exposure to fine Particulate Matter [PM] as the display of interest. PM pollution and COVID-19 mortality data were fed into a GIS model, which in turn was used to analyze and display the results for each county and state.

Similarly, Ramírez and Lee (2020) examined the effects of population density and asthma on COVID-19 mortality. The analysis used dot density and choropleth maps of the COVID-19 cases in ArcGIS. The purpose of another GIS backed study by Shariati et al. (2020) was to understand the spatial distribution of the COVID-19. Cumulative Incidence Rates [CIR] and Cumulative Mortality Rates

[CMR] were utilized to identify COVID-19 hotspots and clusters. Moran's Index was used for spatial correlation in order to reveal any pattern of cluster distribution of the COVID-19 incidence rate. Bherwani et al. (2021) used the Voronoi approach of GIS inputs from the Bayesian probability model in order to identify a spatial relationship between number of cases and population. As the authors claimed, "these unique approaches seem to be useful in adding a deeper layer to understand this pandemic" (Bherwani et al., 2021, p.5861) and were used by medical authorities in India to develop response policies.

Zhou et al. (2020) pointed out that GIS and big data technologies were essential in the accumulation of information on the pandemic, spatial tracking and spatial segmentation. Nonetheless, challenges when trying to collect accurate data speedily still exist and cause some obstacles in the integration of heterogeneous data in GIS. An innovative system was developed for timely epidemic analysis, and the production of epidemic maps using a multi-scale dynamic template technology. Finally, Dangermond et al. (2020) provided insights on the various possible uses of GIS applications in health emergencies world-wide, considering the COVID-19 pandemic as a case study. The development of detailed models on spatial and temporal diffusion with ad hoc data, digital flow (or route) maps, and data tracking, are crucial means in responding to such a pandemic according to the authors. GIS technologies have provided deep insight on spatial and temporal distribution of the virus since 2020, as well as a platform for simulation and analysis (geographical, geospatial, and geostatistical).

The present study focuses on the geographic and demographic aspects of mortality related to COVID-19; specifically, it aims to measure the impact of COVID-19 in the state of Kuwait in terms of mortality in 2020 with the help of Geographic Information System [GIS]. The impact is evaluated according to three demographic

categories: age, gender, and nationality status; furthermore, it is evaluated according to population density.

Prior work has suggested that COVID-19 mortality is correlated to factors such as age and population density (Caramelo et al., 2020; Mohamed et al., 2020). Whilst this appears to be the case in various locations globally, the reality is more complicated and multiple factors need to be considered when assessing the mortality of a pandemic like COVID-19. To the authors' knowledge there has been no study investigating the impacts of multiple demographic and geographical factors in a single statistical framework. This has been identified as a research gap in the field of population geography, namely the determination of whether mortality due to COVID-19 is affected by multiple demographic factors (age, social status, and gender) as well as the population density.

To address this gap, a series of hypotheses and corresponding tests have been devised in the present article:

1. It is hypothesized that the mortality rate has increased in 2020 (COVID-19 pandemic year) versus the recent pre-COVID-19 period between 2016 - 2019 in Kuwait.

2. It is hypothesized that age, nationality status in Kuwait and gender are all significant factors of the mortality rate due to COVID-19.

3. It is hypothesized that population density in Kuwait is a significant factor of the mortality rate due to COVID-19 and the two variables demonstrate a positive correlation.

To test these hypotheses, the present study aims to:

1. Collect data about the parameters to be tested that potentially affect COVID-19 mortality (mortality data, population data, and demographic data).

2. Determine whether COVID-19 increased the mortality rate in 2020 compared to previous years via paired t-tests.

3. Determine whether COVID-19 mortality rate in 2020 differs for various demographic groups via a statistical comparison of the death rates for said groups.

4. Determine whether COVID-19 mortality rate in 2020 differs in regions of varying population density via a statistical comparison of the death rates for said regions.

It should be noted that this research is an extended paper for a bachelor's degree research report, and it is part of a larger project on COVID-19 and its impacts on population geography with multi demographic and socio-economic factors. The analysis presented in this paper relies heavily on statistical methods.

Method

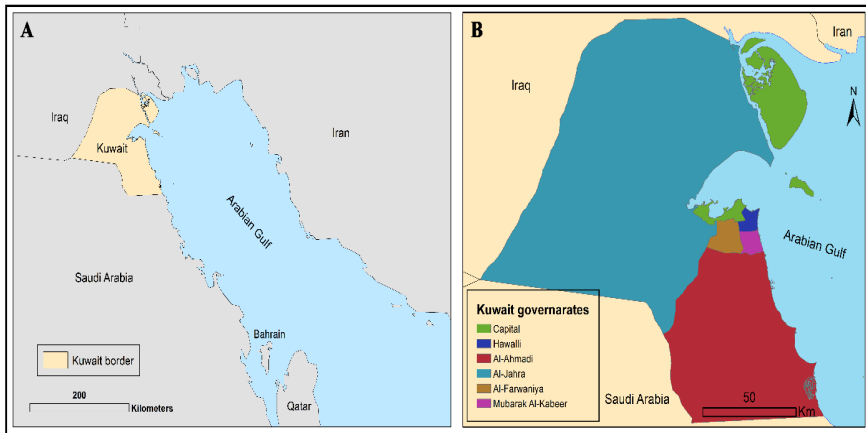
Demographic and sociopolitical data of Kuwait

In order to contextualize the analysis, a variety of geopolitical and demographic data about Kuwait was collected and is presented in this section. A series of basic population data is illustrated to familiarize the reader with the inhabitants of Kuwait.

The state of Kuwait is a small monarchy country located in Northwest corner of the Arabian Gulf sharing its land borders with Saudi Arabia and Iraq as shown in Figure 1-A. 99% of Kuwait's residents live in urban areas (Al-Nakib, 2014). Furthermore, Kuwait is divided into 6 governorates (Capital, Hawalli, Al-Ahmadi, Al-Farwaniya, Al-Jahra and Mubarak Al-Kabeer) as shown in Figure 1-B.

Figure 1

A. The Location and Borders of Kuwait; B. Kuwait's Governorates

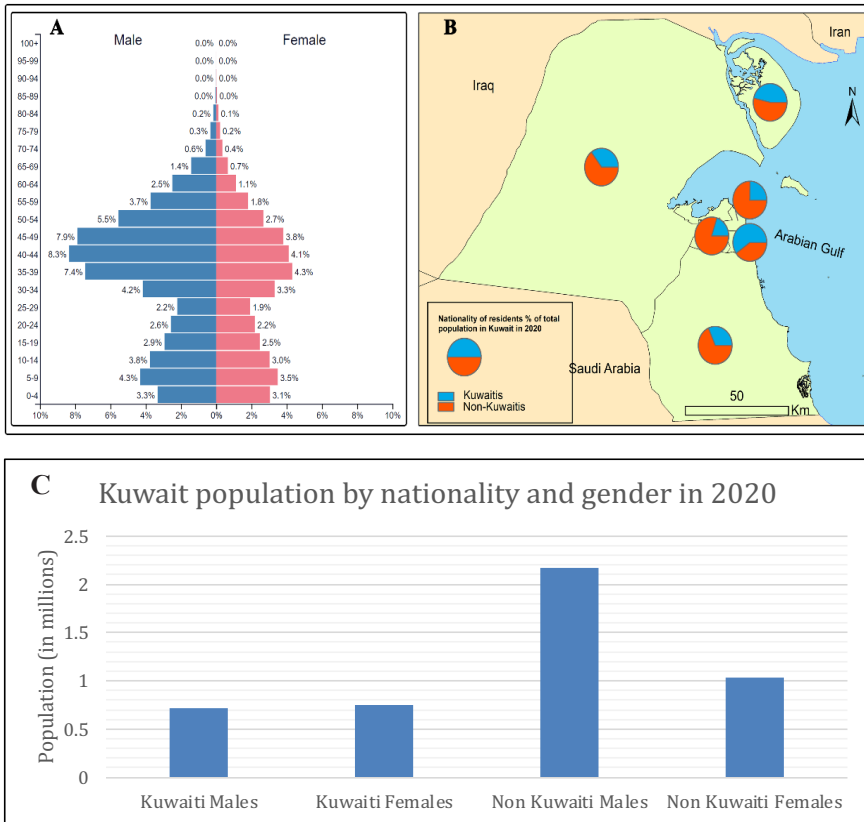


Source. (Alghais, 2018).

