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Original article

Demographic and Temporal Patterns of COVID-19 Infection in Western Libya

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Abstract
This cross-sectional study investigates the demographic and temporal distribution of COVID-19 cases in Western Libya, based on data from 9,445 individuals collected by the Surveillance and Rapid Response Center in Al-Zawiya during 2021. The majority of participants were Libyan nationals (98.2%), with males representing 61.6% and females 38.4%. The overall COVID-19 positivity rate was 32%, indicating a considerable community burden. Gender-based analysis showed no statistically significant difference in infection rates, with males accounting for 46.8% and females for 53.2% of positive cases. This finding contrasts with global trends suggesting higher male susceptibility. Age-stratified data indicated that the highest infection rates were found among adults aged 31–50 years, the most socially and economically active demographic. In contrast, the lowest rates occurred among children under 10 years and adults over 90, likely due to lower exposure or testing coverage. Temporal analysis identified peaks in infection during October and December, which together accounted for over half of all positive cases. These fluctuations may relate to seasonal changes, public behaviors, or shifts in health policy adherence. Although the variation was only borderline statistically significant, the trend highlights the importance of continued surveillance to manage infection surges effectively. The findings underscore the need for targeted public health strategies, particularly for the most affected age groups and high-incidence periods. Additionally, the dominance of Libyan nationals in the dataset suggests a need to better include migrant and minority populations in testing and vaccination efforts. Limitations include the retrospective nature of the study and reliance on surveillance data, which may be subject to reporting bias and lack socioeconomic or clinical details. Future studies should incorporate these factors for a deeper understanding of COVID-19 transmission in Libya.
Keywords: COVID-19, Demographics, Surveillance, Epidemiology, Al-Zawiya, Libya.

Introduction

The coronavirus disease 2019 (COVID-19), caused by the novel coronavirus SARS-CoV-2, has posed unprecedented challenges to global public health since its emergence in late 2019. The pandemic has affected nearly every country, with substantial variations in transmission dynamics, morbidity, and mortality across different regions and population groups [1,2]. Demographic factors such as age, gender, and nationality, as well as temporal variations including seasonal and monthly trends, have been shown to play significant roles in shaping the epidemiological patterns of COVID-19 [3,4].

Globally, studies have consistently demonstrated that elderly individuals and those with underlying comorbidities are at higher risk of infection and severe outcomes [5]. Gender-based differences have also been observed, with some reports indicating higher mortality and severity rates among males, potentially due to behavioral, hormonal, and immunological factors [6,7]. In addition, infection rates have varied over time, often corresponding to policy interventions, population movement, seasonal changes, and public health responses [8].

In Africa and the Middle East, including North African countries such as Egypt, Tunisia, and Morocco, research has highlighted the importance of demographic surveillance in understanding the spread of COVID-19 and allocating resources effectively [9,10]. However, in Libya, limited data has been published on the detailed demographic and temporal characteristics of COVID-19 cases, despite the country's unique sociopolitical context, fragile health infrastructure, and challenges in consistent data reporting [11,12].

A few Libyan studies have addressed general COVID-19 trends, but none have comprehensively analyzed the interplay between infection rates and demographic variables such as age, sex, and nationality, alongside monthly temporal patterns [13]. Understanding these relationships is essential for guiding national response strategies, especially in a resource-limited setting where targeted interventions may prove more effective than broad-based approaches [14].

This study aims to fill this gap by conducting a cross-sectional analysis of COVID-19 cases in Libya, focusing on demographic (gender, age, nationality) and temporal (monthly) distribution patterns. Through statistical evaluation, this paper seeks to provide evidence-based insights that can inform ongoing public health decision-making and future pandemic preparedness strategies [15].

Despite the global proliferation of COVID-19 research, localized data from conflict-affected and resource-limited countries such as Libya remain limited. The evolving nature of the pandemic—shaped by

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demographic factors such as age, gender, and nationality, along with temporal trends—necessitates context-specific analysis. In Libya, inconsistent reporting mechanisms and an underdeveloped epidemiological infrastructure have posed significant challenges to the comprehensive assessment of the disease's spread and burden across different population groups. In the absence of accurate, stratified data, public health interventions risk being inefficient or misaligned with actual infection patterns, thereby leaving vulnerable populations inadequately protected. This study provides valuable insights into how COVID-19 infection is distributed across demographic variables and over time within the Libyan population. By identifying which groups are most affected and during which periods, the findings can inform evidence-based policymaking, enhance targeted interventions, and improve preparedness for future waves or pandemics. Furthermore, this research contributes to filling a critical knowledge gap in the region, offering a scientific foundation for public health planning in Libya and other similarly structured countries facing epidemiological and infrastructural challenges. The primary objective of this study is to analyze the demographic (age, gender, nationality) and temporal (monthly) distribution patterns of COVID-19 infection in Libya using cross-sectional data. The study aims to determine whether statistically significant associations exist between infection status and demographic or time-related variables, thereby supporting more precise and effective public health strategies.

