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Dengue fever in Yemen: a five-year review, 2020–2024

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Abstract

Background Dengue fever (DF) is a mosquito-borne viral infection that has recently become a burden worldwide, particularly in low-income countries, such as Yemen. There have been no epidemiological studies on DF in recent years in Yemen. Therefore, based on secondary data, this study aimed to shed light on the epidemiology of DF in Yemen between 2020 and 2024.

Methods This was a retrospective analysis using secondary data recorded between January 2020 and August 2024 in the Surveillance Center of the Ministry of Health and Population in Aden. The data was gathered in a Microsoft Excel file and descriptively analyzed.

Results A total of 104,562 dengue cases, aged between 1 and 80 years ($SD = 24.93 \pm 17.02$), were enrolled in this retrospective analysis. A higher proportion of DF cases was recorded among males (58.10%), the age group of 15–24 years (26.11%), in 2020 (30.65%), in the Taiz governorate (39.17%), and in the autumn (28.9%). The total incidence of DF was 103.09 per 10,000 individuals. Additionally, the incidence rate of DF per 10,000 individuals was significantly higher among males (118.3 cases), aged 25–34 years (91.73 cases), in 2020 (31.39 cases), and in the Shabwah governorate (176.96 cases). In general, the total fatality rate was 217 (0.21%), with a high rate among females (0.23%), aged ≥ 65 years (0.75%), in 2020 (0.37%), and the Aden governorate (0.82%).

Conclusion These findings indicate that the rates of DF cases have increased in Yemen over the last few years. Therefore, it is critical to introduce an effective program to prevent DF and control dengue vector transmission in Yemen.

Keywords Case Fatality Rate (CFR), Dengue, Epidemiology, Incidence, Trend, Yemenbbr

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Introduction

Dengue fever (DF) is one of the most important mosquito-borne viral infections and endemic in tropical and subtropical regions where the mosquito vector breeds under ideal conditions [1]. In general, the transmission of Dengue virus to humans can occur through the bites of infected female mosquitoes of *Aedes* species, mainly *Aedes aegypti* and *Aedes albopictus* [2]. Moreover, infected blood, organs, or other tissues can transmit dengue virus, as can transplantation and perinatal transmission from an infected mother [1, 3].

There are four confirmed serotypes of dengue virus, including DENV-1, DENV-2, DENV-3, and DENV-4. Exposure with one type of dengue virus frequently provides lifelong immunity to that type [4]. All four serotypes of dengue virus have been documented in different regions of Yemen [5–7]. The signs and symptoms of DF are characterized by a high fever (up to 41 °C) with chills, headache, particularly behind the eyes, muscle and joint pains, malaise, nausea, vomiting, and skin itching and rash. In addition, in some cases, severe DF will progress with complications, such as dengue hemorrhagic fever (DHF) or dengue shock syndrome (DSS) [1, 4].

Many factors contribute to the spread of DF, including environmental conditions of appropriate temperature and humidity, which have led to an increase in the number and reproduction of mosquitoes [1]. Moreover, societal elements such as poverty, overcrowding, inadequate urban planning, heightened immigration, and failure to implement preventative vector control measures in the community. People's knowledge, attitudes, and behaviors regarding DF are also important [8].

Globally, the number of dengue cases has been increased by 85.47% from 30.67 million cases in 1990 to 56.88 million in 2019, and the total number of deaths was increased from 28,151 in 1990 to 36,055 in 2019 [9, 10]. In 2019, approximately 56.7 million documented cases of dengue, with 27.4 million cases in males and 29.3 million in females [10]. In addition, the peak number of cases recorded worldwide is 2023. Approximately 4.5 million dengue cases have been reported in the Americas region, with 2300 deaths. In Asia, the highest number of dengue cases were reported at 369,000 in Viet Nam, 321,000 in Bangladesh, 150,000 in Thailand, and 111,400 in Malaysia [1]. In addition, more than 6.5 million cases of DF resulting in 7,300 deaths were recorded in 2023 [1]. Recently, more than 14 million cases of DF resulting in more than 10,000 deaths were recorded globally between January and November 2024 [11].

Based on the WHO reporting, the DF has significantly increased in Yemen from 6,777 cases in 2015 to 28,185 cases (incidence rate = 10.86 per 10,000 population) with 68 deaths (case fatality rate 0.2%) in 2016 [1]. Moreover,

approximately 27,902 DF cases (incidence rate = 9.65 per 10,000 population), including 46 deaths (CFR = 0.16%), were reported in 2018 [12], and 71,688 cases (incidence rate = 23.86 per 10,000 population), including 258 deaths (CFR = 0.36%), were reported in 2019 [13]. In 2019, between weeks 1 and 8, approximately 4183 suspected cases of DF were recorded in different governorates, with the largest cases in Hudaydah (1466), Aden (1064), Mukala (450), and Shabwah (325) [14]. Furthermore, there are 630 confirmed dengue cases in Hadhramout [5], 134 confirmed cases in Taiz [15], and 46 confirmed in Hajjah [16].

Yemen is one of the poorest countries in the world. In addition to the continuation of war and armed conflict over the past 8 years, it has led to the deterioration of the social and economic situation, the destruction of infrastructure, and the closure of many hospitals and health centers. Furthermore, the high rates of malnutrition, inadequate access to safe water, sanitation and hygiene services, and displacement of many population resulting from sudden climate changes. All of these factors have contributed the spread of diseases, epidemics, and the vectors that transmit many pathogens [17–19]. Moreover, owing to the inadequate availability of data or comprehensive reports on the epidemiology of DF in Yemen, this has become a neglected issue that has not been addressed previously. Therefore, the present study aimed to describe the DF outbreak in Yemen over five years between January 2020 and August 2024.

This analysis will provide an insight into a broader understanding of the epidemiology of the DF burden in Yemen over a five-year period, address critical gaps in the current investigation on this topic, and outline recommendations for improvements on surveillance and control of infectious diseases. Moreover, the finding will be helpful in highlighting the magnitude of the neglected problem, which will lead to greater attention and rapid response coordination to combat and control this type of epidemic disease.