The total area of Kuwait is 17,818 square kms, whilst its population in 2020 was 4,670,713 according to the Public Authority for Civil Information (PACI, 2021). Non-citizens account for nearly 69% of the Kuwaiti population. The age pyramid of Kuwaitis, including non-citizens in 2020 is shown in Figure 2-A. In this figure, it is obvious that adults are the majority residents in Kuwait as the most of non-Kuwaitis are within this age group. Besides, the population composition by nationality and spatial distribution can be seen Figure 2-B. All governorates have majority of non-citizens except Mubarak Al-Kabeer governorate as can be seen. Whereas Figure 2-C shows the population breakdown by nationality and gender. It is clear that non-Kuwaitis males dominates the majority of the population in Kuwait with nearly 50%.

Figure 2

A. Population Pyramid in Kuwait in 2020; B. Population Composition Locals to Foreigners in each of Kuwait's Governorates; C. Kuwait Population by Nationality and Gender in 2020

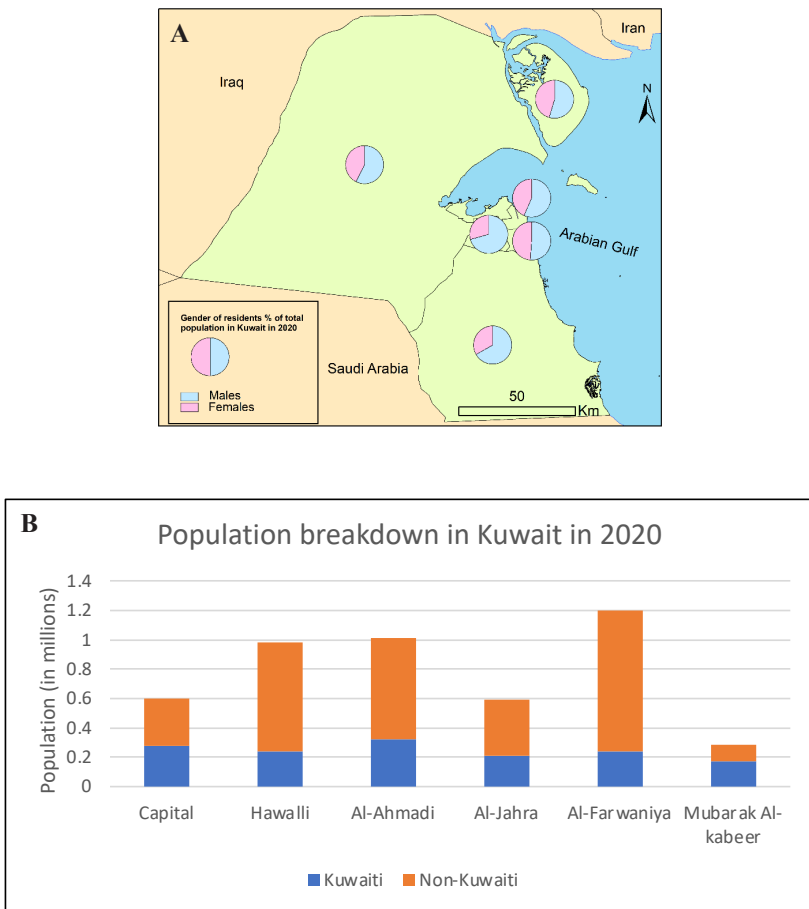


Source. (Population pyramid, 2021) (Central Statistics Bureau [CSB], 2021).

Finally, a map of the population distribution by gender and the unbalanced population in each governorate are shown in Figure 3-A and Figure 3-B respectively. From these two figures it is evident that non-citizens and males are the vast majority in all governorates. With the exception of Mubarak Al-Kabeer governorate due to its high population of Kuwaitis.

Figure 3

A. Population Distribution by Gender in each of Kuwait's Governorates; B. Population by Nationality in each of Kuwait's Governorates in 2020



COVID-19 in Kuwait (2020)

Further to the geopolitical and demographic data, data about the incidence of COVID-19 in Kuwait is extensively used in the

present article. As the analysis was conducted during 2022, the data is limited to the first year (2020) and part of the second year of the pandemic (2021).

The first COVID-19 case in Kuwait was formally recorded in early 2020. The official count for 2020 was 938 cases of mortality and 150,584 morbidity cases. The pandemic started officially with the first five cases on the 24th of February 2020. These cases were detected from passengers arriving to Kuwait from Iran (Abu Dhabi Agencies, 2022). The first COVID related death was recorded on the 4th of April 2020. The peak number of COVID-19 cases for the year 2020 was recorded on the 30th of May 2020 with 15,831 cases. In addition, the peak number of deaths caused by COVID-19 was on the 16th of May 2020 with 11 deaths (Kuwait Ministry of Health, 2021).

The state government, in alignment with many of its global counterparts, quickly implemented a set of public health measures to control the spread and impacts of the pandemic (Gasana & Shehab, 2020). On the 1st of March 2020 in person lessons across all levels ceased and only resumed on the 4th of October 2020 via online learning (Izzak, 2020). Schools reopened for in person learning in September 2021. Furthermore, on the 13th of March 2020 the government suspended all inbound international flights to Kuwait, except cargo flights until some commercial direct flights from select countries resumed on the 1st of August 2020 (Nagraj, 2021). On the 22nd of March 2020 the Kuwaiti government imposed a partial curfew for all residents starting from 17:00 to 04:00. Due to the deteriorating conditions, on the 10th of April 2020 the government enforced a complete curfew across the nation ("Kuwait cabinet", 2020) until it reverted back to a partial curfew from 18:00 till 06:00 on 31st of May 2020 (Wam, 2020). Over June and July 2020, the curfew times were gradually reduced ("Kuwait eases curfew", 2020; "Kuwait to ease", 2020; Nasrallah, 2021). The government disseminated a mobile application that was used by residents required

to book appointments for shopping for essentials or to seek medical attention during the partial curfew period.

Furthermore, on the 6th of April, lockdowns of two areas (Jeleeb Al-Shuyoukh and Mahboula) were implemented (Naar, 2020), with five additional ones following suit on the 31st of May 2020 (Farwaniya, Khaitan, Hawalli, Nukra and Maidan Hawalli). All lockdowns were eased a few weeks later and by the end of July there were no lockdowns in any area of Kuwait. The lockdowns in these districts were deemed necessary because of their high density. They contain buildings with over-crowded units occupied by non-citizen labor force workers. It is not uncommon for 10 workers residing in the same room in these suburbs, in order to overcome the highly priced accommodations. This living arrangement naturally poses higher risk of transmission of COVID-19 due to proximity of the tenants and lower hygienic standards (Singh et al., 2020).

On the 19th of April 2020 the government started to evacuate all Kuwaiti citizens that happened to be stranded when the borders closed around the world. The process was mostly complete by May 2020, with the repatriations to Kuwait occurring in five stages bringing approximately 50,000 citizens in 185 flights from 58 destinations (AlFaam, 2020; "Comprehensive return operation", 2020; "Kuwait ends evacuating", 2020). Furthermore, more than 30,000 non-citizens have left Kuwait to their countries of origin as well (Al-Abdullah, 2020). Besides, on the 27th of December 2020 Kuwait launched its campaign on COVID-19 vaccination, with priority given to the elderly and healthcare workers (Marah, 2020).

Overall, Kuwait has successfully countered the first wave of the COVID-19 pandemic with relatively low losses of lives and cases comparing to other countries. Throughout 2020, it has continued its close cooperation with the WHO, an initiative that has been sincerely acknowledged by the Director-General of the organization (Sanad, 2020).

Data sources and preparation

The data used in this study was collected from Kuwait government’s ministries and authorities and then prepared to be used in ArcMap (GIS software). All data were collected from official public websites with no permissions needed. Besides, there are no human subjects in this article and informed consent is not applicable. The data sources are shown in Table 1.

Table 1

Data Sources

Data	Type	Source
Kuwait governorates map.	GIS layer in SHP format.	(GIS & RS Consultation Unit, 2021).
Kuwait urban neighborhoods (blocks).	GIS layer in SHP format.	(GIS & RS Consultation Unit, 2021).
Population on governorates.	Tables in PDF format.	(PACI, 2021).
Demographic data (size, age, gender and nationality).	Tables in PDF format.	(CSB, 2021).
Mortality rate and causes (2016-2020).	Tables in Excel format.	(CSB, 2021).
COVID-19 cases and death rates.	JPEG format.	(Kuwait Ministry of Health, 2021).

