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COVID-19 pandemic in Taiz Governorate, Yemen, between 2020 and 2023

Wadhah Hassan Edrees[1,2]*, Qais Yusuf Abdullah[3], Wadee Abdullah Al-Shehari[4], Lutf Mohammed Alrahabi[5,6] and Amani Ahmed Fadel Khardesh[7]

Abstract

Background The coronavirus disease 2019 (COVID-19) is highly contagious and causes a series of health problems, particularly in Yemen, which has a fragile healthcare system and cannot handle public health emergencies.

Aims This analysis aimed to determine the epidemiological status of COVID-19 in the Taiz governorate between April 2020 and December 2023.

Methods A retrospective study based on surveillance data from the Taiz governorate was used. The required data were gathered from the Ministry of Health and Population in Aden and analyzed using SPSS.

Results Out of 5826 suspected of COVID-19 cases, 1933 (33.18%) cases were positive for COVID-19 infection. The high rates of COVID-19 cases were reported at 35.40% in males, 37.80% in people aged 35–44 years, 47.20% in 2020, 72.73% in Dhubab district, and 27.78% in March 2021. The overall incidence rate of cases was reported at 6.2 per 10,000 people in Taiz governorate (8.85 in males and 3.80 in females). In addition, the high incidence rate of COVID-19 was observed among age groups ≥ 65 years, in 2021, and in Al-Mukha districts. In total, the rate of fatality cases was 14.12%, the higher rate of fatality cases was 15.46% among males and 32.23% among individuals aged ≥ 65 years, and 26.97% in 2020.

Conclusion In this finding, the incidence rate of COVID-19 is high. It is necessary to increase the public's awareness of the transmission and prevention methods of COVID-19, as well as implement appropriate strategies to protect populations from infectious diseases.

Keywords COVID-19, Case fatality rate, Incidence rate, Taiz Governorate, Yemen

*Correspondence:
Wadhah Hassan Edrees
edress2020@gmail.com
[1]Medical Microbiology Department, Faculty of Applied Sciences, Hajjah University, Hajjah, Yemen
[2]Medical Laboratory Department, Faculty of Medical Sciences, Al-Razi University, Sana'a, Yemen
[3]Microbiology/Biological Sciences, Faculty of Sciences, Sana'a University, Sana'a, Yemen
[4]Microbiology Department, Faculty of Medical Sciences, Ibb University, Ibb, Yemen
[5]Medical Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Sana'a University, Sana'a, Yemen
[6]Dental Department, Faculty of Medical Sciences, Queen Arwa University, Sana'a, Yemen
[7]Biology department, Faculty of Education- Aden, University of Aden, Aden, Yemen

Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is the infectious virus causing Coronavirus Disease 2019 (COVID-19). This virus is rapidly transmitted among individuals via air droplets or aerosols that result from the coughing, sneezing, speaking, singing, or breathing of infected or carrier individuals [1–2]. The symptoms of COVID-19 vary from mild symptoms to severe illness. Fever, headache, anosmia, ageusia, congestion and runny nose, sore throat, cough, muscle pain, diarrhea, and difficulty breathing are the common symptoms [3]. The first reported case was in Wuhan city, China, in December 2019 [4]. Since the outbreak began, over 772 million confirmed cases and 6.9 million deaths have been reported worldwide [5]. Additionally, according to estimates by the World Health Organization, the number of deaths directly or indirectly attributed to the COVID-19 pandemic is approximately 15 million [6].

Older individuals and males over the age of 70 are at a higher risk of infection and severe disease. Adolescents seem to be as susceptible to infection as adults, and children are less susceptible [7]. Children, unlike adults, don't seem to be more vulnerable to serious disease based on sex or age [8]. Variants of viruses can spread faster and more easily among young children than wild-type viruses, but less people have been hospitalized [9].