Materials and methods

Study area

A retrospective study based on reported dengue case data recorded between January 2020 and August 2024 in the surveillance center at the Ministry of Health and Population in Aden governorate in Yemen. Yemen is situated in Western Asia, southwest of the Arabian Peninsula. The Kingdom of Saudi Arabia borders Yemen to the north, while the Sultanate of Oman borders it to the east. Its southern coast is the Arabian Sea, and its western coast is the Red Sea. It covers approximately 555,000 square kilometers and has a population of 33 million [20]. Additionally, it is composed of twenty-one administrative

governorates. The data were only collected from the records of nine governorates, including Aden, Taiz, Hadhramout, Abyan, Lahj, Al Dhale'e, Marib, Al Maharah, and Shabwah governorates. While we were not able to obtain data on the spread of dengue fever in the rest of the governorates.

Data collection and analysis

The data were collected from the database belonging to a Ministry of Health and Population in Aden. In addition, this analysis used data documented in an epidemiological surveillance center between January 2020 and August 2024. Office administrators and health workers received a clear explanation of the concept and purpose of this investigation. DF cases were diagnosed in hospitals and health centers in the governorates under study based on clinical signs and symptoms, laboratory diagnosis using a rapid test, and IgG and IgM antibodies testing using the enzyme-linked immunosorbent assay (ELISA). Data were electronically collected (soft copy) and automatically extracted from the office system in Microsoft Excel. In addition, the database contained the following variables: the epidemiological weeks, the year, seasons, and month of infection, sex, the age groups, and the name of the governorates. The variables were categorized into subgroups based on the epidemiological monitoring system. This analysis included all DF cases from investigated governorates residents with complete information, all age groups, cases from both public and private health institutions, and all cases diagnosed by laboratory or clinically. Conversely, we excluded from the analysis all cases from individuals who did not reside in the investigated governorates and had incomplete information.

The population denominator was obtained from OCHA [20] and used to calculate the incidence rate (per 10,000 population) based on the following formulation:

$$\text{Incidence rate (IR)} = \frac{\text{Total number of DF cases}}{\text{Total population at risk}} * 10,000$$

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

$$\text{CFR (\%)} = \frac{\text{Total deaths from dengue cases}}{\text{Total suspected from dengue cases}} * 100$$

The obtained data were categorized into quantitative variables and presented as frequencies and percentages in tables and figures. In addition, the incidence rate and case fatality rate were calculated. The denominator for incidence rates was the population size at risk. Additionally, we used the Statistical Package for Social Sciences,

SPSS (Version 24, IBM, Chicago, USA), to analyze the data descriptively.

Results

Demographic characteristics of DF

Between 2020 and 2024, a total of 104,562 DF cases aged between 1 and 80 years (mean \pm SD = 24.93 \pm 17.02) enrolled in this retrospective analysis. The proportion of DF was significantly higher in male's individuals at 60,753 (58.10%) compared with females at 43,809 (41.90%). Moreover, the age groups of 15–24 years had the highest proportion of DF infection at 27,305 (26.11%), followed by those of 25–34 at 25,584 (24.47%), 35–44 years at 15,519 (14.84%), and 5–14 years at 15,375 (14.70%), while those \geq 65 years had the lowest proportion at 3449 (3.30%). In addition, a higher proportion of DF infection was reported in 2020 at 32,053 (30.65%), followed by in 2022 with 25,749 (24.63%), and 2023 with 22,040 (21.08%), while the lower proportion was detected in 2024 at 5003 (4.74%). Furthermore, the Taiz governorate was found to have the highest proportion of DF at 40,958 (39.17%), followed by Aden at 12,217 (11.68%), and Ash Shabwah at 11,970 (11.45%), while the lowest was recorded in Al Maharah governorate at 529 (0.51%), as listed in Table 1.

Figure 1 shows that week no. 22 in 2023 recorded the greater number of DF cases with 1508 cases, followed by week no. 42 in 2022 with 1232 cases, week no. 42 in 2020 with 1030 cases, week no. 11 in 2021 with 636 cases, and week no. 02 in 2024 with 227 cases.

Figure 2 shows that June 2023 recorded the largest number of DF at 5282 (23.97%) cases, followed by October 2022 at 4429 (17.2%) cases, June 2020 at 3968 (12.38%) cases, arch 2021 at 2861 (14.51%) cases, and June 2021 at 909 (18.11%) cases. In contrast, August 2024 recorded the lowest number of DF infections at 313 (6.24%), followed by December 2023 at 969 (4.4%), April 2022 at 1118 (4.34%), September 2021 at 1223 (6.2%), and July 2020 at 1727 (5.39%).

Distribution of DF concerning seasons and months of infection

The present findings indicate that 30,248 (28.9%) recorded the highest number of DF cases in autumn, followed by 25,930 (24.8%) in summer, 25,315 (24.2%) in winter, and 23,069 (22.1%) in spring. Additionally, June had a slightly higher number of dengue cases, with 11,623 (11.1%), followed by October with 10,776 (10.3%), November with 10,568 (10.1%), and January with 10,334 (9.9%). April with 6,453 (6.2%) had the fewest DF cases, as shown in Fig. 3.