Kuwait governorates layer and Kuwait urban neighborhoods layer were used to create a new layer showing the governorates’ urban area in order to calculate the urban density and overlay COVID-19 mortality. The data was disaggregated to derive the COVID-19 mortality figures according to various population demographic parameters (size, age, gender and nationality) and entered into the attribute table for Kuwait governorates layer for further analysis. All data was classified according to year: 2016-2019 for data prior to the pandemic and 2020 for data during the first year of the pandemic.

Due to the data being very recent and hence often incomplete, certain assumptions and modifications were applied before using it in GIS platform:

- Some mortality data locations were unknown (not stated). These deaths were distributed uniformly across all the governorates.
- Some of the initial mortality data from CSB were flagged as incorrect; it was recalculated and corrected according to the updated information.
- Population size for 2016, 2017, 2018 and 2019 was not available (as there was no official census during these years) and hence the mortality for this period was not calculated based on Crude Death Rate [CDR].
- Most of the calculated outcomes' percentages (%) were rounded to the nearest one decimal place.

Statistical analysis

The statistical analysis in the present article is mainly relying on two mortality ratios: the Crude Death Rate and Crude Death Rate due to COVID-19. Both statistics show the number of deaths per number of people and are used broadly in all sorts of epidemiological, clinical and socioeconomic studies. The Crude Death Rate [CDR] and COVID-19 specific Death Rate which can be named COVID-19 CDR [CDR-COVID-19] for the readers' convenience were calculated according to the following equations:

$$CDR = \frac{\text{Total annual deaths}}{\text{Total population at specific year}} \times 100000$$

$$CDR-COVID-19 = \frac{\text{Total annual deaths due to COVID-19}}{\text{Total population at specific year}^{**}} \times 100000^{*}$$

* 100,000 was used to provide a more manageable CDR, due to the numerator being small compared to the denominator.

** In the present study, the calculation was only done for 2020.

In order to test the hypotheses raised in this article, a comparison of the normalized CDR and CDR-COVID-19 for each demographic was conducted. The null hypothesis assumes that there should be no difference in the relative magnitudes of the CDR and CDR-COVID-19 between groups. In other words, the null hypothesis suggests that there should be a similar mortality rate due to COVID-19 for each demographic group if the virus affects everyone equally. The alternative hypothesis states that there is a difference in mortality due to COVID-19 in certain demographic groups. Such groups will be observed to have multiple times higher CDR-COVID-19 compared to another group versus CDR compared to the same other group.

The normalization process for each demographic involves dividing each CDR and CDR-COVID-19 by the lowest results in each ratio for that demographic analysis (hence, there is always one group with “1” as the normalized CDR and CDR-COVID-19). This allows to easily compare the multiples of all groups for the two ratios. Since this is an important statistical technique, an example is illustrated below. Assume that there are three groups in a particular demographic, A and B. The normalized CDRs were calculated for each group and placed in a ratio of A:B equal to 1:b. Similarly the normalized CDR-COVID-19s were calculated and placed in a ratio equal to 1:b’.

- If $b=b'$, then the null hypothesis stands true, as the mortality rate due to COVID-19 appears to be the same as the general mortality rate for each of the groups. In this case the demographic does not appear to be a factor in the risk of mortality due to COVID-19.

- If $b > b'$, the alternative hypothesis is supported. This case indicates that group B dies less frequently due to COVID-19 compared to group A as its CDR is comparatively higher than its CDR-COVID-19.
- If $b < b'$, the alternative hypothesis is supported. This case indicates that group B dies more often due to COVID-19 compared to group A as its CDR is comparatively lower than its CDR-COVID-19.

The demographic categories that were tested included age, nationality, and gender for 2020. Furthermore, a comparison between the years 2016, 2017, 2018, 2019 against 2020 was conducted in an attempt to pinpoint the impact of COVID-19 on mortality in Kuwait. The comparison between the base period (2016-2019) and the COVID-19 pandemic (2020) was conducted via paired t-tests, the results of which may be found in Statistical analysis results section.

Spatial analysis

The spatial analysis following the collection and preparation of data provided a visualization of the results in maps that show any variation in COVID-19 related impacts between governorates. ArcMap was used to produce maps showing mortality and the impact of COVID-19 according to population density at a governorate level. Those maps are ought to be read in conjunction with the tables from the statistical analysis in order to start identifying the causes of variation between governorates and compare which ones did better than others in handling the pandemic.

For this step, a new layer (governorates urban area) was created from the data (governorates layer + blocks layer). This was completed with the help of the following tools:

- *Clip*: used to extract the governorate features that overlay the blocks features which allowed to cut from the governorates layer only the blocks, which correspond to the actual urban area.

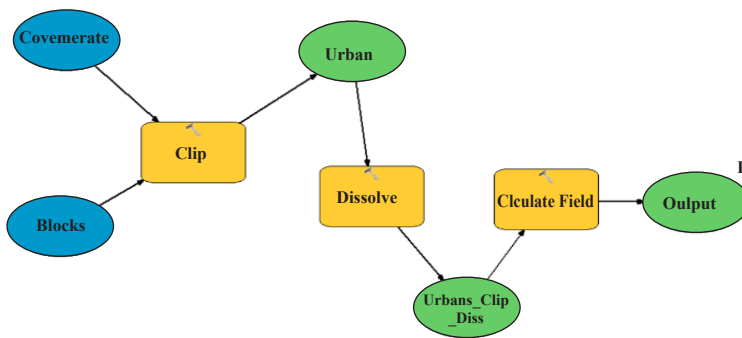
- *Dissolve*: used to aggregate and collect the clipped features of governorates layer in a new feature for each governorate based on the governorate's ID.
- *Calculate Field*: used to calculate the values of urban density for all governorates according to the following equation:

$$\text{Urban density} = \frac{\text{Total Population}}{\text{Total built area}}$$

The spatial data preparation model can be seen in Figure 4.

Figure 4

Flowchart of the Spatial Data Preparation Model

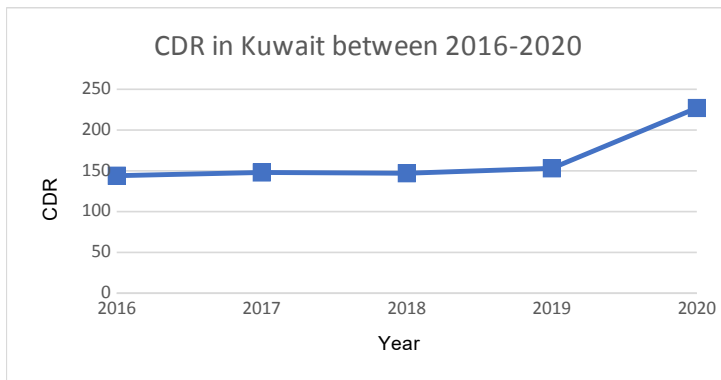


Results

Statistical analysis results

The first statistical task was to test whether the mortality in Kuwait increased during 2020 compared to the pre-COVID-19 period between 2016 - 2019.

CDR, as shown in Figure 5, has increased in 2020 when comparing to the previous years.

Figure 5*Crude Death Rate in Kuwait between 2016 – 2020*

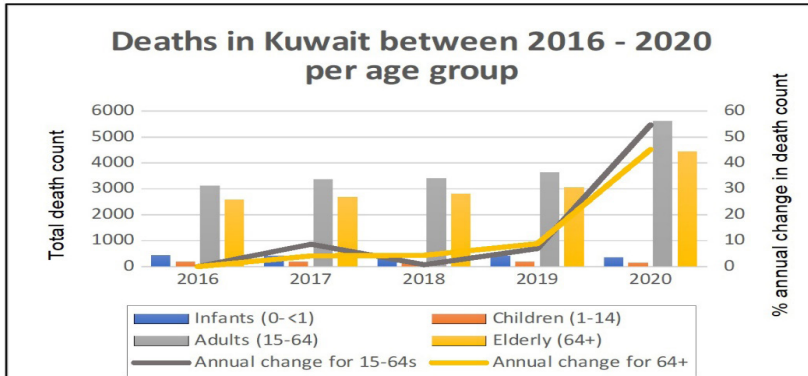
A paired t-test was conducted between the CDR in the pre-COVID years against the COVID year (2020). The null hypothesis stated that there was no difference in CDR between the pre-COVID and COVID periods. The alternative hypothesis claims that there was a higher CDR during the COVID period.