On April 10, 2020, the first confirmed case related to the COVID-19 epidemic in Yemen was announced, with the incident in the Hadhramaut [10]. According to the WHO report on Yemen, more than 11,000 cases and 2,159 deaths were recorded to date. The COVID-19 case fatality rate in Yemen reached a peak of 22.6%, despite the low global fatality rate of 1.0% [5].

The high number of cases and deaths in Yemen may go beyond what the authorities claim. This is due to the fact that Yemen still faces numerous challenges, including political instability, armed conflict, and humanitarian situations [5, 11].

Furthermore, in Yemen, as in other low-income countries, the epidemiological pattern of COVID-19 is uncertain because of the war since 2015, which devastated the healthcare system in Yemen. In addition, there is no surveillance or laboratory capacity, insufficient public health resources, and insufficient financial resources, treatments, or vaccines [12]. Only a few studies have been conducted in certain regions of Yemen. A study conducted in Sana'a, from June 2020 to January 2021 and revealed that the seroprevalence of COVID-19 was reported at 51.4% among suspected patients [13]. In Aden 2020, the pooled seroprevalence of COVID-19 was 27.4% [11]. In addition, the overall frequency of COVID-19 was 94.3% among healthcare workers in the Lahj and AL-Dhalea hospitals [14].

To our knowledge, no previous studies have been undertaken regarding the epidemiological pattern of the COVID-19 pandemic in Taiz, Yemen. Therefore, this analysis aimed to determine the epidemiological patterns of COVID-19 in the governorate of Taiz between April 2020 and December 2023.

Materials and methods

Study design

A retrospective study based on surveillance data of Taiz governorate was used. Taiz governorate is located in the southwest of Yemen and is 280 km from Sana'a, the capital of Yemen. It has a total area of 12,605 km^2 with a total population of 3,309,546 individuals. Taiz governorate is connected to the governorates of Al-Hudaydah and Ibb from the north, some parts of Ibb, Al-Dhale'e, and Lahj governorates from the east, Lahj governorates from the south, overlooking the Red Sea coast and directing the Bab Al-Mandab. The western part of Taiz has a hot, humid, and arid climate, while the eastern part has a moderate to cold and humid climate. The governorate is divided administratively into 23 districts (Fig. 1).

Data collection

The data was collected by surveillance staff, it was for all suspected and confirmed cases reported electronically to the Ministry of Public Health and Population during the period between April 2020 and December 2023. A soft copy of surveillance data in an Excel sheet format was obtained from the Ministry of Health and Population in Aden. The data contained the following variables: the number of weekly infections, the month and year of infection, sex, the age groups, the name of the district, and the result of COVID-19 tests by polymerase chain reaction test (PCR) performed in the AL-Gumhorri hospital and the National Center for Central Public Health Laboratories-Taiz branch. Based on the epidemiological monitoring system, the variables were categorized into subgroups. Eight age groups for those involved were: ≤5, 5–14, 15–24, 25–34, 35–44, 45–54, 55–64, and >65 years.

Data analysis

All COVID-19 cases that came from Taiz governorate residents, completed information, and subjected to laboratory analysis by polymerase chain reaction (PCR) were included in this analysis. On the other hand, all cases from people who did not live in the Taiz governorate, did not have complete information, or were not subject to laboratory analysis were excluded from the analysis.

