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Dengue Fever in Al-Hodeidah Governorate, Yemen: A Seven-Year Epidemiological Analysis, 2019–2025

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Abstract

Background

Dengue fever remains a major public health concern in Yemen, with cases reported from almost all governorates. Dengue has most severely impacted Al-Hodeidah Governorate. Ongoing conflict, population displacement, inadequate infrastructure, and a fragile health system have contributed to the persistence and spread of dengue fever in the region.

Objectives

To describe the epidemiological characteristics and trends of dengue fever from 2019 to 2025

Methods

A retrospective descriptive analysis was conducted. The cumulative dengue fever data for the period from 2019 to 2025 were obtained from the electronic Integrated Disease Early Warning System (eIDEWS) as line-listed records. The WHO and eIDEWS case definitions were used to collect data from suspected cases. Surveillance data were reviewed and cleaned and analyzed by place, person, and time using SPSS version 27.

Results

A total of 115,381 suspected dengue cases were reported during the study period, of which 32,203 (27.9%) were laboratory confirmed. Males accounted for 59.0% of the cases, and the mean age of the patients was 21.6 ± 16.6 years. Most cases occurred among individuals aged 15–29 years (30.9%) and during 2020 (26.9%). The overall incidence of dengue was 302 per 10,000 population, with higher incidence among males (362 per 10,000 population) and individuals aged 15–29 years (389 per 10,000 population). Marked seasonal variation was observed, with 46.6% of cases occurring during winter. A total of 236 dengue-related deaths were reported, corresponding to a case fatality rate (CFR) of 0.2%, with the highest rates observed among females (0.22%), individuals aged ≥ 60 years (0.45%), and in 2019 (0.41%). Fever (100%), headache (99.2%), joint pain (97.3%), and muscle pain (93.0%) were the most common symptoms. Additionally, 446 cases (0.4%) displayed symptoms of dengue hemorrhagic fever.

Conclusion

Dengue fever remains endemic in Al-Hodeidah Governorate and continues to pose a significant public health challenge, with marked temporal, seasonal, demographic, and geographical variation. Higher case burdens in urban and conflict-affected areas emphasize the necessity of targeted interventions.

Strengthening surveillance systems, enhancing community engagement and awareness, improving vector control strategies, and implementing coordinated multisectoral interventions are essential to reduce the burden of dengue and prevent future outbreaks.

Background

Dengue fever (DF) is an acute arboviral disease caused by infection with one of four distinct serotypes of the dengue virus (DENV-1, DENV-2, DENV-3, or DENV-4). Dengue viruses are classified within the genus Flavivirus of the family Flaviviridae (1, 2). The virus is transmitted predominantly to humans via the bite of infected Aedes aegypti mosquitoes (3). Although the majority of dengue infections are asymptomatic, symptomatic individuals exhibit a broad spectrum of clinical manifestations, from a mild self-limiting febrile illness to severe complications characterized by hemorrhagic symptoms and shock (4, 5). Dengue fever imposes significant economic and social hardships on affected nations and presents a substantial public health challenge (6).

Dengue is now endemic in more than 129 countries, putting roughly half of the global population at risk of infection, especially in tropical and subtropical areas (6, 7). The World Health Organization (WHO) estimates that dengue causes approximately 390 million infections globally each year, approximately 96 million of which are clinically apparent, resulting in approximately 40,000 deaths annually (8). The global incidence of dengue has risen markedly recently (9, 10). The number of reported dengue cases increased from approximately 5 million in 2023 to more than 14 million in 2024 (9, 11). This increase may be associated with several interconnected factors, such as climate change, rapid urbanization, globalization, increased international travel and trade, and the expanding geographic distribution of mosquito vectors (11–13). In addition, inadequate environmental sanitation, population growth, and socioeconomic challenges in low-resource settings may contribute to conditions that favor vector proliferation and disease transmission and may be associated with the emergence and re-emergence of dengue in previously unaffected areas (14, 15).

Despite substantial progress in dengue prevention and control, no specific antiviral treatment has been developed, and the implementation of dengue vaccines remains limited (16). Consequently, vector control continues to play a central role in dengue prevention and control (13). Interventions targeting the elimination of *Aedes aegypti* breeding sites and reducing human mosquito contact are considered important strategies for reducing dengue transmission and disease burden, particularly in areas where insecticide resistance is emerging (17).