Table 1 Characterization of DF cases in some governorate of Yemen between 2020 and 2024

Variables	Categorizes	Cases No.	Percentage (%)
Sex	Male	60,753	58.10
	Female	43,809	41.90
Age group	<5	3970	3.80
	5–14	15,375	14.70
	15–24	27,305	26.11
	25–34	25,584	24.47
	35–44	15,519	14.84
	45–54	8821	8.44
	55–64	4837	4.63
	≥ 65	3449	3.30
Year	2020	32,053	30.65
	2021	19,717	18.86
	2022	25,749	24.63
	2023	22,040	21.08
	2024	5003	4.78
Governorate name	Aden	12,217	11.68
	Taiz	40,958	39.17
	Hadhramout	10,993	10.51
	Abyan	9903	9.47
	Lahj	8810	8.43
	Al Dhale'e	1121	1.07
	Marib	8061	7.71
	Al Maharah	529	0.51
	Shabwah	11,970	11.45

Incidence rate of DF

This study reported a total incidence rate of DF in the study governorate of 103.09 per 10,000 individuals. In addition, the incidence rate of DF significantly higher among males with 118.3 per 10,000 populations compared to 91.73 per 10,000 individuals among females. It was also determined that 149.13 per 10,000 individuals were the highest incidence rate of DF among people aged 25–34, followed by 35–54 year-olds with 139.33 cases, 55–64 year-olds with 1435.34 cases, and 35–44 year-olds with 134.49 cases, while the lowest rate was found among those under the age of < 5, with 73.09 cases per 10,000. In addition, the highest rate of DF incidence was recognized at 31.39 per 10,000 individuals in 2020, followed by 25.22 per 10,000 individuals in 2022, 21.58 per 10,000 individuals in 2023, and the lowest was recorded at 4.9 per 10,000 persons in 2024. Additionally, the Shabwah governorate had the highest DF incidence rate at 176.96 per 10,000 individuals, followed by Abyan at 160.1 per 10,000 individuals, Taiz at 131.93 per 10,000 individuals, and Aden at 115.97 per 10,000 individuals, whereas the Al Dhale'e governorate had the lowest DF incidence rate at 13.7 per 10,000 individuals, as shown in Fig. 4.

Figure 5 shows the distribution of DF incidence rates based on sex, age groups, and years of infection in the investigated governorates. Shabwah (237.97) reported the highest rate of DF incidence (per 10,000 inhabitants) in males among these nine governorates, followed by Abyan (197.68), Taiz (137.06), Aden (129.63), Lahj (93.73), Hadhramout (88.91), Marib (83.86), Al Maharah

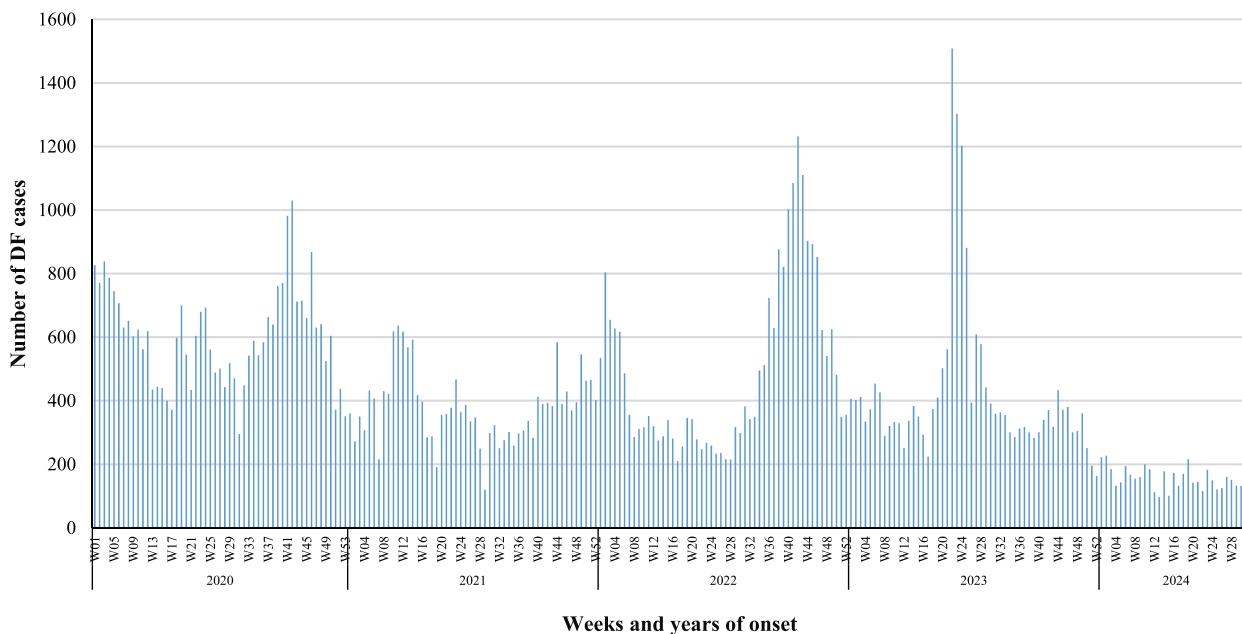


Fig. 1 Epidemiological weekly trends of DF cases in some Yemeni governorate between January, 2020 and August, 2024

