

# The Epidemiological and Spatio-temporal Characteristics of 2019 Novel Coronavirus Diseases (COVID-19) in Libya

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## Research article

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# Abstract

**Background:** COVID-19 is a global pandemic that affected all aspects of life. Studies on understanding the geographical and epidemiological characteristics become particularly important in controlling the spread of the pandemic. Such studies are lacking in Northern African countries particularly in Libya, which considered being, the second largest country in Africa with the longest coast facing Europe. The objectives of this study are to; determine the epidemiological parameters and spatiotemporal patterns of COVID-19 in this large country and outline the needed strategies to contain the spread and the consequences of the pandemic.

**Methods:** This comprehensive study included all the confirmed cases of COVID-19 since its emergence in Libya, from early April 2020 until August 31<sup>th</sup>. The epidemiological characteristics of COVID-19 were analyzed and the spatial dynamic trends were explored. A region -based counts of weekly reported cases were used to characterize and quantify the spatial dynamics of COVID-19.

**Results:** A total 3695 of confirmed cases of OVID-19 were collected, 2515(68.1%) were males and 1180(31.9%) female with a male-to-female(M:F) ratio 2.1:1. Aged between 2 -78 years old. Older age patients infected with COVID-19 are at higher severity and mortality. A broad geographic variability and Spatiotemporal spread variation of the COVID-19 pandemic in Libya was observed. Indicating a higher significant increase of COVID-19 from the middle of July particularly in the West and Southern regions although it was consistently observed in Meddle and Southern regions.

**Conclusion:** Evaluating the epidemiological data and the spatiotemporal dynamic trends of COVID-19 at early stages are particularly important in understanding the pandemic spread. These parameters are essential in designing effective prevention and control programs aimed at reducing the impact of COVID-19 pandemic particularly in countries with limited resources.

## Background

The ongoing coronavirus disease (COVID-19) pandemic has reached each country in the world and no one can be considered safe. The pandemic affects all aspects of life, socially, economically, politically and even morally. Since its emergence, countries and health authorities responded comprehensively but differently[1]. However, the impact may vary both between and within countries, partly because of the degree to which control strategies are adopted and executed. Countries like, Sweden, and Germany responded early and successfully. Though others such as Italy, Spain and France, the action was different and thus it resulted in a high number of deaths [2-4] . The impact was even worse in developing countries such as Iran and Brazil as the early action was improper and influenced by virtual local understanding [5,6]. Hence then, the epidemiology and the impact of COVID-19 varies greatly from one country to another and thus understanding these epidemiological parameters became particularly important to each country.

In Africa, the Incidence of COVID-19 varies considerably between countries possibly reflecting variations in volumes of air travel and differences in coverage of SARS-CoV-2 testing [7]. The preparation of tackling COVID-19 is becoming increasingly difficult in Northern and sub-Saharan countries, where the effects of the internal armed conflicts and the emergence of other viral epidemic on the economy and health structures are still being felt [8,9]. However, only a few African states have been successful in implementing detection, prevention, and control measures. Yet the COVID-19 pandemic poses a challenge not only for fragile African countries but also for those with well-functioning health systems. Until now, studies evaluating the epidemiological and spatial spread of the COVID-19 pandemic in Africa are limited. However, understanding the spread of the COVID-19 outbreak is critical to predicting local outbreaks and developing public health policies during the early stages of COVID-19[10,11].

Libya, the second largest country in Africa with the longest coast in the Mediterranean facing Europe has been involved in an armed conflict since 2011. The country is considered vulnerable to the spread of infectious diseases such as COVID-19. As armed conflicts and internal instability challenge disease control and have a very deleterious effect on provision of health services [12,13]. Due to low levels of international commerce and travel in the country , the seeding of COVID-19 was delayed compared to other Northern African countries [ 14]. The first few cases of COVID-10 embarked in Libya were arrived from Italy and Egypt as early March this year. Now, that COVID-19 has taken a strong hold in the country, displaced people and immigrants can help spread from one city to another[15,16]. Accordingly, it is expected that COVID-19 is likely spreading rapidly and undetected in the Libyan community. Hence then understanding the epidemiological manifestations and local variation in the dynamics of the pandemic is a crucial step in developing more effective strategies for mitigating risk of infection in vulnerable communities. Unfortunately, to date, there is not a global and standard response to the pandemic and each country is facing the crisis based on their own possibilities, expertise and hypotheses [17].