Dengue fever is a major public health concern in Yemen and is endemic in several regions of the country (18, 19). It is estimated that more than 60% of the population lives in areas at risk of dengue transmission (20). In the past decade, the number of dengue outbreaks in Yemen has increased considerably, particularly from 2019 to 2023, with the greatest burden in coastal governorates, including Al-Hodeidah, where ecological and climatic conditions are conducive to the breeding and propagation of Aedes mosquitoes (21). In 2020, Yemen experienced a massive surge in dengue cases, with a number

approximately seven times greater than that in 2019 and six times greater than that in 2018 (18). National surveillance reports recorded 9,770 dengue cases and six deaths (CFR 0.06%) in Yemen in 2024. Among these cases, 7,662 (78.4%) were reported from the Al-Hodeidah Governorate (22).

Yemen has experienced a prolonged humanitarian crisis driven by more than a decade of armed conflict, economic decline, and the deterioration of essential public services. Consequently, the country has faced widespread poverty, population displacement, infrastructure damage, and disruptions to healthcare services, including disease surveillance and vector control efforts (21, 23–27). Limited access to safe water, inadequate sanitation, rapid urbanization, and poor waste management have further created favorable conditions for the proliferation of Aedes mosquitoes and the transmission of the dengue virus (13). In addition, climate-related factors, including increasing temperatures, high humidity, seasonal rainfall, and recurrent flooding events, may have contributed to the expansion of mosquito breeding habitats and the increasing occurrence of dengue outbreaks across several regions of Yemen (21, 24, 27, 28).

Al-Hodeidah Governorate has been identified as a high-risk area for dengue transmission in Yemen, potentially because of its coastal location, tropical climate, high population density, and environmental conditions conducive to year-round mosquito breeding (29–31).Despite recurrent dengue outbreaks and the substantial disease burden in the governorate, comprehensive epidemiological studies describing long-term temporal trends, demographic characteristics, geographical distribution, incidence rates, and mortality patterns remain limited. Therefore, this study aimed to describe the epidemiological patterns and temporal trends of dengue fever in the Al-Hodeidah Governorate from 2019 to 2025. The findings of this study may help fill existing knowledge gaps regarding the burden and epidemiology of dengue fever in the Al-Hodeidah Governorate. In addition, these findings can also contribute to strengthening epidemiological surveillance systems, improving outbreak preparedness, and guiding dengue prevention and control efforts more effectively in the governorate.

Methods

Study design and area

A retrospective descriptive analysis was conducted using routinely collected surveillance data to characterise the temporal, demographic, and geographical patterns of dengue fever in Al-Hodeidah Governorate, Yemen, from January 2019 to December 2025.

Al-Hodeidah Governorate is located on Yemen’s western Red Sea coastal plain and covers an area of approximately 17,509 km² (32). It is the fourth-largest governorate in the country and had an estimated population of 4,093,212 inhabitants (33). Administratively, the governorate is divided into 26 districts, three of which (Al-Hali, Al-Hawak, and Al-Mina) are urban districts, and the remaining 23 are rural districts. These districts are further subdivided into approximately 410 subdistricts and about 689 villages.

The governorate has a tropical climate with temperatures frequently exceeding 40°C during summer and averaging approximately 29–30°C during winter. High humidity levels and seasonal rainfall create favourable ecological conditions for the breeding and survival of Aedes aegypti, the principal vector responsible for dengue virus transmission, facilitating year-round dengue transmission (31, 34, 35).

Case definitions

Dengue fever cases were identified and classified according to the national case definition adopted by the eIDEWS (36), which is aligned with WHO guidelines (37), as follows:

Suspected dengue case

A suspected dengue case was defined as any person with a sudden fever of more than 38°C for 2–10 days, with two of the following symptoms: severe headache, retro-orbital pain, myalgia, arthralgia, rash, hemorrhagic manifestations, and leukopenia.

confirmed dengue case

A confirmed dengue case was defined as a suspected case with laboratory confirmation of dengue infection by at least one of the following diagnostic methods: detection of dengue NS1 antigen, detection of dengue-specific IgM antibodies, or detection of dengue viral RNA by molecular techniques where available.

Data collection and extraction

Dengue surveillance data for the period 2019–2025 were obtained from eIDEWS and the Epidemiological Surveillance Department of the Office of Health and Environment in Al-Hodeidah Governorate.

Dengue surveillance data are routinely collected by epidemiological surveillance teams from several public and private healthcare facilities that provide healthcare and participate in disease surveillance activities across all governorate districts. At these facilities, suspected dengue cases were initially identified according to the standardised case definitions established by the WHO and eIDEWS. Suspected cases were subsequently confirmed via rapid diagnostic tests (RDTs).