Materials & Methods

Study Design and Setting

This cross-sectional study was conducted in Libya, covering data collected from January to December 2021. The study focused on individuals who underwent COVID-19 diagnostic testing at various healthcare facilities distributed across major cities in Libya.

Study Population and Sample Size

The study population included all individuals tested for COVID-19 within the specified period. A total of 9,445 cases were analyzed. The sample included Libyan nationals and non-Libyan residents. Demographic variables such as age, gender, and nationality were recorded for all participants.

Data Collection

Data was retrospectively collected from the COVID-19 surveillance and rapid response center database in the city of AL-Zawiya, including test results (positive or negative), demographic information (age, gender, nationality), and test dates. The identities of all patient data were anonymized to maintain confidentiality.

Inclusion and Exclusion Criteria

Inclusion criteria: Individuals of all ages and genders tested for COVID-19 during the study period.
Exclusion criteria: Cases with incomplete demographic data or inconclusive test results were excluded from the analysis.

COVID-19 Testing Method

COVID-19 infection status was determined using real-time reverse transcription polymerase chain reaction (RT-PCR) assays performed on nasopharyngeal swab samples, following WHO-approved protocols. Testing was conducted in certified laboratories across Libya.

Variables

Dependent variable: COVID-19 infection status (positive/negative). Independent variables: Age groups (categorized into decades), gender (male/female), nationality (Libyan/non-Libyan), and month of testing.

Data Analysis

Data was entered and analyzed using SPSS (version 21). Descriptive statistics was employed to summarize demographic characteristics and infection prevalence. Frequencies and percentages was calculated for categorical variables. Chi-square tests were used to assess associations between COVID-19 infection status and categorical demographic variables, as well as temporal distribution by month. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Ethical Review Board of. All data were handled confidentially, and patient anonymity was preserved throughout the study.

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Results

Demographic Characteristics of the Study Population

A total of 9,445 individuals were included in the study. Among them, 5,819 (61.6%) were male and 3,626 (38.4%) were female (Figure 1). The majority of the participants were Libyan nationals (9,274; 98.2%), while non-Libyan individuals accounted for 171 cases (1.8%).

The age distribution showed that the largest groups were those aged 31-40 years (20.8%) and 21-30 years (20.1%), followed by 41-50 years (17.7%). The smallest groups were those aged 91 years and above (0.3%) and those with unknown age (0.1%).

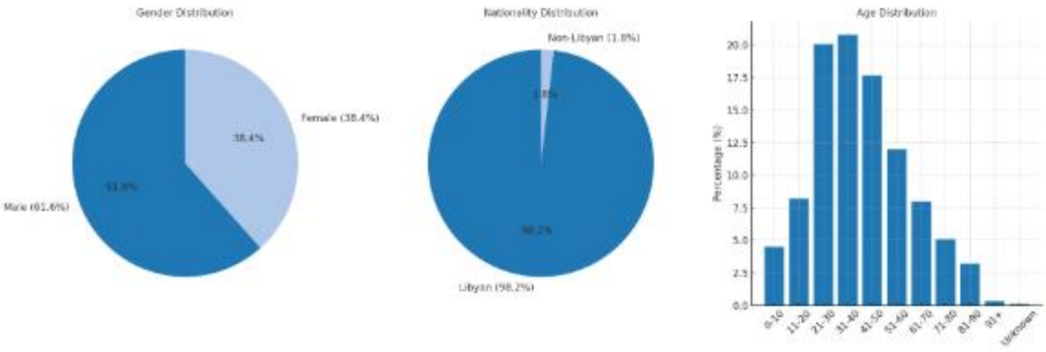

Figure 1. Demographic Characteristics of the Study Population

COVID-19 Test Results

Of the total cases, 3,019 (32.0%) tested positive for COVID-19, while 6,426 (68.0%) tested negative (Figure 2).