Different studies have been made to analyze the epidemiological manifestations and geographic mapping of COVID-19[10,18]. Such information are particularly important not only in framing and controlling COVID-19 but also for planning, how to combat the consequences and aftermaths of this vital pandemic. However, there is lack of information regarding the epidemiology and clinical features of COVID-19 patients in North Africa, particularly Libya. Therefore, the objectives of this study were to evaluate the epidemiological and spatiotemporal distribution of COVID-19 in Libya and highlights the needed strategies and how appropriately allocate the healthcare resources to combat the spread of the pandemic.

## **Methods**

### **Patients' information and data collection**

The demographic data and epidemiological information, clinical symptoms and outcomes from all reported cases of COVID-19 between March 24,2020 till July 31,2020 allocated by National Centre for Disease Prevention (NCDC)were collected. All investigation, contact tracing, and quarantine were

conducted by the NCDC at regional or district level. The data were recruited from all registered patients and extracted from the hospital records and checked by clinical epidemiologist. Furthermore, the daily-updated numbers were cumulated from all confirmed COVID-19 cases across all the Libyan regions.

## Case definitions

The definitions of the confirmed cases of COVID-19 were based on our previous publication [14,19]. Among all confirmed cases, the degree of clinical severity was categorized as following criteria : Mild cases were defined are those with only mild symptoms, without evidence of pneumonia and even they don't require oxygen therapy. Moderate cases are those with fever, respiratory tract symptoms, and imaging shows pneumonia. Severe cases are those who have of the following signs: (a) respiratory distress, respiratory rate 30 beats / min; (b) in the resting state, finger oxygen saturation 93%) arterial blood oxygen partial pressure (PaO<sub>2</sub>/oxygen concentration (FiO<sub>2</sub>) 300 mmHg (1 mmHg = 0.133 kPa). Critical cases were defined as those who are exhibiting , respiratory failure, requires mechanical ventilation and septic shock occurs. ICU admission is required with multiple organ dysfunction/failure.

## Laboratory testing of COVID-19

Laboratory confirmation of COVID-19 is being done by the National Center for Disease Control. Nasopharyngeal and oropharyngeal swab samples are collected following standard safety procedures. RNA is extracted using QIAamp™ viral RNA mini kit from Qiagen™ according to the manufacturer's instructions, as previously published [20]. Analysis is done by the real-time reverse transcriptase-polymerase chain reaction (RT-PCR) for all suspected cases following the protocol established by the WHO. Biosafety cabinets are used and the work is done according to laboratory biosafety guidelines [21].

## Statistical analysis

A descriptive statistical analysis was performed to analyze the epidemiological characteristics of confirmed cases of COVID-19 using computer software version 11.0 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP). Logistic regression was conducted to identify the factors associated with COVID-19 infection. Data were expressed as means ± standard deviation (SD), and as number and percentage with 95% confidence interval (CI), as appropriate. Spatiotemporal analysis and geographic mapping of COVID-19 cases was carried out using GraphPad Software as previously described[22-24]

## Results

The study population consisted of all confirmed cases of COVID-19 reported in Libya by July 31 (12.00 AM) 2020. A total of 3695 were reported , the epidemiological and clinical characteristics of the these