According to the results, the one tail p-value was 1.46×10^{-1} , which is much lower than an assumed α of 0.05; hence it can be said that the evidence suggests that there was a statistically significant increase in CDR during 2020.

In addition, total deaths were classified according to age (4 groups: infants, children, adults, elderly) and overlaid with the annual % change for the over 64s and under 64s as shown in diagram in Figure 6.

Figure 6

Total Deaths in Kuwait between 2016 – 2020 per Broad Age Group



Paired t-tests were conducted in the same fashion as earlier, comparing the death count for each age group during the pre-COVID period against the 2020 count. The null hypothesis stated that there was no difference in CDR between the pre-COVID and COVID periods for each age group. The alternative hypothesis claims that there was a higher CDR during the COVID period for each age group.

For the infant and children’s groups, the alternative hypothesis can be rejected as the actual death count in 2020 was lower for both groups compared to the mean death count of the pre-COVID-19 period. For the adult and elderly groups, the one tail p-values were calculated as 0.00012 and 0.00025 respectively. Both are lower than the assumed α value of 0.05, so the alternative hypothesis can be accepted.

The next statistical step involved an attempt to understand the actual impact of COVID-19 on mortality rates for each age group and the calculation of CDR and CDR-COVID-19. Table 2 shows the percentage of COVID-19 deaths compared to total deaths for each age group and as a percentage of for the group’s population. It also includes the CDR and CDR-COVID-19 ratios. The reader shall refer to Statistical analysis section for reviewing the relevant calculations as necessary.

Table 2

Mortality Statistics According to Age in Kuwait, 2020

Age group	COVID-19 deaths	Total deaths	Total population	COVID-19 % of all deaths in group	COVID-19 deaths as % of population in group	CDR	CDR-COVID-19
0->1	1	365	49372	0.27%	0.00%	739	2.02
1-14	3	142	828718	2.11%	0.00%	17	0.36
15-64	520	5625	3669200	9.24%	0.01%	153	14.2
64+	410	4437	118168	9.24%	0.35%	3755	347.0

In order to compare the CDR and CDR-COVID-19 statistics for the various demographic groups, the calculations had to be normalized by dividing each ratio by the lowest result. For instance, all CDRs were divided by 17, which was the lowest CDR in the children group and all CDR-COVID-19s were divided by 0.36, which was the lowest CDR-COVID-19, also in the children group. The results (after rounding to the nearest whole number) indicate that:

- The CDRs by broad age group are in the ratio: 43:1:9:221 (infants: children: adults: elderly).
- The CDR-COVID-19s by broad age group are in the ratio: 6:1:39:964 (infants: children: adults: elderly).

Following the statistical analysis of the data per age group, a similar mortality analysis was carried out according to nationality status and gender, in order to identify any potential trends. Tables 3 and 4 summarize the results for nationality status and gender respectively.

Table 3

Mortality Statistics According to Nationality Status in Kuwait, 2020

Nationality	COVID-19 deaths	Total deaths	Total population	COVID-19 % of all deaths in group	COVID-19 deaths as % of population in group	CDR	CDR-COVID-19
Kuwaitis	366	4931	1459661	7.42%	0.03%	338	25.0
Non-Kuwaitis	568	5638	3205797	10.07%	0.02%	176	17.7

Similar to the prior step, the CDRs and CDR-COVID-19s for nationality status were normalized by dividing by 176 and 17.7 respectively. The results indicate that:

- The CDRs by nationality are in the ratio: 2:1 (Kuwaitis: Non-Kuwaitis).
- The CDR-COVID-19s by nationality are in the ratio: 1.4:1 (Kuwaitis: Non-Kuwaitis).

Table 4

Mortality Statistics According to Gender in Kuwait, 2020

Gender	COVID-19 deaths	Total deaths	Total population	COVID-19 % of all deaths in group	COVID-19 deaths as % of population in group	CDR	CDR-COVID-19
Male	666	7036	2889478	9.47%	0.02%	243	23.1
Female	268	3533	1775980	7.59%	0.02%	199	15.1

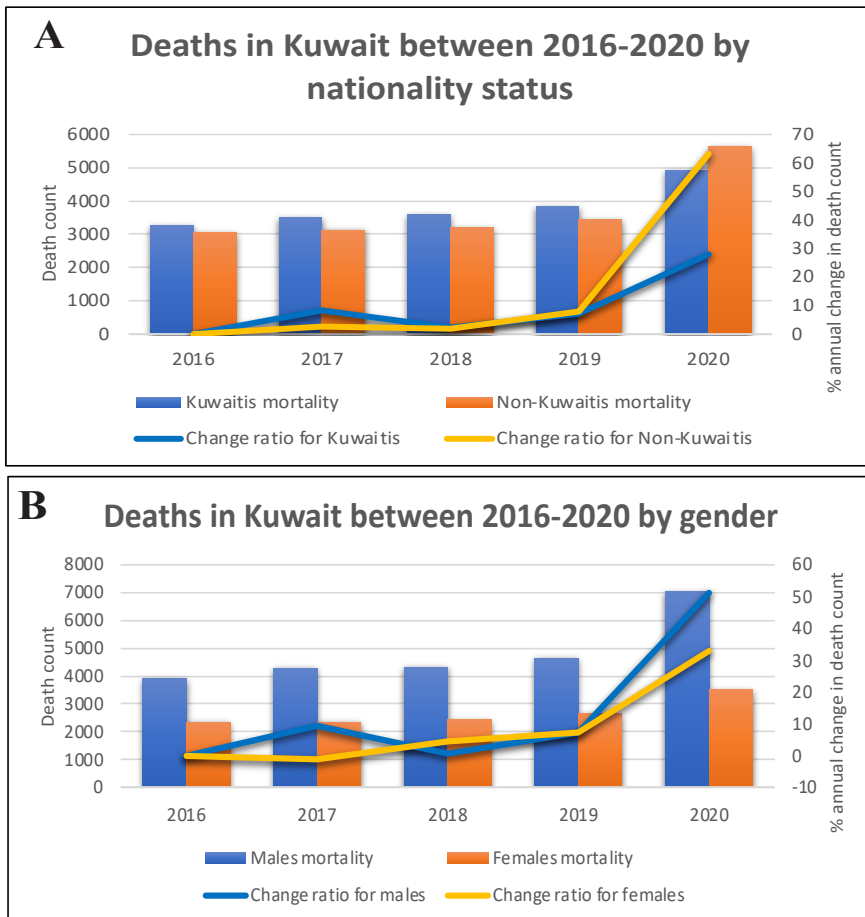
Similar to the prior steps, the CDRs and CDR-COVID-19s for gender were normalized by dividing by 199 and 15.1 respectively. The results indicate that:

- The CDRs by gender are in the ratio: 1.2:1 (male: female).
- The CDR-COVID-19s by gender are in the ratio: 1.5:1 (male: female).

Additionally, figures 7-A and 7-B compare the death count and annual change for both nationality groups and gender. From Figure 7-A, the most significant point was noted is that at the first time the non-Kuwaitis total death rates were more than Kuwaitis total death rates since 2016. Whereas in Figure 7-B, it is clear that males dominate the mortality for all the years since 2016.

Figure 7

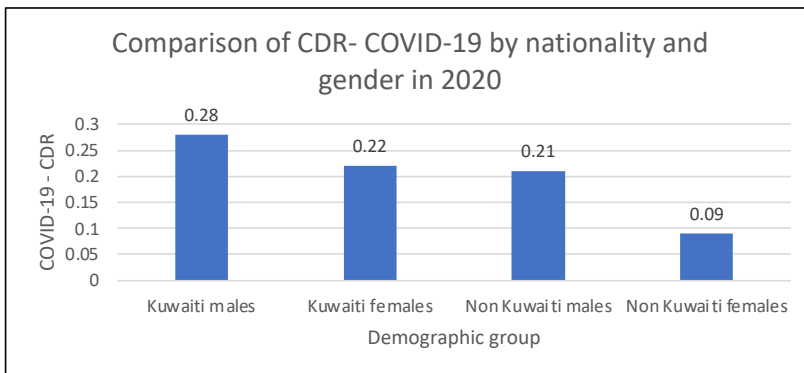
A. Total Deaths in Kuwait Between 2016 – 2020 by Nationality Status; B. Total Deaths in Kuwait Between 2016 – 2020 by Gender



Finally, a comparison of the CDR for each demographic of interest by nationality and gender is shown in Figure 8. In this figure, although the convergence of CDR-COVID-19 rates, Kuwait males are in the highest risk.