The positivity rate of COVID-19 was calculated by dividing the number of confirmed cases by the total number of tested cases.
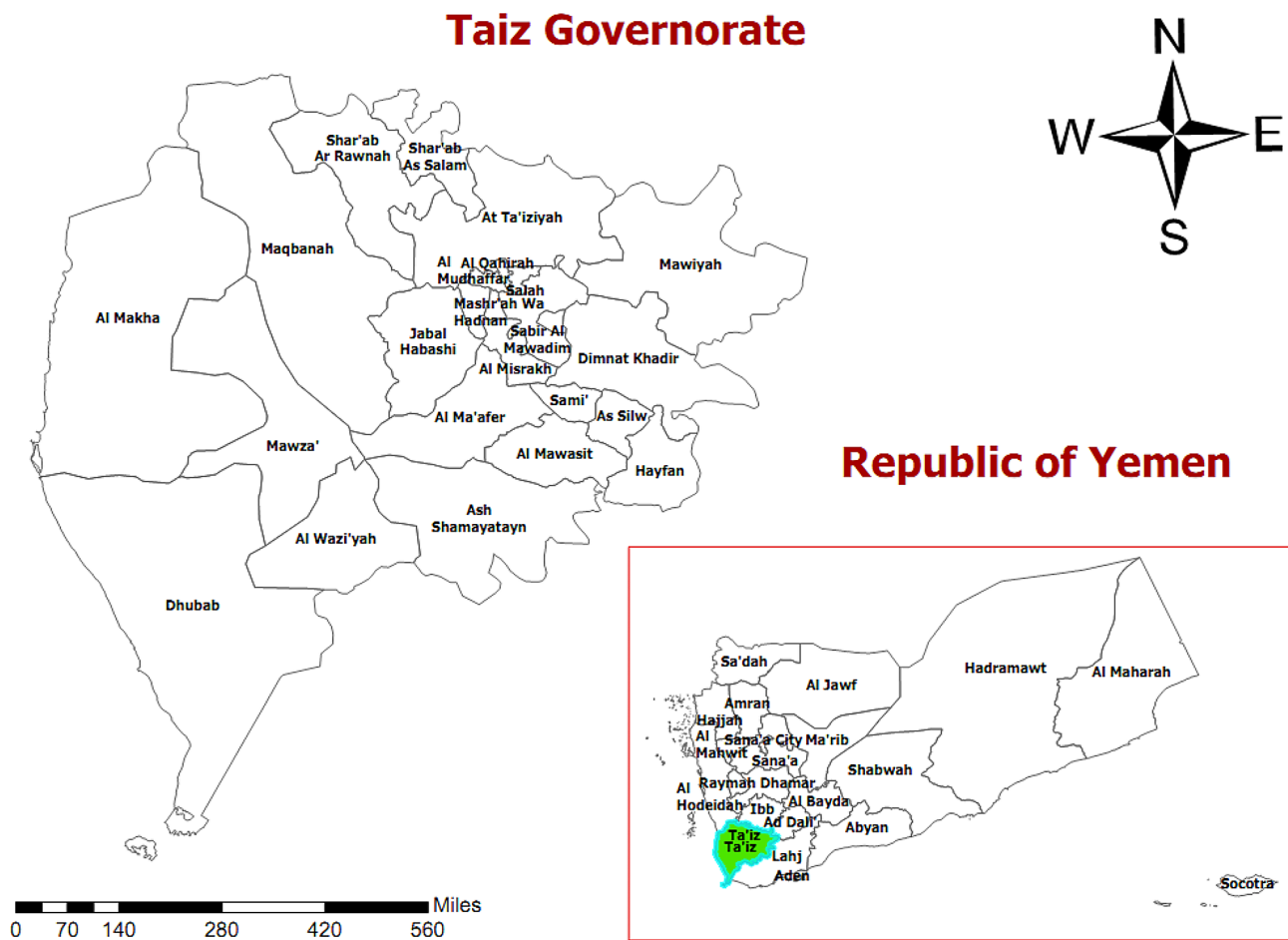
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Fig. 1 Map of Taiz governorate

The population denominator was obtained from OCHA [15] and used to calculate the incidence rate (per 10,000 population) based on the following formulation:

$$\text{Incidence rate} = \frac{\text{Total number of confirmed COVID} - 19\,\text{cases}}{\text{Total number of population size at risk}} * 10,000$$

The Case Fatality Rate (CFR) was calculated according to follow formula:

$$\text{CFR }(\%) = \frac{\text{Number of deaths from COVID} - 19\,\text{cases}}{\text{Number of confirmed cases of COVID} - 19\,\text{cases}} * 100$$

Statistical analysis

Descriptive statistics: frequencies and percentages were used to present the quantitative variables in tables and figures. In addition, the statistical package for social sciences (SPSS) program was used to calculate the confidence interval (95% CI) and chi-square test (χ^2) between variables. A probability (P) value was considered statistically significant at ≤0.05.