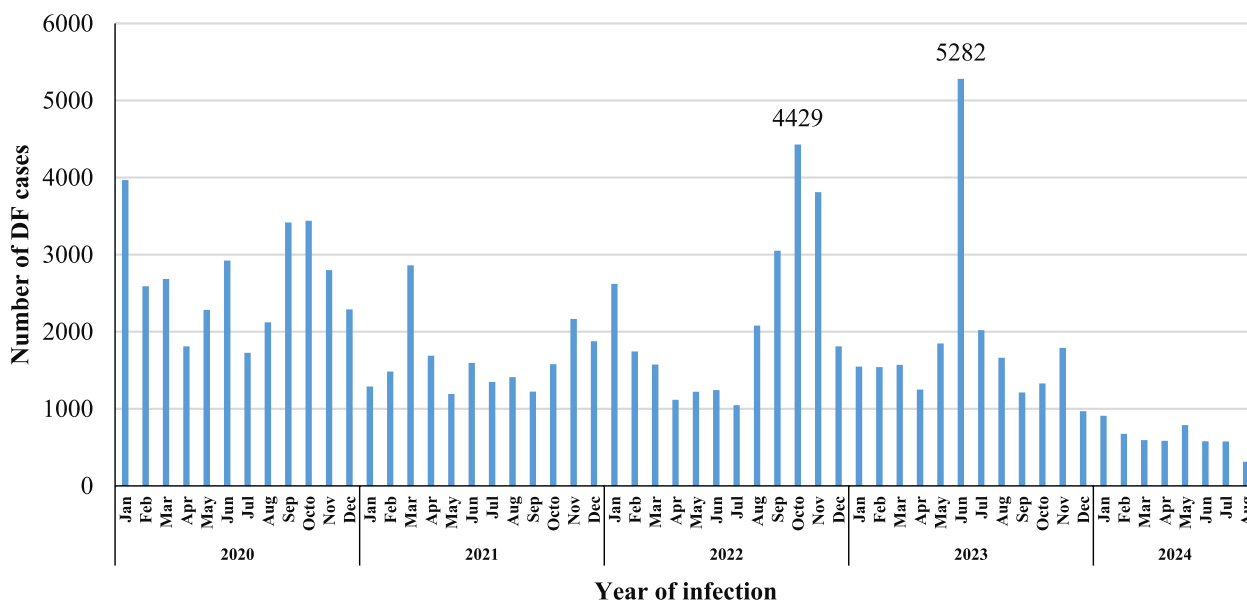


Fig. 2 Epidemiological monthly trends of DF cases in some Yemeni governorate between January, 2020 and August, 2024

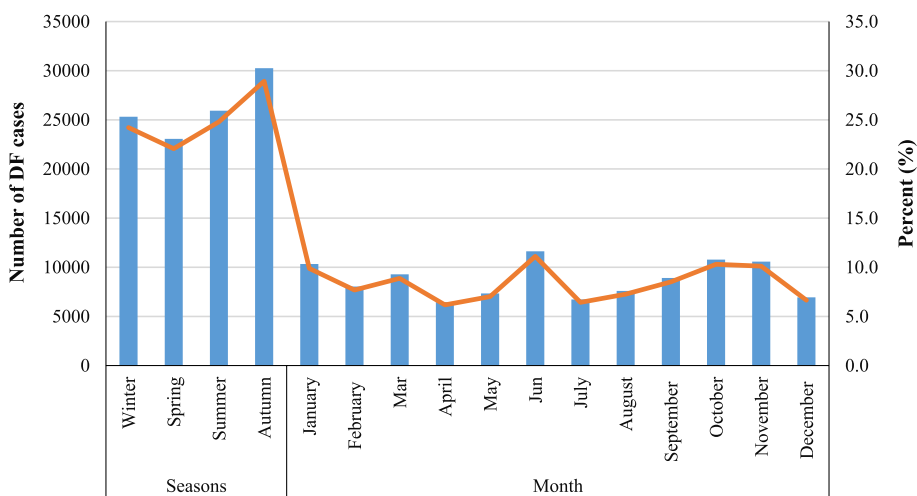


Fig. 3 Frequency of DF cases concerning seasons and months of infection during 2020 to 2024

(38.94), and Al Dhale'e (19.26). In addition, the age group of 25–34 years recorded the highest rate of DF incidence per 10,000 individuals in the governorates of Shabwah (260.04), Taiz (178.38), Lahj (129.58), Marib (114.31), and Hadhramout (100.76). Furthermore, the governorates of Aden (188.51), Al Maharah (56.95), and Al Dhale'e (24.43) had the highest rates of DF incidence per 10,000 individuals among those aged 35–44 years, 65 years, and 55–64 years, respectively. Additionally, a higher rate of DF incidence was recorded in 2020 in the governorates of Shabwah (56.65), Aden (48.81), Lahj (40.06), Marib (32.62), Taiz (31.04), and Al Dhale'e (8.61). Moreover, a

higher rate of DF incidence was documented in 2021 in 2021 Abyan (41.15), while in 2023 in Hadhramout (27.34) and Al Maharah (10.36).

Case fatality rate of DF cases

From the 12,203 DF cases, the total fatality rate was 217 (0.21%) recorded in the studied governorate throughout the study period. The results showed that the fatality rate was slightly higher among females (0.23%) than among males (0.19%). In addition, the highest fatality rate was observed among individuals who aged ≥ 65 years (0.75%), followed by age groups of 55–64 years (0.27%), 5–14

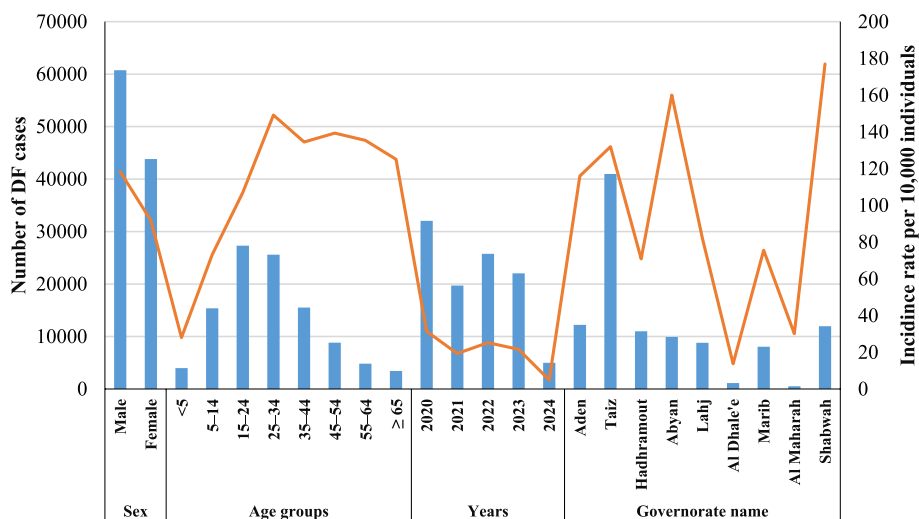


Fig. 4 Incidence rate of DF infection based on governorate between 2020–2024

years (0.25%), and 35–44 years (0.23%). While the rest of the age groups had less than 0.17% of fatality rates. In terms of the infection year, a high rate of DF fatality was recorded in 2020 (0.37%), and the lower rate was in 2023 (0.08%). Additionally, the Aden governorate showed the highest rate of DF cases fatality (0.82%), followed by Lahj (0.41%) and Al Maharah (0.38%), whereas the remaining districts had less than 0.19% of fatality rates (Fig. 6).