Figure 8

Compare COVID-19 Mortality by Nationality and Gender in 2020



Spatial analysis results

Following the statistical tests, localized analysis of mortality figures and ratios was conducted in order to investigate whether certain governorates were affected by the pandemic more than others and evaluate the government’s responses.

Figure 9-A shows the annual average death count in each governorate from 2016 to 2019. Whereas Figure 9-B shows the total death count and Figure 9-C shows the COVID-19 death count in 2020 in each governorate. By using the results as illustrated in Figures 9-B and 9-C, a ratio of COVID-19 deaths as a fraction of total deaths in each governorate was calculated and is shown in Figure 10. In this figure, the sort of the governorates by worst situation of COVID-19 incidents by mortality ratio is Al-Farwaniya, Al-Ahmadi, Hawalli, Al-Jahra, Capital then Mubarak Al-Kabeer.

Figure 9

A. Average Annual Number of Deaths in Governorates in Kuwait between 2016-2019; B. Death Count in Each Governorate in Kuwait in 2020; C. Death Count in Each Governorate in Kuwait in 2020 Due to COVID-19

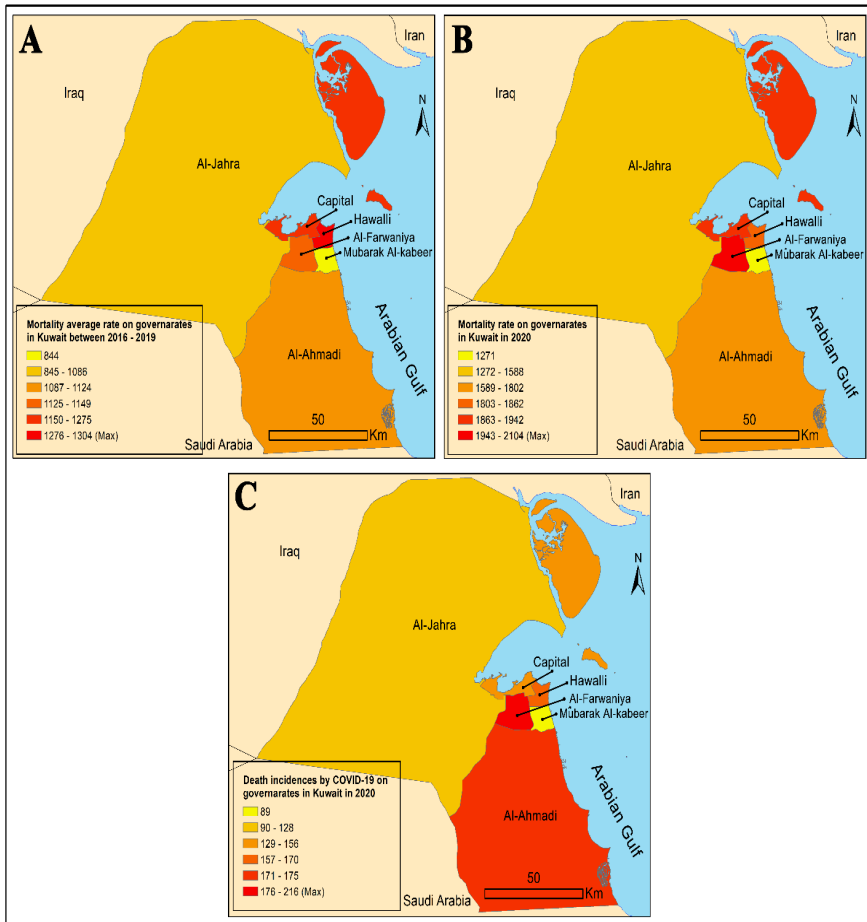
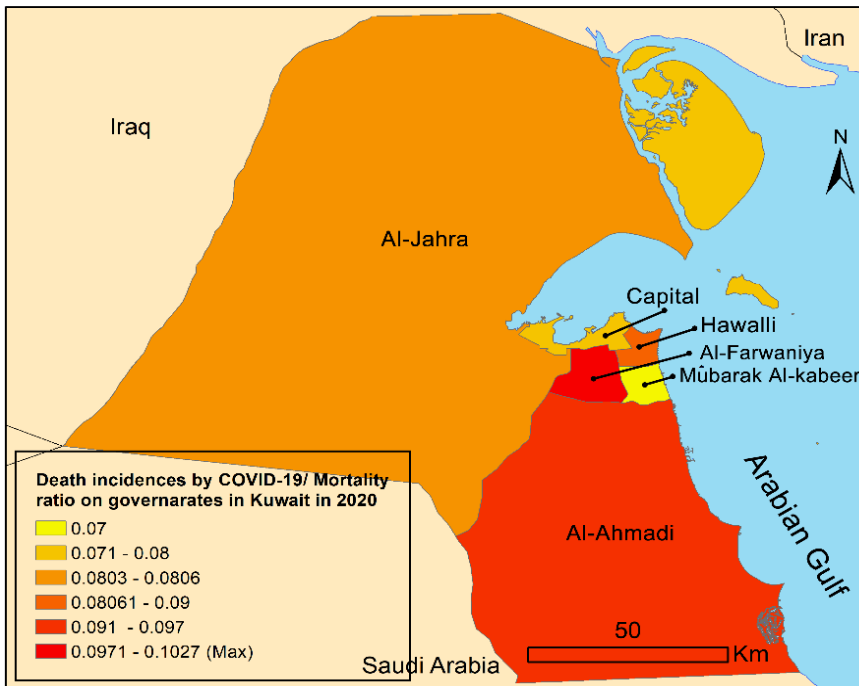


Figure 10

Fraction of Deaths Attributed to COVID-19 in Each Governorate of Kuwait in 2020



The final set of spatial calculations includes overlaying the CDR and CDR-COVID-19 spatially against population density. The null hypothesis states that population density would not make any difference in the expected COVID-19 deaths and hence the ratios of CDRs and CDR-COVID-19s for areas of various population densities would be similar. The alternative hypothesis would suggest that in areas with population density the CDR-COVID-19 will be relatively higher in comparison to the CDR; accordingly, it will be relatively lower in areas with low population density. Thus, Table 5 shows the mortality rates for each governorate of Kuwait.

Table 5*Mortality Data by Governorate in Kuwait, 2020*

Governorate	COVID-19 deaths	Total deaths	Total population	COVID-19 % of all deaths in governorate	COVID-19 deaths as % of population in governorate	CDR	CDR-COVID-19
Capital	156	1942	601356	8.03%	0.026%	323	26
Hawalli	170	1862	977864	9.13%	0.017%	190	17
Al-Ahmadi	175	1802	1008150	9.71%	0.017%	179	17
Al-Jahra	128	1588	588550	8.06%	0.022%	270	22
Al-Farwaniya	216	2104	1202166	10.27%	0.018%	175	18
Mubarak Al-Kabeer	89	1271	287372	7.00%	0.031%	442	31

The next step involved normalizing the CDR and CDR-COVID-19 results and putting them in a ratio by governorate to detect any potential differences that would support the alternative hypothesis.

- The CDRs by governorate are in the ratio: 1.8: 1.1 : 1 : 1.5 : 1 : 2.5 (Capital : Hawalli : Al-Ahmadi : Al- Jahra : Al-Farwaniya : Mubarak Al-Kabeer)
- The CDR-COVID-19s by governorate are in the ratio: 1.5: 1 : 1 : 1.3 : 1.1 :1.8 (Capital : Hawalli : Al-Ahmadi : Al- Jahra : Al-Farwaniya : Mubarak Al-Kabeer)

Direct comparison of the ratios reveals that there are no significant deviations in CDR-COVID-19 from CDR for each governorate. In other words, the COVID-19 related mortality is in similar proportion to the general mortality across all areas. This evidence supports the null hypothesis, i.e., that population density does not have a significant impact in COVID-19 mortality.

In order to further test the hypothesis about the potential relationship between population density and COVID-19 deaths, the

urban density was calculated. As Kuwait is a sparsely populated country, with predominantly urbanized population centers, the built area (from data shown in Figure 4) was used in the density calculation instead of the real area of each governorate according to the mentioned formula in Spatial analysis section. Table 6 summarizes the results.