Results

Demographic characterizations and positivity of COVID-19 cases

Between April 2020 and December 2023, a total of 5826 suspected COVID-19 cases enrolled in the surveillance were tested by molecular method. They were almost from all districts and all age groups with the highest proportion of 29.1% and 21.49% from Al Mudhaffar district and people > 65 years., respectively. Nearly two-thirds 62.12% were males and 58.07% were reported in 2021. The overall positivity rate of cases was 33.18% (1933), it was higher among males (35.40%) compared with females (29.54%). A higher rate of COVID-19 cases was observed in the 35–44 years (37.80%), followed by the 25–34 years (36.50%), and 45–54 years (33.79%) age groups. In addition, a lower rate of COVID-19 cases was in the aged 5–14 years (19.75%). Regarding the year of infection, the

Table 1 Demographic characterizations of suspected and confirmed COVID-19 cases

| Variables	Categorizes	Total cases		Positive cases	
		No.	(%)	No.	(%)
Sex	Male	3619	62.12	1281	35.40
	Female	2207	37.88	652	29.54
Age group	≤5	10	0.17	2	20.00
	5–14	81	1.39	16	19.75
	15–24	513	8.81	145	28.27
	25–34	1211	20.79	442	36.50
	35–44	1029	17.66	389	37.80
	45–54	867	14.88	293	33.79
	55–64	863	14.81	283	32.79
	≥65	1252	21.49	363	28.99
Year	2020	644	11.05	304	47.20
	2021	3383	58.07	1404	41.50
	2022	1261	21.64	209	16.57
	2023	538	9.23	16	2.97
District name	Al Mukha	677	11.62	399	58.94
	Al Ma'afer	127	2.18	29	22.83
	Al Mawasit	140	2.40	21	15.00
	Al Misrakh	302	5.18	40	13.25
	Al Mudhaffar	1698	29.15	550	32.39
	Al Qahirah	830	14.25	307	36.99
	Al Wazi'iyah	148	2.54	37	25.0
	As Silw	20	0.34	4	20.0
	Ash Shamayatayn	580	9.96	105	18.10
	At Ta'iziyah	7	0.12	5	71.43
	Dhubab	11	0.19	8	72.73
	Dimnat Khadir	4	0.07	2	50.0
	Hayfan	4	0.07	0	0.00
	Jabal Habashy	249	4.27	63	25.30
	Maqbanah	113	1.94	28	24.78
	Mashra'a Wa Hadnan	98	1.68	30	30.61
	Mawiyah	2	0.03	0	0.00
	Mawza	13	0.22	5	38.46
	Sabir Al Mawadim	253	4.34	93	36.76
	Salh	512	8.79	192	37.50
	Sama	15	0.26	3	20.0
	Shara'b Ar Rawnah	6	0.10	3	50.0
	Shara'b As Salam	17	0.29	9	52.94
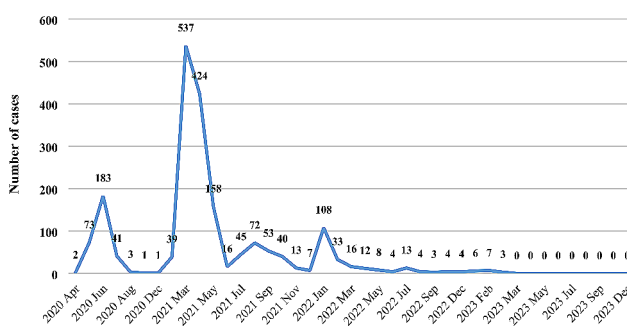
Fig. 2 Monthly trends of COVID-19 cases in Taiz between April, 2020 and Dec, 2023
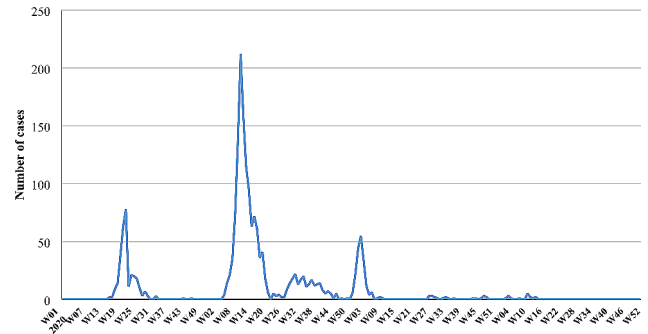