cases were illustrated in Table 1. Of 3695 cases , 2515(68.1%) were males and 1180(31.9%) female with a male-to-female(M:F) ratio 2.1:1. Aged between 2 -78 years old. The number of a live cases was reported to be 3621(98%) and only 74 ( 2%) cases we dead. The case fatality rate was higher among males 53 (71.6%), though it was only 21(28.4%) among females. Of the deceased cases 39 (52.7 %)  $\geq$  55 age group particularly over 66 years , although only 5 (6.6%)cases below 40 years and 21 (28.4%)cases aged between 41 -55 years. Epidemiological investigations indicated that of these cases, 782(21.2%)were Imported , though 2913(78.8) cases acquired locally (  $p<0.001$ ). Those imported cases were mainly from Egypt 257(32.9%),Turkey 219(28%), Tunisia 209 (%26.7) and Saudi 96 (12.3%) cases .The largest number of cases was reported in Western Region with a total of 1755(47.5%) cases with 23(31.1%) deaths, followed by Southern Region 1133(30.7%)cases with 31(41.9) deaths. Although, Eastern Region reported 738(20%) cases and 9(12.2 %) deaths and the Meddle region has 429(11.1%) cases and 11(14.9 %) deaths . Of all confirmed case-patients, 2330(36.1%) were mild, 1108(30% )moderate, 128(3.5% ), sever and 91 129(3.5%) were critical. The highest mortality rate was reported among Critical and sever cases which was found to be 38(51.4%) and 26(35.1 %)respectively (  $P>0.001$ ) while it was only moderate 7(9.5 %) and mild 3(4.1%) and cases.

Table 1  
Epidemiologic Characteristics of 3695 confirmed case-patients with COVID-19  
Infection in Libya.

Demographic Characteristics	Alive	Death	Total	<i>P</i> value
<b>Total No (%)</b>	<b>(No = 3621)</b>	<b>(No=74)</b>	<b>(No=3695)</b>	
<b>Gender</b>				
Male	2462(68)	53(71.6)	2515(68.1)	<0.001
Female	1159(32)	21(28.4)	1180(31.9)	0.01
<b>Age group</b>				
≤ 15	86(2.38)	0(0)	86(2.3)	0.01
16-20	142(4)	0(0)	142(3.8)	0.01
21-25	161(4.5)	1(1.4)	162(4.5)	0.02
26-30	241(7.5)	0(0)	241(6.5)	0.01
31-35	271(7.5)	0(0)	271(7.3)	0.01
36-40	307(9)	3(4.1)	310(8.4)	0.01
41-45	327(9)	5(6.8)	332(9)	0.01
46-50	350(9.5)	7(9.5)	367(10)	0.01
51-55	379(10.5)	9(12.2)	388(10.5)	0.01
56-60	398(11)	13(17.6)	409(11.1)	<0.001
61-65	427(11.8)	15(20.3)	442(12)	<0.001
66	541(14.9)	21(24.4)	562(12.2)	<0.001

<b>Source of Infection</b>				
Imported	751(20.2)	31(42)	782(21.2)	0.01
Local	2870(79.3)	43(58)	2913(78.8)	<0.001
<b>Clinical severity</b>				
Mild	2327 (64.3)	3(4.1)	2330(36.1)	0.01
Moderate	1101(30.4)	7(9.5)	1108(30)	0.01
Sever	102(2.8)	26(35.1)	128(3.5)	<0.001
Critical	91(2.5)	38(51.4)	129(3.5)	<0.001
<b>Geographic region</b>				
Western Region	1732 (47.8)	23(31.1)	1755(47.5)	<0.001
Meddle region	418(11.5)	11(14.9)	429(11.1)	0.01
Southern Region	1102(30.4)	31(41.9)	1133(30.7)	<0.001
Eastern Region	729(20.1)	9(12.2)	738(20)	0.01

The age distribution of patients stratified by sex is shown in **Fig 1**. The median age of the infected cases was 55 years. 26.7 % were aged sixty or above and only 86 (2.4%) were children < 15 years old. The incidence of infection rates increased progressively with age with males showing higher rates except for the latest (greater than 65 years of life) ( $p = < 0.001$ ). This difference was also significant among patients above 50 years of age. The number of infected cases was a higher among males patients (68 %) indicating that men's cases of COVID-19 tended to be more serious than women's according to the clinical classification of severity.