Figure 7 shows the largest rate of DF case fatality in females was reported in the governorates of Aden (1.07%; $n=52$), followed by Al Maharah (0.7%; $n=1$), Shabwah (0.3%; $n=11$), Hadhramout (0.26%; $n=12$), Taiz (0.06%; $n=13$), and Marib (0.06%; $n=2$). Whereas, Lahj (0.49%; $n=25$), Al Dhale'e (0.24%; $n=2$), and Abyan (0.19%; $n=12$) recorded higher rates of DF case fatality in males. In addition, the age group of ≥ 65 years recorded the highest rate of DF fatality in the governorates of Abyan (0.66%), Aden (3.96%), Al Dhale'e (2.56%), Lahj (1.89%), Marib (0.48%), and Shabwah (0.69%). Furthermore, the governorates of Hadhramout (1.69%), Al Maharah (1.0%), and Taiz (0.12%) had the highest rates of DF fatality among those aged < 5 years, 35–44 years, 65 years, and 45–54 years, respectively. Additionally, the governorates of Aden (1.19%), Al Maharah (0.96%), Abyan (0.39%), Shabwah (0.37%), and Hadhramout (0.32%) recorded higher rates of DF fatality in 2020. Moreover, Al Dhale'e recorded a higher DF fatality rate in 2024 (4.0%), followed by Lahj (0.64%) in 2023, and Marib (0.19%) and Taiz (0.11%) in 2022.

Discussion

Global dengue numbers have increased rapidly in recent decades owing to demographic changes, aging, urbanization, warming climates, and greater mobility [10, 21]. In

this analysis, Yemen recorded 104,562 DF cases for five years from 2020 to 2024. In previous reports, the number of dengue cases has been reported in different Yemeni governments [12, 13, 22]. Furthermore, the total number of dengue cases during the outbreak period was reported in 2019 at 281,698 cases in Bangladesh [23], 27.99 million in India in 2019 [9], 13,169 cases in Indonesia in 2020 [24], and 114,853 cases in China between 2004 and 2023 [25]. Additionally, Bangladesh, Indonesia, and India have reported epidemic dengue in recent years [9].

The high number of dengue cases in this study could be attributed to various factors, including the ongoing armed conflict that has deteriorated the health system and the discontinuation of infectious disease control programs. Therefore, health institutions in Yemen must establish an alliance and cooperate with global health organizations to develop and implement effective strategies in combating the outbreak of DF and eliminating the mosquito vectors.

The current finding is that male cases of dengue represented 58.10% of cases compared to 41.90% of female cases. This observation is comparable to that of other reports that documented a higher proportion of dengue cases among males [26–28]. Recently, a retrospective analysis conducted in Saudi Arabia between 2010 and 2016 revealed that the DF cases were predominantly male, with 3.8 times that of female cases [29]. In the majority of the population in Yemen, males spend most of their time outside the home to provide livelihoods and may be exposed to mosquito bites, which explains the high prevalence of the disease.

This study found that the number of dengue cases increased significantly in autumn and summer and