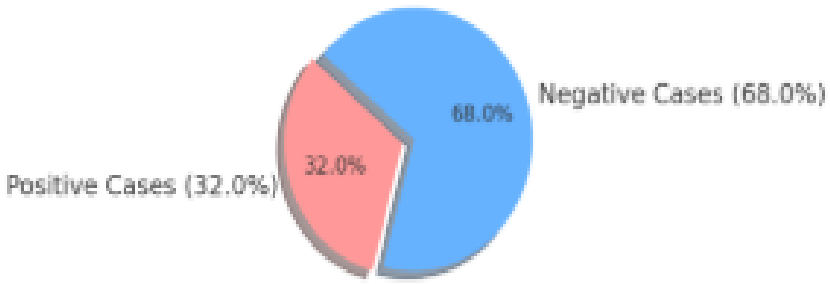

Figure 2. COVID-19 Test Results of Participants

Infection Prevalence by Gender

Among males, 1,412 (24.3% of males) tested positive, representing 46.8% of all positive cases. Among females, 1,607 (44.3% of females) tested positive, representing 53.2% of all positive cases (Figure 3). Statistical analysis using the Chi-square test indicated no significant difference between males and females regarding infection rates (x^2=0.360, p=0.549).

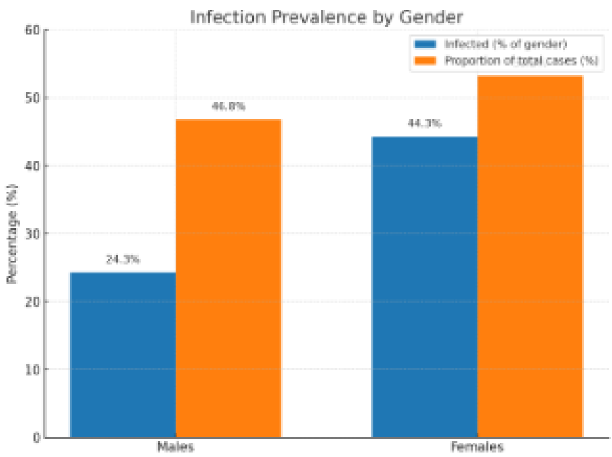

Figure 3. Prevalence of COVID-19 Infection by Gender

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Infection Prevalence by Age Group

The highest numbers of positive cases were observed in the age groups 31-40 (546 cases, 18.1%), 41-50 (558 cases, 18.5%), and 21-30 (486 cases, 16.1%). The lowest infection rates were recorded in the youngest (10 years and under: 86 cases, 2.8%) and oldest (91 years and above: 20 cases, 0.7%) age groups (Figure 4). The association between age groups and infection status was statistically significant (x^2=44.200, p<0.001), indicating that age is a relevant factor in infection prevalence.

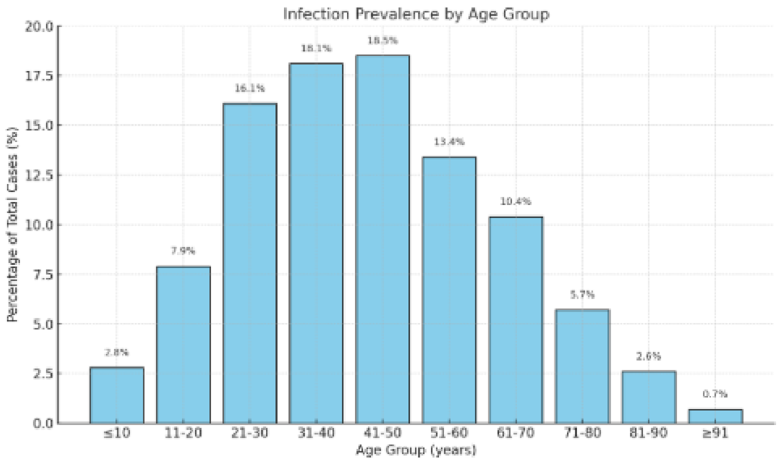

Figure 4. *COVID-19 Infection Prevalence by Nationality*

Infection Prevalence by Nationality

Due to the overwhelming majority of Libyan nationals in the (Figure 5), the comparison between Libyan and non-Libyan infection rates was limited and thus not emphasized in statistical tests.

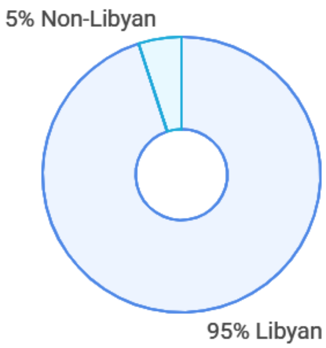

Figure 5: COVID-19 Infection Prevalence by Nationality of Participants

Temporal Distribution of COVID-19 Cases

The monthly distribution of positive cases revealed peaks in October (1,073 cases, 35.5%) and December (640 cases, 21.2%). Other months such as September (727 cases, 24.1%) and November (547 cases, 18.1%) also showed notable infection numbers (Figure 6). The Chi-square test for temporal variation was close to significance (x^2=7.545, p=0.056), suggesting seasonal trends may influence infection rates.