The association between illness severity and age was shown in Fig. 2. It was shown that illness severity aggravated with age. The largest number Mild cases were reported among those aged below 45 years followed by moderate cases. moderate cases was higher among those aged below 45 years cases were mainly The large number of sever and critical cases were reported among older patients particularly after 60 years of age ( $P < 0.001$ ) which accounted for 45(44.1%) and 51 (56%) for mild and sever cases respectively.

Figure 3 shows the overall temporal trend of weekly counts of newly confirmed COVID-19 cases by four Libyan Regions during the study period. COVID-19 pandemic had occurred sporadically until early May (first nine epi-weeks); 120 confirmed cases were reported mainly in Western region with 97 cases. The number of weekly confirmed COVID-19 cases subexponentially increased across the country from the 10th to 17th epi-week, followed by a slowly decrease over recent weeks. During the entire observation period, the highest number were reported within the Western (47.8%), followed by Southern region (30.4%) Middle (30.4%) and East regions (20.1%) as shown in Fig 4. However, During epi-weeks 9-16, the proportion of confirmed cases decreased East and Middle region, but highly increased in South Regions (Figure 4).

The dynamics of COVID-19 during the study period was shown in Fig 5. In the first eight epi-weeks the emergence of the pandemic was detected in five counties in Western region including, Tripoli which hosted the largest number of cases followed by , Zawia, Surman, Aljalaet and Nalut. Two counties in Middle region, Musrata and Zleitan and only one county in Western region ( Benghazi) and Southern region (Sebha) as illustrated in Fig. 5A.

The results from geographic clustering analysis are robust. Starting in the 9th epi-week, new clusters were emerged and came out largely from the Southern and West regions ( $P < 0.001$ ). In the following epi-weeks pandemic spread all over the country and new cases were reported in each of the 22 counties as shown in Fig 5B. It is clearly evident that there is a positive correlation among the confirmed cases according to the geographical structure, and its spatial distribution has obvious agglomeration characteristics (Fig 5). The increase of confirmed cases in one city will inevitably lead to the increasing cases in adjacent cities, which means that a positive spillover effect occurs. The highest number were reported in Sebha (Southern region), Tripoli (Western region) and Musrata (Middle region).

## Discussion

The epidemiological and clinical details of COVID19 pandemic in Libya are well characterized in this study. Up to July 31<sup>th</sup> a total of 3695 were reported which accounted of 6.2/10000 of population. The mean age was 53 years old, with a male to female ratio of 2.1:1. Of these patients, 74 (1.3%) were died. The largest number were reported in the Western and Southern regions which accounted for 1732 (47.8%) and 418 (11.5%) respectively. Though it was less in the Eastern 729 (20.1%) and Middle 418 (11.5%) regions . Our data showed that COVID-19 infects men more than women; these findings are in concordance with other studies reported from China and Iran [25,26]. Although, there is no obvious reason for such gender variability speculation has been raised regarding the hormonal and genetic variation or even to social culture particularly in Middle-east and African countries. However, other studies have shown , similar susceptibility to SARS-CoV-2 between males and females [27].

Taking the patients' age into consideration, children (<15 years) accounted only for 2.4 and those aged 20-50 years accounted for (4-9.5.%) although those aged over 60 years represents the largest number of infected cases which accounted for 10-24 %. This is clearly evident that COVID-19 among Libyan correspondence to a higher age. In fact most deaths in infected individuals occurred in Italy, Spain and

France occurred in old people suffering from severe conditions particularly in the early phases of the epidemics[28]. However, a recent study carried on the Libyan population demography shows that over 65 % of the Libyan population are aged less than 60 years old[29].

Based on our data the majority of the reported cases were mild 2327 (64.3%) and moderate 1101 (30.4%). Although only 102 (2.8%) were Severe and 91 (2.5%) Critical. The association between illness severity and age was evident in this study. It was shown that illness severity aggravated with age. Although the infected and deceased patients were significantly older than the patients who survived COVID-19, ages were comparable between males and females in both the deceased and the patients who survived. Furthermore, this study has showed that males tend to experience more serious cases of COVID-19 than females according to the clinical classification of severity including Mild, Moderate, Severe, and Critical. This is in agreement with other studies carried by Li *et al*, and Jian-Min *et al*. who showed that men's cases tended to be more serious than women's[19,30]. Therefore, gender may be considered as a risk factor for higher severity and mortality in patients with COVID-19, independent of age and susceptibility.