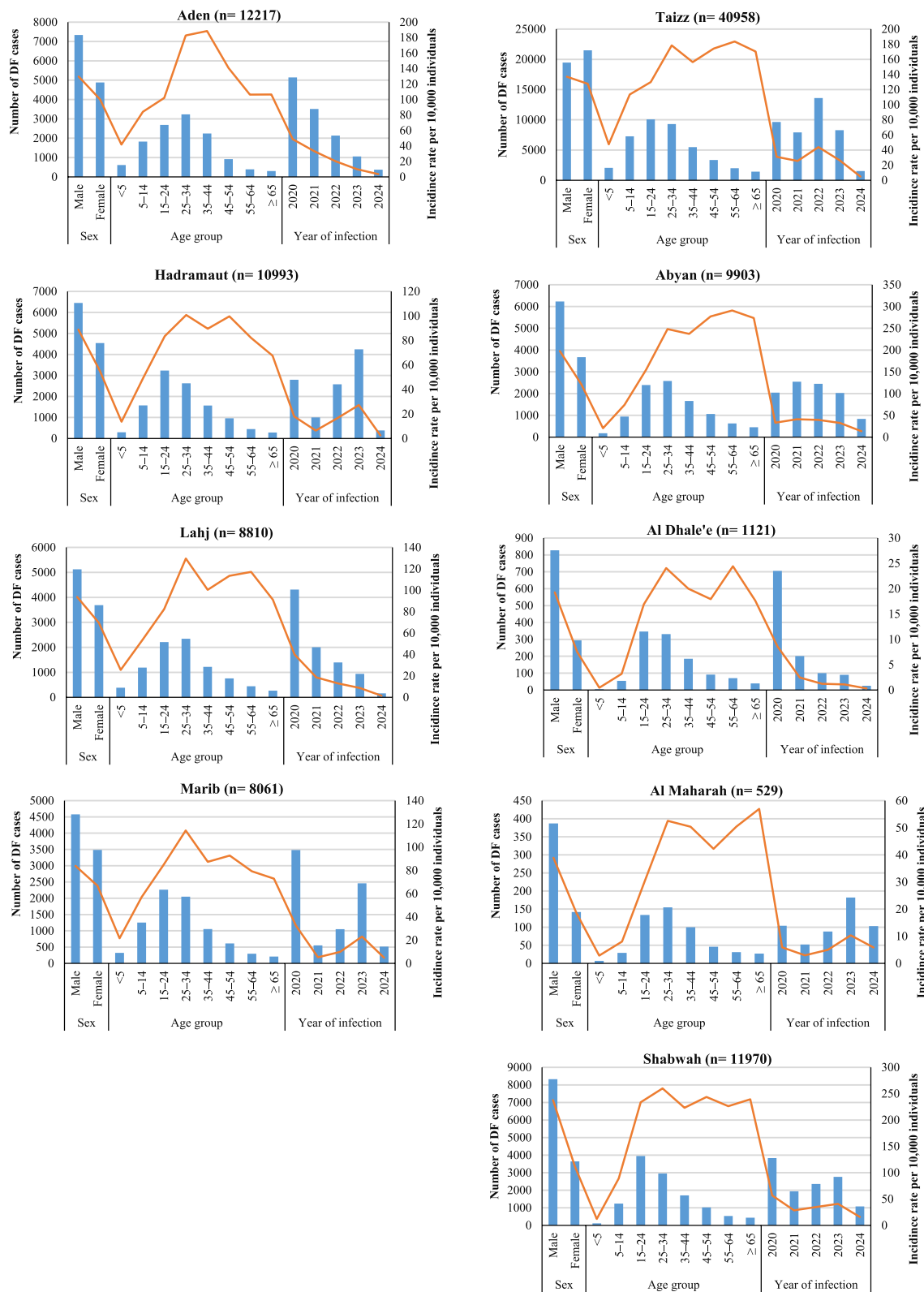


Fig. 5 Distribution of incidence rate of DF infection by sex, age groups, and year of infection in nine governorates

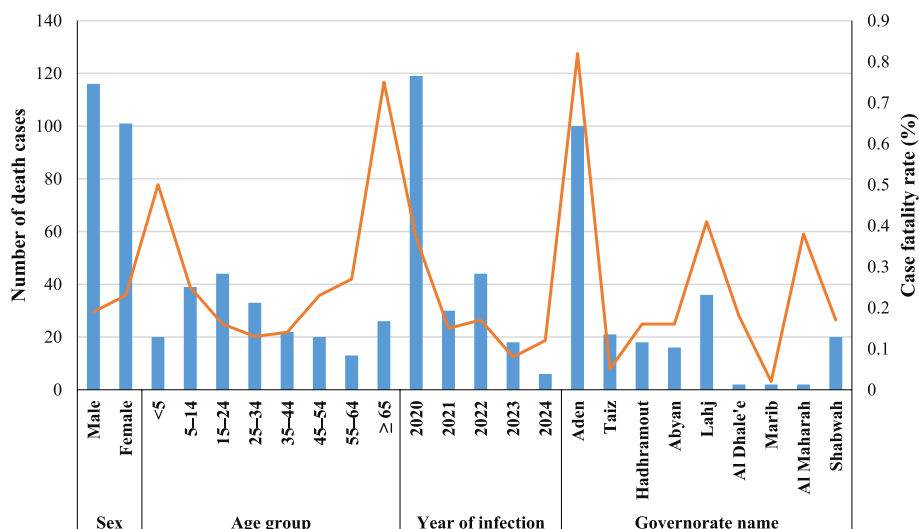


Fig. 6 Five-year cumulative case fatality rate of DF in the investigated governorates from 2020 to 2024

decreased in winter and spring. Furthermore, June accounted for the majority rate of DF cases (11.1%), followed by October (10.3%), November (10.1%), and January 10,334 (9.9%). A similar study in Saudi Arabia found that the summer and December saw the highest number of dengue cases [28, 30]. A similar report found that the highest number of cases were in December 2022 and May 2023 [31]. Mosquito proliferation and dengue incidence are strongly influenced by rainfall and temperature [32]. An earlier report revealed the influence of climate changeability on the incidence of dengue [33]. Furthermore, Taiz governorate reported a high number of dengue cases beginning in August 2015 [34]. Therefore, timely surveillance and vector control interventions can reduce the mosquito population and prevent further transmission. In addition, the prevention of dengue must be taken into consideration when traveling to endemic areas during peak dengue transmission seasons.

One Health’s role lies in early detection and rapid response to the outbreak of the disease by establishing an early warning system in the governorates where dengue fever is endemic. Moreover, the One Health approach effectively focuses on reducing mosquito densities through a combination of environmental management, such as improved environmental sanitation, chemical control, and biological interventions aimed at eliminating mosquito breeding sites. Moreover, community mobilization, such as raising public health awareness and encouraging public participation, plays a crucial role in dengue prevention efforts and effectively contributes to mosquito control [25].

The present study reported that a total incidence rate of DF in the governorate under investigated was 103.09 per

10,000 individuals. Similarly, previous reports recorded an overall rate of DF at 17 per 10,000 individuals in Eastern Ethiopia [35], 25 per 100,000 in Indonesia [24], 8749.54 per 100,000 in Niue, 8687.22 per 100,000 in the Northern Mariana Islands, and 8050.59 per 100,000 in Kiribati [9]. This high incidence rate of DF in this study may be due to misdiagnosis of dengue fever, as many febrile diseases such as malaria or typhoid are similar to the symptoms of dengue fever, and this has been confirmed by many previous studies [36, 37]. As dengue is not routinely screened in health care settings, clinicians are forced to rely on empirical treatment; as a result, DF can be misdiagnosed as typhoid fever and malaria, causing serious public health problems in large areas of Yemen. To avoid this issue, health institutions must provide laboratory diagnostic equipment and solutions, and train their health staff to diagnose febrile diseases other than dengue fever, such as malaria and typhoid fever, as well as dengue co-infection, with high efficiency and effectiveness.