Table 6

Urban Density by Governorate in Kuwait, 2020

Governorates	Total population*	Real area (in km ²)	Built area (in km ²)	Urban density (person/ km ²)
Capital	601356	175	138.1	4354.5
Hawalli	977864	85	83.0	11781.5
Al-Ahmadi	1008150	5120	485.8	2075.2
Al-Jahra	588550	12130	261.6	2249.8
Al-Farwaniya	1202166	204	191.1	6290.8
Mubarak Al-Kabeer	287372	104	101.3	2836.8

Note. From the Kuwait Public Authority for Civil Information (PACI, 2021).

Plotting both mortality rates against the urban density reveals that there is no positive correlation whatsoever. This complements the evidence from earlier that the null hypothesis may be accepted – the population density does not appear to have any significant impact on COVID-19 mortality. Figure 11 shows the close alignment of the two mortality ratios, as well as the absence of any clear trend with population density. Finally, Figure 12 shows the spatial output of the CDR-COVID-19 per governorate. These two figures confirmed that there is no effect of urban density on COVID-19 mortality.

Figure 11

Mortality Ratios as Functions of Urban Density of Kuwait's Governorates

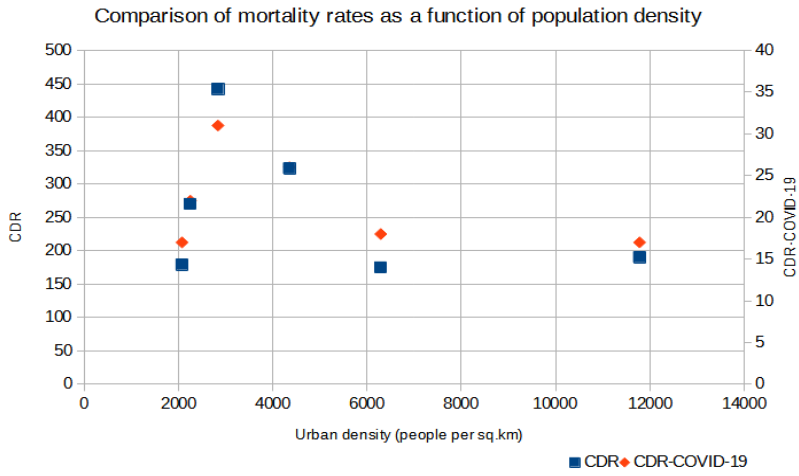
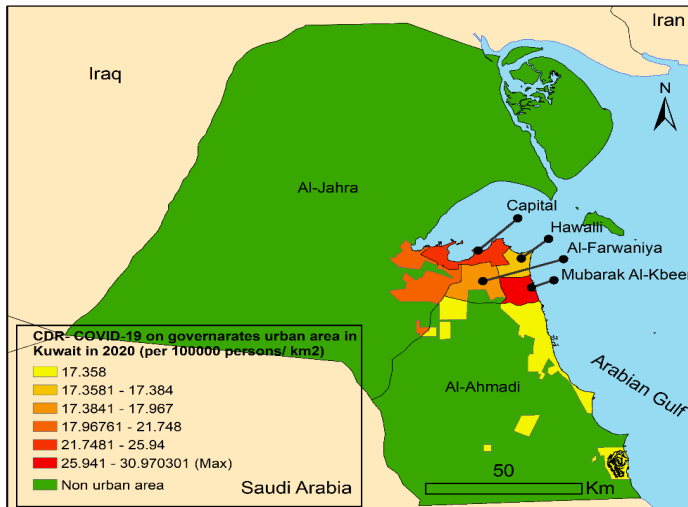


Figure 12

CDR-COVID-19 Map by Governorate, 2020



Discussion

COVID-19 and age groups

Firstly, according to the results shown in figure 5 and the following paired t-test, it is clear that mortality has increased in 2020. At the absence of any other explanation, this result strongly implies that the pandemic made a clear impact by raising the CDR in 2020. Investigating the effects of the pandemic in each age group (figure 6 and corresponding paired t-test), it can be concluded that the death count has increased for adult and elderly age groups during 2020, whereas it actually decreased for infants and children. The authors believe that parental concern and fear led to this direct reduction of their children's infection and mortality. Thus, this indicates that COVID-19 had a notably different impact on deaths in these two age groups in Kuwait. The explanation may be multifaceted, but factors for the reduced mortality among younger Kuwaitis include the lower risk of infection by COVID-19 or other diseases whilst staying and learning from home, and lower risk of accidents at home versus outside. Furthermore, global evidence suggests that COVID-19 is not a severe disease for younger kids. It is beyond the scope of this article to delve into the medical reasons for this observation, however the data from the current analysis appears to confirm this hypothesis.

On the contrary, many adults conducting essential work (hospitals, airport, supermarkets, army, police, etc.) were continuously exposed to the COVID-19 pandemic, which appears to have contributed to their relatively higher death count. Similarly, the elderly, many of whom may have underlying health issues, were exposed to interactions with their carers or family and hence faced with higher risk of infection and death. This is confirmed by the significantly higher CDR-COVID-19 calculation for the elderly group. However, it may be argued that if it was not for COVID-19, these elderlies may have got ill and/or passed away due to another disease or condition.

It is beyond the scope of this paper to investigate this claim; the authors simply confirm that the CDR-COVID-19, i.e. the rate of deaths compared to the group size for the elderly due to COVID-19 is significantly higher than any other group.

According to the calculated ratios of CDR and CDR-COVID-19 for each age group, it is evident that COVID-19 affects adults and the elderly the most. There are about 4 times as many deaths as expected in both adults and elderly groups due to COVID-19. On the contrary, there are approximately 7 times fewer deaths than expected due to COVID-19 in the infants group. Hence, it can be concluded that the alternative hypothesis is supported by the evidence and age is a significant factor in COVID-19 mortality.

COVID-19 and nationality status

In relation to nationality status of the deceased, Table 3 indicates that the percentage of COVID-19 deaths compared to total deaths of each group was similar in magnitude. However, both the CDR and CDR-COVID-19 were notably higher for Kuwaitis compared to non-Kuwaitis. An important reason behind this observation may be that the curfew that was mandated by the government in high density districts populated by non-Kuwaitis reduced the COVID-19 cases and death rates in this group. Furthermore, most of the working employees in essential roles during the lockdown period were Kuwaiti citizens, which may have boosted COVID-19 deaths, as they may have accumulated greater viral load than non-Kuwaitis (mainly working in construction and service industries, which were shut down completely). Finally, the average age of non-Kuwaitis is lower than Kuwaitis (since most of them are emigrating to the country at their younger working stage in life). This in turn may have contributed to the lower CDR for this group; Kuwaitis are older in general and hence there are more deaths expected in a typical year for this group.

From Figure 7-A, it can be seen that 2020 was the first time the non-Kuwaiti death count was higher than Kuwaiti death count total death rates since 2016. The annual percent increase in Kuwaiti deaths between 2020 and 2019 was 28% and in non-Kuwaiti deaths was 63%. Both these ratios are much higher than the averages for the pre-COVID-19 period – 5.8% increase for Kuwaitis and 3.9% for non-Kuwaitis. Non-Kuwaitis tend to reside in high density accommodations and districts, which appear to have increased their odds of serious infection and mortality from COVID-19.

The mortality ratio comparison confirms that if the null hypothesis was to stand true, there were 60% fewer deaths observed due to COVID-19 in the Kuwaiti group compared to the non-Kuwaiti group, as the CDR ratio was 2:1(Kuwaitis: Non-Kuwaitis) versus a COVID-19 CDR ratio of 1.4:1 (Kuwaitis: Non-Kuwaitis). Hence, the alternative hypothesis is supported by the evidence and the nationality status does indeed affect COVID-19 mortality.

COVID-19 and gender

Finally, Table 4 illustrates that males have a higher CDR-COVID-19 comparing to females. In fact, if the CDR and CDR-COVID-19 are compared for males and females, it can be concluded that the CDR-COVID-19 is much higher for males (25% more deaths than expected if the null hypothesis was true). This observation implies that males tend to be affected by this virus more adversely than females and hence the alternative hypothesis, that gender makes a difference in mortality due to COVID-19, is supported.