In this study we evaluated the spatial and temporal patterns of the COVID-19 pandemic in Libya within the first 16 Epi-weeks of the epidemic. In the early stage of the COVID-19 outbreak, few sporadic cases were reported in first six Epi-weeks in Tripoli at the Western region. By the end of the 8<sup>th</sup> epi-week, the cases spread to cities neighboring Tripoli such as Musrata and Zawia; the first-order neighboring cities showed a particularly increased number of confirmed cases. Since then, the number of weekly confirmed COVID-19 cases exponentially increased across the country from the 9<sup>th</sup> to 16<sup>th</sup> epi-week. During the entire study period, the prevalence of COVID-19 in Libyan regions showed striking variations. The epidemic was much higher and important in Western and Southern regions though it was less in Middle and Eastern regions. This is more likely to depend on the different timing of the onset of the outbreak in each region [31,32].

It is clearly evident in this study that the dynamics of the epidemic in Libya followed a geographical differentiation, with a strong West to South gradient, although no region was free of cases and deaths at the end of August. In all regions, both morbidity and mortality curves tended to depart from linear lines up and no sign of flattening with time, thus highlighting a critical situation of the epidemic. Similar trends were observed in early stages of spread COVID-19 in Italy, Spain and France. Hence then specific strategies should be implemented to contain the soaring of the pandemic [33,34].

Despite that the study gave a detailed information regarding the Epidemiology of COVID-19 in Libya. The reported data suffer from many uncertainties and limitations. These may include. First, the confirmed cases of COVID-19 might not reflect the actual number of persons infected by COVID-19 as many cases were asymptomatic and some went untested further to the limited testing resources in the country. Second the study did not highlight the impact of the ongoing armed conflict on spread of COVID-19 in Libya which defiantly hinder the accurate number of cases in certain cities. Third, the study, did not cover certain groups such as immigrants displaced population and injured people who are prone at higher risk of COVID-19 [35-37].

## **Conclusion**

This study is the first to provide information on epidemiological characterization and the spatial and temporal patterns of the COVID-19 pandemic in Libya. It is conclusively evident that the pandemic has affected the whole country, with incidence rates varying from region to another. Meanwhile, the prevention and control of COVID-19 in Libya is still a severe fight. We have seen the health system of the some European countries buckled under the surge of COVID-19 and appealed for help[38,39]. The internal conflict in Libya has affected the national health care system immensely. There is a dearth of information on the capacity to provide care for critically ill patients in ICUs in Libya in addition to lack of accuracy and efficient tracing policy of COVID-19 infected cases. Hence then, Swift action to control further spread of the virus, and to improve the response capabilities is urgently needed[40,41]. The study demonstrated the spatiotemporal characteristics and trends of COVID-19 in Libya which is essential to better focus on preventive efforts. The country must scale up its containment and mitigation strategies – quarantine, isolation, and social distancing. Establishing a functional infection prevention and control practices that could help to detect and to contain the ongoing epidemic[42,43]

## **Declarations**

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## **Ethical approval and consent to participate**

The Medical Ethics Committee at the Faculty of Medicine, University of Tripoli approved the study and waived the need for approval by the Libyan National Ethics Committee. As the study was an analysis of epidemiological data obtained at a national population level, it needed no consent from the participants.

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## **Availability of data and materials**

The data presented in this paper are freely available upon request.

## **Authors' contributions**

MD conceived and designed the study. MD and AE contributed to the analysis tools,. MD designed the analysis, analyzed the data, and performed cartography. MD wrote the paper. AE and MA; made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data MD, MA, and AE provided advice and critically reviewed the manuscript. All authors read and approved the final manuscript.