According to the current results, the age group 25–34 years had the highest incidence rate of DF, and the age group under 5 years had the lowest rate. From 1990 to 2019, the age group of 5–14 years recorded the highest incidence rate of DF globally [38]. On the other hand, a study conducted by Du et al. [9] found that individuals over 65 years of age had a higher incidence of DF than those in other age groups. This age group may be more susceptible to the DF disease because they spend more time outdoors, in schools, and in agriculture, all of which increase their risk of mosquito bites. Therefore, raising the level of awareness and health education among this age group regarding the ways this type of disease spreads,

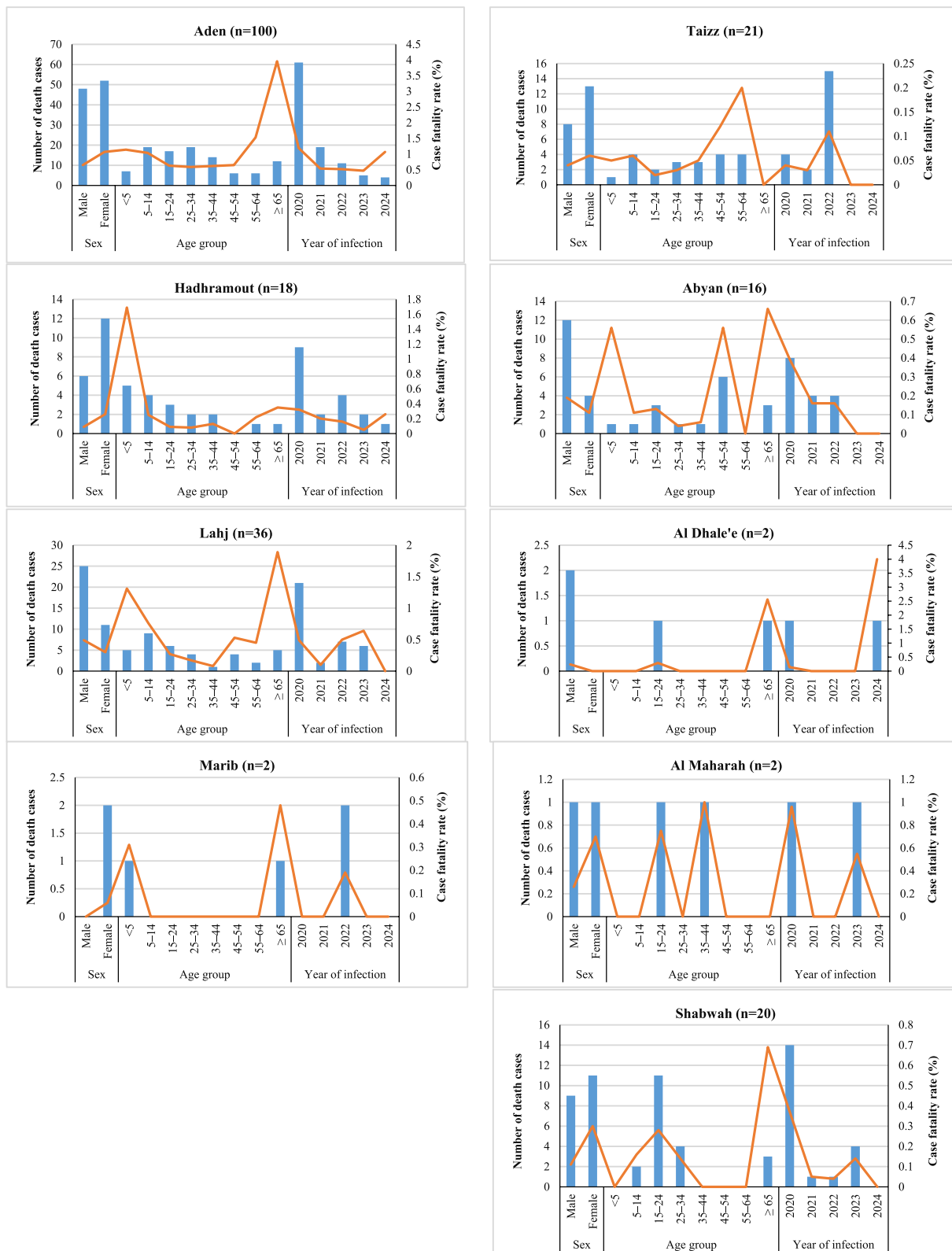


Fig. 7 Frequency of case fatality rate of DF by each investigated governorate from 2020 to 2024

its risks, and methods of prevention will enhance the health of the general population. This is supported by Nikookar et al. [39] and Abbasi et al. [40].

Furthermore, the highest rate of DF incidence was recognized at 31.39 per 10,000 individuals in 2020, while the lowest was recorded at 4.9 per 10,000 persons in 2024. This finding is comparable with the report of Du et al. [9]. The COVID-19 pandemic between 2020 and 2022, which led to the delay or cessation of surveillance efforts worldwide, including in Yemen, is primarily responsible for the increase in dengue fever cases in 2020 compared to previous years, putting millions of lives at risk. Therefore, decision-makers in health institutions must implement robust surveillance systems to monitor, identify early, and control outbreaks of dengue and other infectious diseases, even during pandemics of other infectious diseases such as COVID-19.

These findings revealed that the highest DF incidence rate per 10,000 individuals was predominant in the Shabwah governorate (176.96), followed by Abyan (160.1), Taiz (131.93), and Aden (115.97). Recently, a higher rate of dengue incidence per 1000 population were observed in Aden at 3.4%, Abyan at 2.8%, Lahj at 2%, Hadhramout at 1.7%, and Shabwa at 1.5% governorates [41]. This increase in DF cases in these governorates could be attributed to weaknesses in the surveillance systems, which can lead to delayed reporting and response, as well as missed symptom identification, thereby contributing to an increase in severe dengue outcomes. In endemic areas, all inhabitants must participate in mosquito control, such as using insecticide-impregnated mosquito nets while sleeping, cleaning up discarded tires and places where stagnant water collects, using an electronic light trap lamp, and spraying walls with insecticides.