Fig. 3 Cumulative weekly trends of COVID-19 cases in Taiz between April, 2020 and Dec, 2023

highest rate of cases was in 2020, and the lowest in 2023. The highest rate of COVID-19 cases was from Dhubab (72.73%), At Ta'iziyah (71.43), Al Mukha (58.94%), and Shara'b As Salam (52.94%) while there no data about COVID-19 cases reported in Hayfan and Mawiyah districts, as listed in Table 1.

Figure 2 shows that the highest proportion of COVID-19 cases was recorded in March 2021 (27.78%), followed by April 2021 (21.93%), June 2020 (9.47%), May 2021 (8.17%), and January 2022 (5.59%). The lowest rate was noted in November and December 2020 (0.05%) with statistical differences ($P=0.001$).

Figure 3 shows that a greater number of COVID-19 cases were documented in week no. (13) in 2021, with 212 cases followed by Week No. (24) in 2020, with 74 cases in Week No. (4) in 2022, with 55 cases and week No. (12) in 2023 for five cases.

## Incidence rate of COVID-19 according to demographic factors

In this finding, the total incidence rate of COVID-19 was reported at 6.2 per 10,000 people in the Taiz governorate. According to the results based on sex, the incidence rate of cases was 8.85 per 10,000 individuals among males compared with 3.80 per 10, 000 individuals among females. Similarly, the highest incidence rate of COVID-19 infection was detected in the age group≥65 years, followed by the age groups of 55–64 years (25.55) and 45–54 years (14.93), and a lower rate was observed among the age group of ≤5 years (0.05). In addition, the highest incidence rate of COVID-19 was documented at 4.52 per 10,000 people in 2021, followed by 1.00 per 10,000 people in 2020, 0.65 per 10,000 people in 2022, and 0.05 per 10,000 people in 2023, as summarized in Table 2.

Regarding the district under investigation, the highest incidence rate of COVID-19 was reported at 49.44 per 10,000 people in Al Mukha, followed by 40.20 per 10,000 people in Mashra'a Wa Hadnan, 32.60 per 10,000 people in Al Mudhaffar, 22.84 per 10,000 people in Salh, 22.25

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Table 2 Incidence rate of COVID-19 according to socio-demographic parameters in Taiz governorate

Variables	Categorizes	Population size	Cases No.	Incidence rate	95% CI	χ^2	P value
Sex	Male	1,447,351	1281	8.85	1.32–1.36	204.67	0.000
	Female	1,716,950	652	3.80			
Age group	≤ 5	439,838	2	0.05	5.53–5.67	822.0	0.000
	5–14	651,846	16	0.25			
	15–24	791,075	145	1.83			
	25–34	531,602	442	8.31			
	35–44	357,566	389	10.88			
	45–54	196,187	293	14.93			
	55–64	110,751	283	25.55			
	≥ 65	85,436	363	42.49			
Year	2020	3,049,274	304	1.00	1.94–1.99	2428.24	0.000
	2021	3,104,589	1404	4.52			
	2022	3,193,793	209	0.65			
	2023	3,309,546	16	0.05			