## Consent for publication

Not applicable.

## Competing interests

The authors declare that they have no competing interests.

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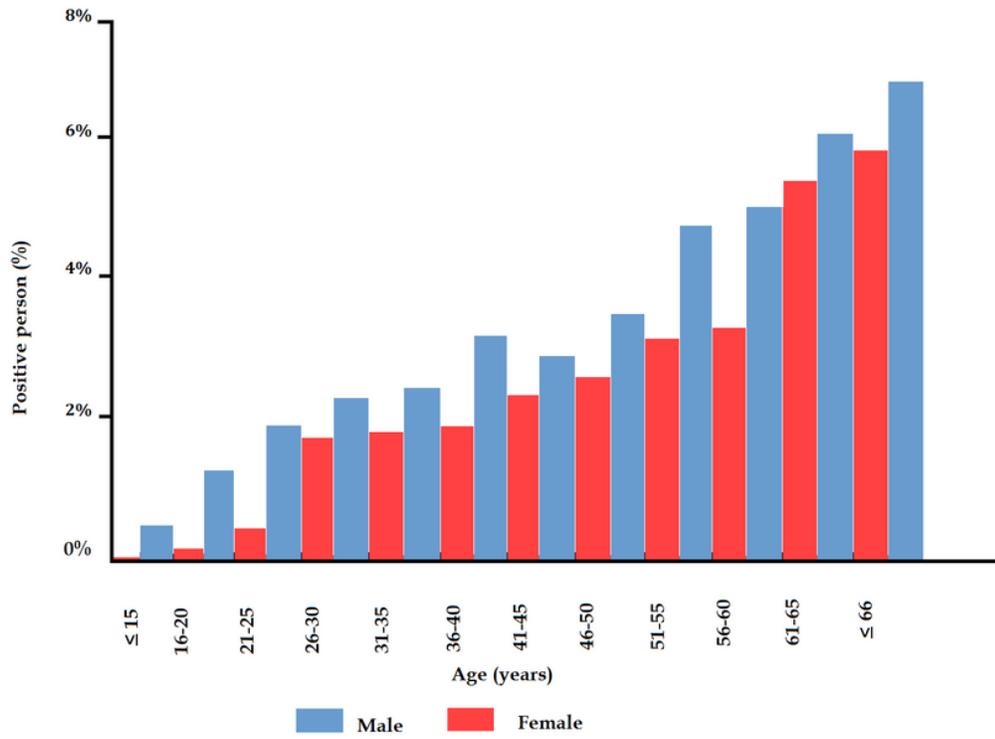
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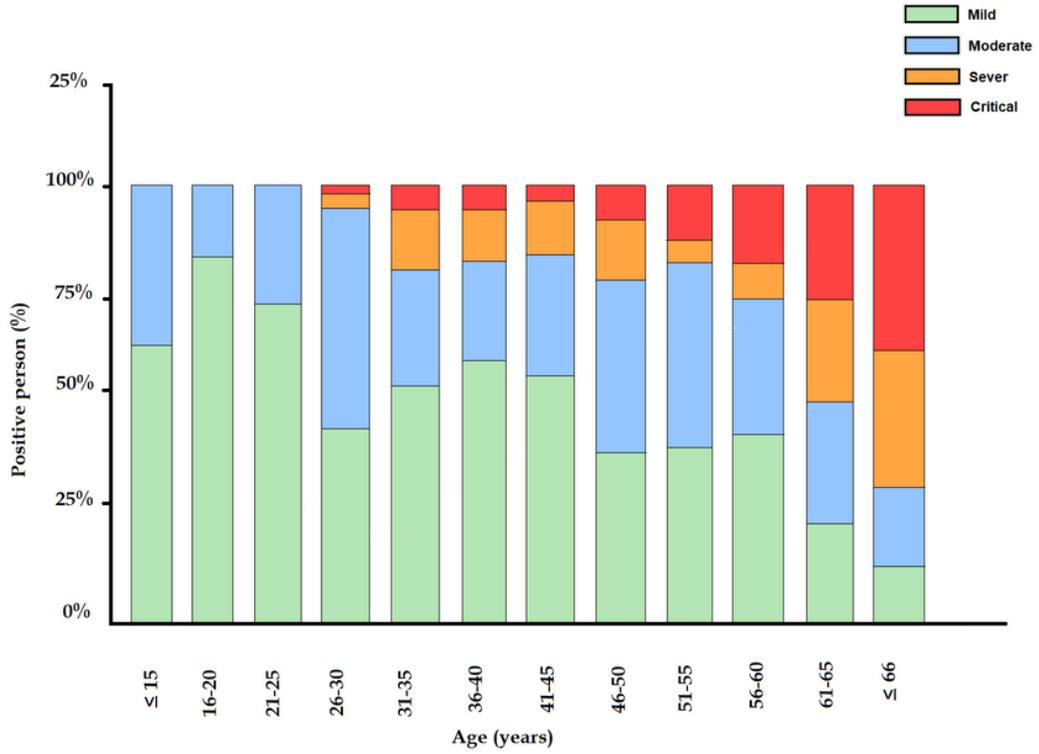
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## Figures