According to the present study, the overall rate of DF fatality was recorded at 217 (0.21%). In the earlier reports in Yemen, the case fatality rate of DF was reported between 0.4 and 0.5% in 2019 [14], 1.9% in Hadhramout between 2005 and 2009 [5]. Globally, the total number of deaths increased from 28,151 in 1990 to 36,055 in 2019 [10]. Moreover, the overall rate of DF fatality was recorded at 1% in Eastern Ethiopia [35], and approximately 1417 deaths have been recorded in Bangladesh [23]. The continued rise in the DF outbreak in Yemen without a response from the relevant institutions may put the lives of the general population at risk. Furthermore, it is necessary to establish a system to monitor and control the spread of DF in different regions of Yemen, especially after noticing an increase in dengue cases in recent years compared to previous years.

Globally, a significant decline in dengue mortality was observed only among females (by 0.5% per year), while an

increase was seen among males (by 0.6% per year) [10]. On the other hand, these results revealed that the fatality rate was slightly higher among females (0.23%) than among males (0.19%). This result is in consonance with the recent report in Bangladesh that showed the CFR was significantly higher among females compared with males (17.69% vs. 15.36%) ($P < 0.001$) [23]. The high mortality rate among females in this study may be due to the difficult economic conditions in Yemen, which led to a lack of health services and deterioration in nutritional status, especially among females. In addition, physiological and immunological changes may have contributed to the spread of DF in females.

Furthermore, the highest fatality rate was observed among individuals aged ≥ 65 years, and the lowest was among under 5 years. This finding is in line with global reporting [38, 42, 43]. Recently, the mortality rates were increased gradually among those > 70 years old and decreased gradually among those under 5 years [44]. Moreover, advanced age, physiological dysfunction, immunological reduction, and the presence of chronic diseases are factors that increase the risk of fatal dengue among elderly individuals [45, 46]. Consequently, prevention strategies targeted at older populations must be developed more fully.

In terms of the year of infection, a high rate of DF fatality was recorded in 2020 (0.37%), and the lowest rate was recorded in 2023 (0.08%). An increase in the CFR in Yemen was observed from 0.1% in 2018 to 0.2% in 2019 [12]. Furthermore, the Aden governorate showed the highest rate of DF cases fatality (0.82%), followed by Lahj (0.41%) and Al Maharah (0.38%). This result is consistent with earlier report in Yemen documented that the highest rate of CFR was recorded in Aden (25 deaths, 0.7%) [41].

Strength and limitations

This is the first study that included a more comprehensive analysis of DF epidemiology in Yemen than any previous publication. Furthermore, the results of this analysis are critical for health institutions to establish an effective system for monitoring and controlling the prevalence of the dengue epidemic in Yemen. This analysis relied on data for both laboratory diagnosis using an enzyme-linked immunosorbent assay (ELISA) and clinical diagnosis based on clinical signs and symptoms, which is considered one of its strengths. Nevertheless, this analysis has several limitations. First, the absence of data on dengue infections in some governorates under the control of the Sana'a government is considered the most significant shortcoming, as it hinders the accurate presentation of the DF epidemiology in Yemen. Secondly, there is a lack of data on the vectors that contributed to the spread of DF, in addition to the lack

of access to factors affecting the transmission of the dengue disease, such as environmental conditions, economic status, level of education, and others. Third, the inability to obtain dengue virus serotypes in the study areas, which will add great importance to this study.

Conclusion

The present results indicate that the DF increased gradually, particularly in the last year, with an increase in the case fatality rate that threatened the lives of the population in the investigated areas. It has been observed that males and adults are more affected by dengue fever. In addition, the highest cases of DF were recorded in 2020 during the COVID-19 pandemic, while the governorates of Taiz, Shabwah, and Aden were considered to be endemic to dengue fever. Therefore, local health institutions should collaborate with the international organizations to implement effective programs to combat and control the outbreak of DF, particularly in the governorates where DF was high. In addition, health offices should promote and improve early diagnosis, qualify health care staff, and engage and educate the community, which is important in reducing the transmission of DF in the community. A comprehensive study is essential to evaluate the epidemiology of dengue fever in governorates where epidemiological data is not available in order to present an accurate picture of DF in Yemen. Furthermore, a further study is required to determine the epidemiological vector-borne mesquite and their associated risk factors that contribute to the transmission of dengue viruses. Additionally, it is important to conduct a molecular epidemiological study of the dengue virus to determine its genotyping, circulating chains, and distribution in the Yemeni governorates. Promoting international cooperation to conduct dengue vaccine research, accelerate clinical trials, and obtain approval for its use is extremely important, which will aim to effectively control dengue epidemics in the world.

Abbreviations

CDC	Centers for Disease Control and Prevention
CFR	Case Fatality Rate
DF	Dengue Fever
ELISA	Enzyme-Linked Immunosorbent Assay
IR	Incidence rate
SPSS	Statistical Package for Social Sciences
WHO	World Health Organization

Acknowledgements

The authors thank the staff working in the Health institution, in the Aden Governorate, for providing the data for this study.

Author's contributions

Edrees W and Al-Shehari W conceived of the study, Edrees W and Al-Haddad A collected the data, Alrahabi L and Al-Haddad O analyzed the data, and Edrees W and Al-Halani A prepared the original manuscript. All authors reviewed, revised, and approved the manuscript for submission.

Funding

Not applicable.

Data availability

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

Declarations

Ethics approval and consent to participate

The proposal of this study was submitted to the Medical Microbiology Department at the College of Applied Sciences, Hajjah University, which subsequently forwarded it to the Ethical Review Committee of the College of Applied Sciences, which approved ethical clearance for this investigation with Reference Number (018) on July 16, 2024. Then, an official letter describing the purpose and benefits of this investigation was written from the Dean of the Applied Sciences, Hajjah University, to the Ministry of Health and Population for permission to obtain related data for this study. Therefore, owing to the retrospective nature of the study, the Ministry of Health and Population granted permission for the use of database data for research purposes based on Article 51 of the Yemeni Public Health Law No. (4) 2009 and waived the need for informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 11 November 2024 Accepted: 27 December 2024

Published online: 06 January 2025

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