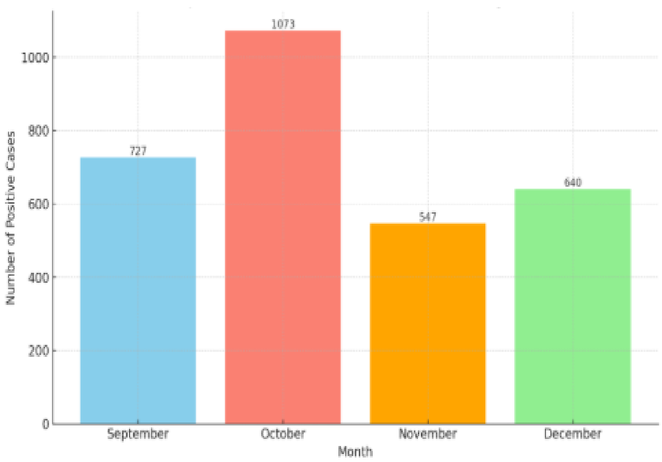

Figure 6: Temporal Distribution of COVID-19 Positive Cases by Month

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Discussion

The current study analyzed the demographic and temporal distribution of COVID-19 infection in Libya, revealing important patterns that align with global findings but also highlight unique local dynamics.
Although the total number of male cases tested was higher than female cases, the proportion of positive cases was slightly greater among females (53.2%) compared to males (46.8%). However, statistical analysis indicated no significant difference in infection prevalence between genders. This contrasts with several international studies that have often reported higher infection severity and mortality among males (2,3). The lack of significant gender difference in this Libyan cohort could be attributed to sociocultural factors affecting exposure and healthcare-seeking behaviors, or variations in testing access and reporting.
Consistent with global trends, infection prevalence varied significantly with age. The highest infection rates occurred in the 31-50 year age group, representing the most active and economically productive segments of the population. This pattern may reflect higher social interaction, occupational exposure, and mobility within these age brackets (Guan et al., 2020). Conversely, children under 10 and the elderly above 90 years exhibited the lowest infection rates, which could be due to limited exposure or under-testing in these groups. The significant association between age and infection emphasizes the need for targeted interventions, such as prioritizing vaccination and public health messaging to the most affected age groups.
Given the overwhelming majority of Libyan nationals in the sample, the study was limited in assessing differences by nationality. However, recognizing the presence of a small non-Libyan population underscores The findings of this study underscore the importance of inclusive public health strategies that address the needs of all residents in Libya, regardless of nationality, particularly given the potential vulnerabilities of migrant or displaced populations. A detailed examination of temporal trends revealed a noticeable increase in infection rates during the months of October and December. These peaks may be attributed to seasonal factors, increased social gatherings, or shifts in the enforcement and adherence to public health measures. Although the statistical analysis showed a p-value slightly above the conventional threshold for significance ($p = 0.056$), the observed pattern suggests a potential seasonal effect consistent with other respiratory viruses. This reinforces the importance of continuous monitoring of infection dynamics over time, which can help anticipate future surges and inform more efficient allocation of healthcare resources.
The demographic and temporal insights obtained from the study offer critical guidance for public health policy in Libya. Targeted interventions focusing on age groups most affected and on months with elevated transmission rates can significantly improve the impact of containment strategies. Furthermore, there is a pressing need to strengthen data collection mechanisms, particularly for marginalized and underrepresented groups, to ensure equitable access to testing, treatment, and vaccination services.
Despite the value of the findings, this study has several limitations. Being retrospective in design, it relies on existing surveillance data, which may be subject to reporting errors, incomplete records, or selection bias. The overwhelming proportion of Libyan nationals in the sample restricts the applicability of the results to other demographic segments within the country. Additionally, the absence of key variables—such as comorbidities, socioeconomic background, and vaccination status—limits the ability to assess the broader determinants of infection risk. Future research should aim to address these gaps to provide a more comprehensive understanding of COVID-19 epidemiology in Libya.

Conclusion

The study offers valuable epidemiological evidence on COVID-19 infection distribution in Libya, emphasizing the influence of demographic and temporal factors. These findings can guide more targeted and efficient public health interventions, aiding Libya's ongoing response to the pandemic. Focus awareness campaigns and preventive measures on the age group 31 to 50 years. Improve data collection quality to include additional health and social factors. Strengthen healthcare preparedness during peak infection months (October and December).

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