CFR=Case Fatality rate, 95% CI=Confidence interval. χ^2=Chi-square test, P value≤0.05 (statistically significant)
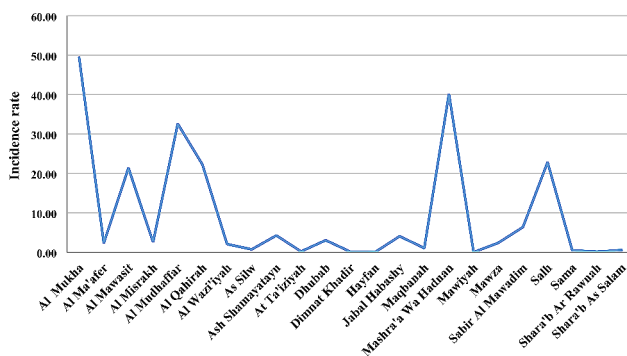
Fig. 4 Trend of incidence rate of COVID-19 concerning district in Taiz between April, 2020 and Dec, 2023

per 10,000 people in Al Qahirah, and 21.38 per 10,000 people in Al Mawasit while the other district was less than 7.0 per 10,000 people (Fig. 4).

Case fatality rate of confirmed COVID-19 cases

Among the 1933 COVID-19 cases, the overall case fatality rate was 273 (14.12%). The fatality rate was significantly higher among males (15.46%) than females (11.50%). The older age group of ≥65 years had the highest fatality rate (32.23%), followed by those aged 55–64 years (26.86%) and 45–54 years (14.33%). Whereas, the 15–24 years age group had the lowest fatality rate (0.69%). The fatality rate increased to 26.97% in 2020 and gradually decreased to 12.75% and 5.75% in 2021 and 2022, respectively. Regarding the location of cases in districts, the Shara'b Ar Rawnah district reported the highest rate of fatality (66.67%). More than one-third of the rates were 37.93%, 36.51%, and 33.33% in Al Ma'afer, Jabal Habashy, and Al Mawasit, respectively. Additionally, less than one-third of the fatality rates were in Ash Shamayatayn (29.52%) and Dhubab (25%). However, a lower rate

was in the Al Wazi'iyah (2.7%) and Al Mukha (1.25%) districts (Table 3).

Discussion

To our knowledge, this analysis is the first one conducted in Yemen, particularly in the Taiz governorate. From April 2020 to December 2023, 5826 COVID-19 cases were included in this work and only 1933 cases were positive for COVID-19 infection by molecular techniques. In the current results, the prevalence of cases was observed to be significantly higher among males (35.40%) as compared to females (29.54%). Similar reports have been conducted in different countries in the world showing COVID-19 infections are more in males than females [16–20]. These data were in disagreement with the results of several studies [11, 14, 21].

Females have stronger immune systems, including antiviral interferon and humoral and adaptive immunity that fight against viruses, particularly SARS-CoV-2 infections [22]. The results of the 2017 research revealed that female mice were less susceptible to the SARS-CoV virus than their male counterparts. However, after having an ovariectomy, the differences between genders' vulnerability to the virus disappeared. This means that estrogen may have been responsible for the differences in vulnerability [23].

In addition, the X-chromosome in women, unlike the Y-chromosome in men, contains the majority of immune-associated genes, giving them a stronger immune system. Males having higher levels of angiotensin-converting enzyme-2, the primary SARS-CoV-2 receptor, than females [24–25].

At the beginning of the 2019 pandemic COVID-19 outbreak, most COVID-19 cases were observed among elderly individuals [26]. The age groups 35–44 had the highest proportion of COVID-19 cases (37.80%), while those aged 5–14 years (19.75%) had the lowest rate.