Figure 7-B shows that males dominate the raw number of deaths since 2016. This is not surprising as they constitute the higher ratio of the population in Kuwait. However, the point made previously about COVID-19 affecting males more can be extracted from the fact that the annual percentage increase of deaths in 2020 for males was much higher than females (51% vs 33%). Besides, any medical reasons for the mortality discrepancy between genders, the authors believe that the following have played a role:

- The majority of essential workers in the curfew period were males – hence, they were more likely to interact with COVID-19 carriers, be infected and potentially die.
- The majority of the group that appears to be more susceptible to COVID-19, non-Kuwaitis, are males (68%).

Nevertheless, comparing to the average annual increase in deaths in the pre-COVID-19 era of (males 5.7% and females 3.6%), the increase was substantial for both genders in 2020.

COVID-19 and urban density

In relation to the spatial distribution of deaths, and as seen in figures 9A, B and C, whilst all governorates experienced higher death count compared to the pre-COVID era in 2020, The impact was most obvious in Al-Farwaniya. This governorate is the home of a large majority of non-Kuwaiti males, a group with very high CDR-COVID-19, which justifies its poor performance.

The hypothesis that population density would trigger a positive correlation to the COVID-19 mortality can be rejected. According to the data in Tables 5 and 6 and the following analysis of the ratios summarized in Figure 11, CDR-COVID-19 does not demonstrate any notable positive correlation to the population density. In fact, the governorate with the highest CDR-COVID-19 was Mubarak Al-Kabeer, which is amongst the least densely populated regions. On the other hand, Hawalli, which has by far the highest population density, is tied for the lowest CDR-COVID-19. A possible explanation for that is densely populated areas that populated mostly by non-citizens may have more stringent public health measures and regulations, such as mask mandates and restrictions on large gatherings and their fear of deportation, which could help reduce virus spread and help mitigate the virus's impact.

Conclusion

In conclusion, the present study has investigated the relationship between COVID-19 mortality and demographic parameters in Kuwait in 2020 via statistical and spatial analysis. The results confirm that:

1. The mortality rate has increased in 2020 (pandemic year) versus the pre-pandemic years (2016-2019) in Kuwait across all governorates; there is evidence to reject the null hypothesis that the mortality rate was no different between 2016-2019 and 2020.
2. The mortality due to COVID-19 varies depending on all demographic parameters tested: age, nationality status and gender. There is evidence to reject the null hypothesis that the mortality rate was no different for all population groups. Furthermore, it is evident that multiple demographic and population factors need to be considered when assessing the epidemiological effects of an infectious disease.
3. The mortality due to COVID-19 does not appear to demonstrate any positive correlation to the urban density. There is not enough evidence to reject the null hypothesis that the mortality rate would increase with higher population density.

In respect to the mortality increase in Kuwait in 2020, it was about 50% on average (across all governorates) – however, it shall be noted that not all of this was due to COVID-19, as an unfortunate side-effect of the government’s restrictions was that ill citizens skipped or reduced their diagnoses and treatments for other conditions. It is out of the scope of this article to investigate how many such deaths contributed to the higher CDR in 2020; the authors acknowledge this as an opportunity for further research that may be useful in tweaking policy settings for future pandemics.

In regard to the relationship between COVID-19 deaths and age, it is evident that adults and the elderly suffered the worst in 2020 compared to the younger populace. This confirms empirical observations and all other studies suggesting the increasing risk of serious complications due to COVID-19 with age. In addition to age, an increased mortality ratio was statistically evident for males versus females. Both the age and gender factors (independently of each other) have been confirmed in the literature (Goldstein & Lee, 2020; Bhadra et al., 2021; Mohamed et al., 2020) said. More interestingly, a relationship emerged from the analysis between COVID-19 mortality and nationality status in Kuwait. Kuwait has the unique demographic setting that the majority of inhabitants are foreign workers without citizenship rights. Their lifestyle differs dramatically from that of Kuwaiti citizens. In regard to the pandemic, the main difference that may explain the difference in mortality is the living situation, as non-Kuwaitis tend to reside in overcrowded units in close proximity to other workers and have less access to open spaces and hygienic conditions than Kuwaitis.

Finally, the authors could not detect any relationship between the mortality rate due to COVID-19 and population density; in fact, the trend was somewhat counter-intuitive as governorates with lower density had a high CDR-COVID-19 and vice versa. The reason behind that could be using urban density rather than regular population density which the authors recommended as it shows more realistic results for density. Further investigation at higher resolution may reveal more interesting statistics and perhaps any underlying relationship (using density at a neighborhood/suburb level, rather than governorate).

As per the recommendations of similar studies, the authors endorse using GIS as a method for visualizing the impacts of COVID-19 on population in maps. Maps may be used in public health and political decision making, as well as epidemiological research. For instance, the worst affected governorate in Kuwait was identified by the analysis to be Al-Farwaniya, which hosts

the highest fraction of non-citizens and young males in Kuwait. Thus, it could be argued that the Kuwait government would focus its COVID-19 mitigation efforts, such as vaccination, healthcare monitoring, awareness raising and testing in this area and consider it as a high-risk zone in future epidemics or pandemics. Nevertheless, Kuwait policymakers can improve healthcare for most vulnerable population (Kuwaitis, males, elderly) by giving them priority in the vaccination campaigns, allowing the employees in these groups to work virtually.

Furthermore, the analysis presented in this study may be applied globally, and the hypotheses can be tested in other countries or regions. The authors believe that the outcomes of the statistical and spatial techniques presented in this article will be similar in other Arabian Gulf countries, as their population and demographic compositions are quite alike to those in Kuwait. Future research possibilities include studying the effects of COVID-19 vaccinations on mortality in Kuwait, as well as extending the CDR ratio comparison method to other demographic factors (education level, employment status, household income, household size etc.), other factors such as healthcare access, quality, and curfew, as well as population factors (comparison to other states in the Arabian sphere, comparison to other countries globally etc.).

References

- Abu Dhabi Agencies. (2020, February 24). Kuwait and Bahrain announce the first infections with the Corona virus. *Sky news Arabia* [in Arabic]. <https://www.skynewsarabia.com>
- Airhihenbuwa, C. O., Iwelunmor, J., Munodawafa, D., Ford, C. L., Oni, T., Agyemang, C., Mota, C., Ikuomola, O. B., Simbayi, L., Fallah, M. P., Qian, Z., Makinwa, B., Niang, C., & Okosun, I. (2020). Culture matters in communicating the global response to COVID-19. *Preventing Chronic Disease, 17*. <https://doi.org/10.5888/pcd17.200245>.
- Al-Abdullah, Y. (2020, May 12). 29 thousands expats have left the country since mid-March. *Aljarida* [in Arabic]. <https://www.aljarida.com/articles/1589213606622846600>
- AlFaam, R. (2020, April 14). With dates. Stages of the evacuation plan. *Alanbaa* [in Arabic]. <https://www.alanba.com.kw>

- Alghais, N. (2018). *Developing urban models to address population growth impacts and assisting with future urban planning in Kuwait and other Arabian Gulf countries*. [Doctoral dissertation, The University of Queensland]. <https://doi.org/10.14264/uql.2018.754>
- Al-Nakib, F. (2014). Towards an urban alternative for Kuwait: Protests and public participation. *Built Environment*, 40(1), 101–117.
- Benitez, J., Courtemanche, C., & Yelowitz, A. (2020). Racial and ethnic disparities in COVID-19: Evidence from six large cities. *Journal of Economics, Race and Policy*, 3, 243–261. <https://doi.org/10.1007/s41996-020-00068-9>
- Bhadra, A., Mukherjee, A., & Sarkar, K. (2021). Impact of population density on Covid-19 infected and mortality rate in India. *Modeling Earth Systems and Environment*, 7, 623-629. <https://doi.org/10.1007/s40808-020-00984-7>.
- Bherwani, H., Anjum, S., Kumar, S., Gautam, S., Gupta, A., Kumbhare, H., Anshul, A., & Kumar, R. (2021). Understanding COVID-19 transmission through Bayesian probabilistic modeling and GIS-based Voronoi approach: A policy perspective. *Environment, Development and Sustainability*, 23, 5846–5864. <https://doi.org/10.1007/s10668-020-00849-0>
- Caramelo, F., Ferreira, N., & Oliveiros, B. (2020). Estimation of risk factors for COVID-19 mortality-preliminary results. *MedRxiv*. <https://doi.org/10.1101/2020.02.24.20027268>
- Central Statistics Bureau. (2021). *Population statistics*. <https://www.csb.gov.kw/>
- Comprehensive return operation plan. (2020, May 7). *KUNA* [in Arabic]. <https://www.kuna.net.kw/>
- Dangermond, J., De Vito, C., & Pesaresi, C. (2020). Using GIS in the time of the COVID-19 crisis, casting a glance at the future. A joint discussion. *J-READING Journal of Research and Didactics in Geography*, 1, 195-205. <https://doi.org/10.4458/3099-16>
- Fang, H., Wang, L., & Yang, Y. (2020). Human mobility restrictions and the spread of the Novel Coronavirus (2019-nCoV) in China. *Journal of Public Economics*, 191, 104272. <https://doi.org/10.1016/j.jpubeco.2020.104272>
- Gasana, J., & Shehab, M. (2020). Coronavirus disease (COVID-19): Handling challenges in Kuwait. *Sci*, 3, 63. <https://doi.org/10.3390/sci2030063>
- GIS & RS Consultation Unit. (2021). *Collected GIS data*. College of Social Sciences, Kuwait University. <http://kuweb.ku.edu.kw/COSS/ar/CentersUnits/GIS/index.htm>
- Goldstein R. J., & Lee, R. D. (2020, November). *Demographic perspectives on the mortality of COVID-19 and other epidemics*. Proceeding at the National Academy of Sciences, USA. 117, 22035-22041 <https://pnas.org/cgi/doi/10.1073/pnas.2021355117>