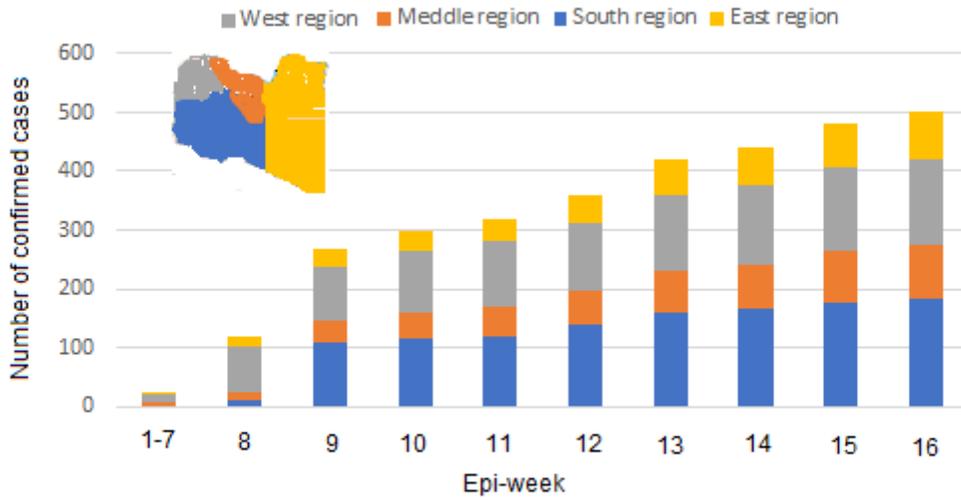
**Figure 1**

The age and gender distribution of confirmed cases of COVID-19 infection during the study period. Males (blue bars) and females (red bars)