Table 3 Frequency of case fatality rate of COVID-19 in Taiz governorate

Variables	Categorizes	Cases No.	CFR (%)	95% CI	χ^2	P value
Sex	Male	198	15.46	1.22–1.33	55.42	0.001
	Female	75	11.50			
Age group	≤ 5	0	0.0	6.80–7.09	292.15	0.001
	5–14	1	6.25			
	15–24	1	0.69			
	25–34	9	2.04			
	35–44	27	6.94			
	45–54	42	14.33			
	55–64	76	26.86			
	≥ 65	117	32.23			
Year	2020	82	26.97	1.68–1.81	154.57	0.001
	2021	179	12.75			
	2022	12	5.74			
	2023	0	0.00			
District name	Al Mukha	5	1.80	7.48–8.62	581.57	0.001
	Al Ma'afer	11	11.22			
	Al Mawasit	7	5.88			
	Al Misrakh	6	2.29			
	Al Mudhaffar	83	7.23			
	Al Qahirah	61	11.66			
	Al Wazi'iyah	1	0.90			
	As Silw	0	0.00			
	Ash Shamayatayn	31	6.53			
	At Ta'iziyah	1	50.00			
	Dhubab	2	66.67			
	Dimnat Khadir	0	0.00			
	Hayfan	0	0.00			
	Jabal Habashy	23	12.37			
	Maqbanah	2	2.35			
	Mashra'a Wa Hadnan	6	8.82			
	Mawiyah	0	0.00			
	Mawza	1	12.50			
	Sabir Al Mawadim	7	4.38			
	Salh	23	7.19			
	Sama	0	0.00			
	Shara'b Ar Rawnah	2	66.67			
	Shara'b As Salam	1	12.50			

CFR = Case Fatality rate, 95% CI = Confidence interval. χ^2 = Chi-square test, P value ≤ 0.05 (statistically significant)

These results were different from a study that found more cases of COVID-19 cases were more prevalent in the older people than the younger people [16, 20–21]. On the contrary, a study by Sallam et al. [13] found a higher rate of COVID-19 cases among the age group of subjects aged 19–49 years. Similarly, the highest frequency rates were observed among the age group of 15–29 years [11]. In Australia, adults aged 20 to 29 have a higher infection rate [27].

Older individuals are more vulnerable to COVID-19 and are at a meaningfully increased risk for morbidity and death [28]. Infections in older adults frequently manifest in an atypical manner, thereby complicating their identification and management. The physiological

changes associated with old age, several age-related co-morbid diseases like diabetes and heart and lung disease, and the use of related medications are all factors contributing to poor health status [24].

Regarding the period of infection, the highest rate of cases was in 2020, and the lowest in 2023. This outcome was supported by some reports [29–30]. The continuous conflict in the governorate since 2015 that led to the destruction of the healthcare infrastructure, increased poverty, inadequate health resources, and the escape of healthcare staff to another area are all factors contributing to the increase in COVID-19 cases in 2021.

Recently, the Worldometer reporting COVID-19 in Yemen revealed that the high cases were reported at

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119, 178, and 245 cases, respectively, in June 2020, April 2021, and January 2022 [31]. These data are similar to our results showed that a high rate of COVID-19 cases was recorded at 9.47%, 27.78%, and 5.59% in June 2020, March 2021, and June 2022, respectively. COVID-19 has been reported in Yemen in three waves as of 3 January 2022: the first wave occurred from April to July 2020, the second wave occurred from February to May 2021, and the third wave occurred between August and October 2021 [32].

Four waves were the result of the global COVID-19 pandemic: the first, which lasted from January 2020 to February 2021; the second, which lasted from March 2021 to June 2021; the third, which lasted from July 2021 to October 2021; and the fourth, which lasted from November 2021 to March 2022 [29].

The seasonal trends in COVID-19 cases were estimated to be between November and April for all outcomes and in all countries [33]. Many viruses that infect the respiratory system have different patterns during the winter months [34]. It is widely acknowledged that factors such as the host, pathogen, and environmental factors, such as an increase in indoor activity and seasonal weather fluctuations, have a significant impact on the viral stability beyond the host [35].