- Izzak, B. (2020, March 19). Kuwait closes schools till August. *Kuwait Times*. <https://www.kuwaittimes.com/kuwait-extends-school-vacation-till-august-4/>
- Karmakar M., Lantz, P. M., & Tipirneni, R. (2021). Association of social and demographic factors with COVID-19 incidence and death rates in the US. *JAMA Network Open*, 4(1). <https://doi.org/10.1001/jamanetworkopen.2020.36462>
- Kuwait cabinet consider full coronavirus curfew. (2020, April 10). *Arab News*. <https://arab.news/>
- Kuwait eases curfew hours to start from 7 pm till 5 am effective June 21. (2020, June 19). *Arab News*. <https://www.arabnews.com>
- Kuwait ends evacuating its citizens from abroad by air. (2020, May 20). *Alkhaleej Online* [in Arabic]. <https://alkhaleejonline.net/>
- Kuwait Ministry of Health. (2021). *Cases by Date List*. <https://corona.e.gov.kw/en/Home/CasesByDate>
- Kuwait to ease curfew from June 30. (2020, June 25). *Gulf Insider*. <https://www.gulf-insider.com/>
- Marah, M. (2020, December 27). Officially... the start of the vaccination campaign against "Corona" in Kuwait. *Alqabas* [in Arabic]. <https://alqabas.com/>
- Mohamed, M. O., Gale, C. P., Kontopantelis, E., Doran, T., Belder, M., Asaria, M., Luscher, T., Wu, J., Rashid, M., Stephenson, C., Denwood, T., Roebuck, C., Deanfield, J., & Mamas, M. A. (2020, July). Sex differences in mortality rates and underlying conditions for COVID-19 deaths in England and Wales. *Mayo Clinic Proceedings*, 95, 2110–2124. <https://doi.org/10.1016/j.mayocp.2020.07.009>
- Naar, I. (2020, May 20). Coronavirus: Kuwait orders two areas into full lockdown. *Alarabiya News*. <https://english.alarabiya.net/News/gulf/2020/04/06/Coronavirus-Kuwait-orders-two-areas-into-full-lockdown-extends-partial-curfew-to-6->
- Nagraj, A. (2021, June 29). Kuwait to resume direct flights to 12 destinations, opens land and sea borders for vaccinated citizens. *Gulf Business*. <https://gulfbusiness.com/>
- Nair, S. C., Gasmelseed, H. I., Khan, A. A., Khafagy, I.N., Sreedharan, J., Saleem, A. A., Abdrhman, H. I., Alhosani, A. H., Siddiqua, A. R., Ahmed, A. R., Shubbar, A. I., Aleissae, A. R., Alanqar, A. W., Hamadeh, A. M., Safdani, F. A., Habbal, F. W., Shoker, H. B., Bashir, K. M., Alblooshi, M. A., ... & Doileh, W. F. (2021). Assessment of mortality from COVID-19 in a multicultural multi-ethnic patient population. *BMC Infectious Diseases*, 21, 1115. <https://doi.org/10.1186/s12879-021-06762-9>
- Nasrallah, T. (2021, March 22). Kuwait changes partial curfew timing. *World Gulf*. <https://gulfnnews.com/world/gulf/kuwait/kuwait-changes-partial-curfew-timing-1.78022175>
- Newbold, K. (2017). *Population geography: Tools and issues* (3rd ed.). Rowman & Littlefield.

- Public Authority for Civil Information. (2021). *Statistical Services Systems*.
<https://www.paci.gov.kw/stat/Default.aspx>
- Population pyramid. (2021). *Population Pyramids of the World from 1950 to 2100*.
<https://www.populationpyramid.net/kuwait/2020/>
- Ramírez, I., & Lee, J. (2020). COVID-19 Emergence and social and health determinants in Colorado: A rapid spatial analysis. *International Journal of Environmental Research and Public Health*, *11*, 3856. <https://doi.org/10.3390/ijerph17113856>
- Rimawi, A., & Rimawi, A. (2021). COVID-19-associated mortality across the countries of the Gulf Cooperation Council and how it compares to Europe: A comparative study. *Qatar Medical Journal*, *2*(28), 1-7. <https://doi.org/10.5339/qmj.2021.28>
- Sanad, A. (2020, April 4). Kuwait continues its humanitarian approach in light of its efforts to combat the Corona virus. *KUNA* [in Arabic]. <https://www.kuna.net.kw/ArticleDetails.aspx?id=2884089&language=ar#>
- Singh, I., Chand, K., Singh, A., & Kandadi, K. (2020). Time for a culture change: understanding and reducing risk, morbidity and mortality from COVID-19 in those of black and minority ethnicity. *British Journal of Hospital Medicine*, *5*, 1–4. <https://doi.org/10.12968/hmed.2020.0241>
- Shariati, M., Mesgari, T., Kasraee, M., & Jahangiri-rad, M. (2020). Spatiotemporal analysis and hotspots detection of COVID-19 using geographic information system (March and April, 2020). *Journal of Environmental Health Science and Engineering*, *18*, 1499–1507. <https://doi.org/10.1007/s40201-020-00565-x>
- Urban, R., & Nakada, L. (2021). GIS-based spatial modelling of COVID-19 death incidence in São Paulo, Brazil. *Environment & Urbanization*, *1*, 229-238. <https://doi.org/10.1177/0956247820963962>
- Wam. (2020, May 26). Coronavirus: Kuwait to end full Covid-19 curfew on May 30. *Khaleej Times*. <https://www.khaleejtimes.com/coronavirus-pandemic/coronavirus-kuwait-to-end-full-covid-19-curfew-on-may-30>
- WU, X., Nethery, R., Sabath, M., Braun, D., & Dominici, F. (2020). Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study. *MedRxiv*. <https://doi.org/10.1101/2020.04.05.20054502>
- Zhou, C., Su, F., Pei, T., Zhang, A., Du, Y., Luo, B., Cao, Z., Wang, J., Yuan, W., Zhu, Y., Song, C., Chen, J., Xu, J., Li, F., Ma, T., Jiang, L., Yan, F., Yi, J., Hu, Y., & Xiao, H. (2020). COVID-19: Challenges to GIS with Big Data. *Geography and Sustainability*, *1*, 77–87. <https://doi.org/10.1016/j.geosus.2020.03.005>

Dr. Nayef Alghais, Associate professor at Kuwait University, Department of Geography. Ph.D. in Geography from the University of Queensland, Australia (2018). Research interest in GIS, Urban modelling, Population Geography, Urban planning and Urban Geography.
E-mail: nayef.alghais@ku.edu.kw

Barrak Alkharaz, Employee at Ministry of Defense-Kuwait. BA. D. in Human Geography and GIS from Kuwait University, Kuwait (2022). Research interest in GIS, Urban planning and Human Geography.
E-mail: balkharraz@gmail.com

To cite:

Alghais, N. F., & Alkharaz, B. A.(2024). Statistical and spatial analysis of the impact of COVID-19 mortality on some demographic factors in Kuwait in 2020. *Journal of the Gulf and Arabian Peninsula Studies*, 50(192), 425- 464.
<https://doi.org/10.34120/jgaps.v50i192.185>