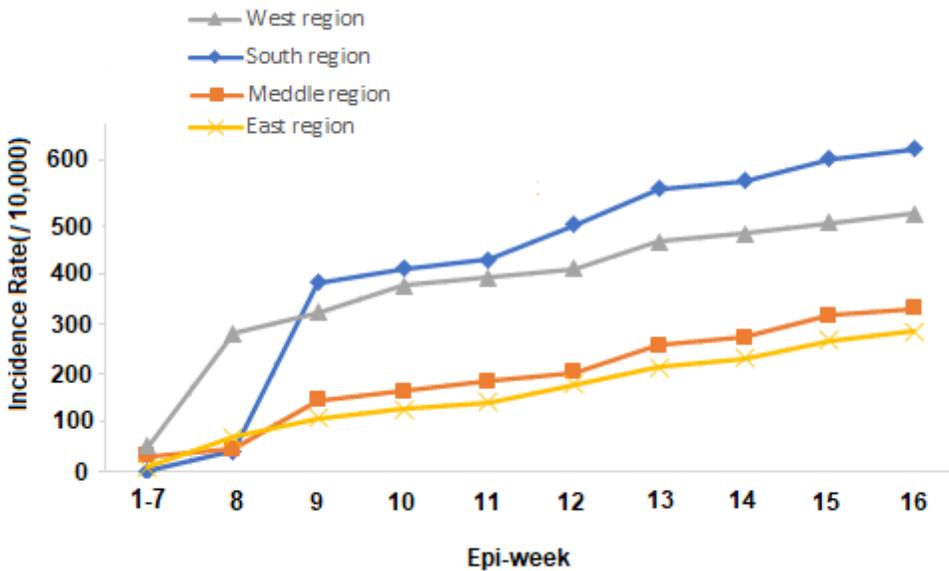
**Figure 2**

The clinical severity of confirmed cases with COVID-19 infection .The different version of definition for confirmed cases were marked, Mild, Moderate, Sever , Critical



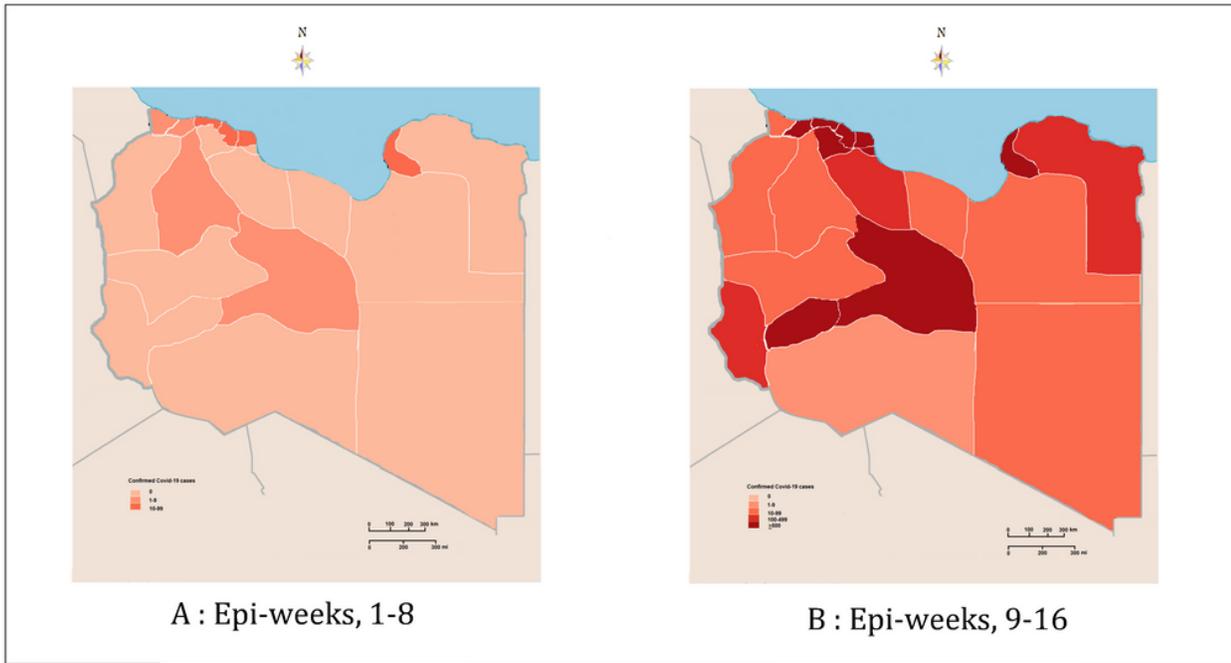
**Figure 3**

The weekly incidence trends of confirmed cases of COVID-19 in each Libyan region during the study period.



**Figure 4**

The prevalence of COVID-19 cases among the Libyan population across the four geographic regions over 16 epi-weeks, April 03–August 31, 2020.



**Figure 5**

Geographic and spatiotemporal distribution of the confirmed cases of COVID-19 in Libya A-during the early stage of the epidemic ( 1- 8 ) epi-weeks B-During the second stage of the epidemic ( 9-16) epi-weeks