In this finding, the overall incidence rate of COVID-19 was 6.2 per 10,000 people in Taiz. A report by Lai et al. [36] found that the incidence varied from 0.0002 per 1,000,000 populations in India to 61.4 per 1,000,000 populations in Korea. According to the results based on sex, the high incidence rate of COVID-19 was higher among males compared with females. This finding is similar with previous reports [11, 14, 21]. Similarly, the highest rate of COVID-19 infection was noticed among age group ≥ 65 years and the lowest was found among age group of ≤ 5 years and this finding is in consistent with early research [15, 19–20]. In addition, the incidence rate of COVID-19 was highly increased in 2021 and decreased in 2023. This finding is supported by a previous report [37]. This decrease in the COVID-19 pandemic in the study area may be due to factors such as adherence to COVID-19 preventive measures, progress of vaccination campaigns to achieve herd immunity (population immunity) in Yemen, and stopping flights and land ports to and from Yemen. These factors may play important roles either directly or indirectly in reducing and controlling the COVID-19 pandemic in Yemen.

Furthermore, The Al Mukha district exhibited the highest incidence of COVID-19. This could be attributed to the fact that the majority of the nearby residents were moved to the Al Mukha district during the armed conflict.

This finding revealed an average 14.12% rate of fatality cases. Recently, the overall case fatality rate was 22.9% in Yemen [5]. Globally, the case fatality rate was recorded at 1.0% [5]. The case fatality rate was reported at 2.3% in China [16] and between 3.3 and 4% in Africa [19, 38], 0.16% in Australia [27], 2.92% in Germany [38], 1–20% in Ethiopia [39], and 3.72% in Latin America [40].

The present data showed the fatality rate was significantly higher in males (15.46%) compared to females (11.50%). This result aligns with the recent findings that documented that the fatality case rate was higher in males than females [16, 40–41].

The fatality rate was higher among individuals aged ≥ 65 years. This finding is in agreement with the results of previous studies [16, 42]. COVID-19 is more likely to cause serious illness or death in older adults if they are unvaccinated, have a disability, have an impaired immune system, or have certain medical conditions. Therefore, they are more likely to need hospitalization, intensive care, or a ventilator breath; otherwise, they may succumb to death [43].

Limitations of this study

This work has several limitations. First, there are no data on COVID-19 cases in the Mawiyah and Hayfan districts, which are under the control of the Sana'a authorities, and this is considered the most important limitation. Second, some cases were clinically diagnosed as being infected with COVID-19 but without laboratory confirmation and were excluded from this data anlysis. Third, there is a weakness in the data documentation and recording in health centers, which is another limitation of this work.

Conclusion

The high incidence rate of COVID-19 infection in the study area may be due to the fragile health system resulting from the continuing armed conflict and a lack of financial resources. Health institutions must establish awareness efforts and adopt modern communication methods to raise the community's knowledge and effective practices for COVID-19 prevention. In addition, it is necessary to establish epidemiological surveillance centers to control and prevent emerging diseases such as COVID-19 through follow-up on implementing effective vaccination programs in the community. Additionally, encouraging the conduct of studies and research as well as the early detection of emerging communicable diseases will encourage the decision-maker to implement strategies that are effective in protecting populations from infectious diseases.

Abbreviations

CCDC	Chinese Center for Disease Control and Prevention
CDC	Centers for Disease Control and Prevention
CFR	Case Fatality Rate
COVID-19	Coronavirus Disease 2019
PCR	Polymerase Chain Reaction
SPSS	Statistical Package for Social Sciences

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WHO	World Health Organization
χ^2	Chi-Square Test
95% CI	Confidence Interval

Data availability

The datasets used and analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethical approval

This study did not involve direct contact with humans. It is a retrospective study using the available data that was obtained from the Ministry of Health and Population. The Research and Ethics Committee of the Faculty of Applied Sciences at Hajjah University approved the ethical statement for conducting this study. In addition, permission to use the data in databases for research purposes was obtained from the Ministry of Health and Population. Furthermore, due to the retrospective nature of the study, the need for informed consent was waived by the Ministry of Health and Population.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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