Data were extracted from the surveillance database in the form of electronic line lists (Microsoft Excel format) and included demographic, epidemiological, clinical, and laboratory information for all reported dengue fever cases during the study period. The demographic and epidemiological variables included sex, age group, district of residence, epidemiological week, year of reporting and month of infection. Clinical manifestations and patient outcomes (recovery or death) were also recorded.

Inclusion and exclusion criteria

All reported dengue fever cases among residents of the Al-Hodeidah Governorate during the study period were included in the study. Cases with missing key epidemiological variables, duplicate records, or residences outside the governorate were excluded from the analysis to ensure data quality and validity.

Data management and statistical analysis

The data was initially reviewed, cleaned, and validated via Microsoft Excel 2021 before statistical analysis. Completeness, consistency, and duplication checks were performed, and records that did not meet the inclusion criteria were excluded. The cleaned dataset was subsequently imported into the Statistical Package for Social Sciences (SPSS), version 27 (IBM Corp., Armonk, NY, USA), for analysis.

Descriptive epidemiological analysis was conducted according to person, place, and time characteristics. Categorical variables were summarised using frequencies and percentages. Temporal patterns were analysed annually and monthly to identify seasonal patterns, while the spatial distribution of dengue cases was assessed across the districts of the governorate to highlight the district-wide distribution of the disease burden.

Annual dengue incidence rates were calculated for each year by dividing the number of dengue cases during that year by the total population at risk and multiplying by 10,000 people. The population denominators were obtained from the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) population estimates (33). The case fatality rate (CFR) was calculated by dividing the number of total deaths associated with dengue by the total number of suspected dengue cases and multiplying by 100. The results are presented in tables and graphs.

Results

Demographic characteristics of the DF patients

A total of 115,381 suspected cases of DF were reported in Hodeidah Governorate, Yemen, between 2019 and 2025. Males accounted for a greater proportion of cases than females, accounting for 68,121 (59.0%) and 47,260 (41.0%) cases, respectively. The mean age of the DF patients was 21.6 ± 16.6 years. The largest proportion of cases occurred in the 15–29-year age group (30.9%), followed by 5–14 years (22.0%), 30–44 years (18.8%), and < 5 years (17.8%).

The annual number of reported DF cases fluctuated throughout the study period, with the highest number recorded in 2020 (31,032; 26.9%), followed by 2019 (25,938; 22.5%) and 2022 (23,218; 20.1%). The lowest number of cases was reported in 2021 (7,335; 6.4%). With respect to patient outcomes, 115145 (99.8%) recovered, while 236 (0.2%) deaths were recorded (Table 1).

Table 1
Demographic characteristics, annual distribution, and clinical outcomes of dengue fever cases in Hodeidah Governorate, Yemen, 2019–2025. (n = 115,381)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	68,121	59.0
	Female	47,260	41.0
Age Group	< 5 years	20,595	17.8
	5–14 years	25,412	22.0
	15–29 years	35,709	30.9
	30–44 years	21,661	18.8
	45–59 years	7,553	6.5
	≥ 60 years	4,451	3.9
Mean age	(21.6 ± 16.6 years)		
Year	2019	25,938	22.5
	2020	31,032	26.9
	2021	7,335	6.4
	2022	23,218	20.1
	2023	9,890	8.6
	2024	7,675	6.7
	2025	10,293	8.9
Outcome	Cure	115145	99.8
	Death	236	0.2

Trend of Dengue Fever Cases by Epidemiological Week

The weekly distribution of DF cases exhibited substantial temporal variation throughout the study period (2019–2025). A substantial increase in case numbers was observed during epidemiological weeks 43–53 of 2019, with the highest weekly count recorded in week 50 (3,598 cases). Elevated case numbers persisted during the early weeks of 2020 before declining progressively throughout the remainder of the year. In 2021, weekly case counts remained relatively low compared with those in other years. A second increase in DF activity was observed in 2022, reaching a peak of 1,183 cases in epidemiological week 20. From 2023 to 2025, weekly case counts fluctuated at comparatively lower levels without reaching the epidemic peaks observed from 2019 to 2020 and 2022 (Fig. 1).

Distribution of DF cases according to year and month of infection

Figure 2 shows the monthly distribution of DF cases from 2019 to 2025. The highest monthly number of DF cases was recorded in December 2019 (14,645 cases), followed by January 2020 (12,856 cases) and November 2019 (9,455 cases). In subsequent years, the highest monthly counts were reported in December 2021 (1,746 cases), May 2022 (4,090 cases), January 2023 (1,386 cases), May 2024 (1,065 cases), and April 2025 (1,219 cases).

Temporal trends of dengue fever cases by month and season

Marked seasonal variation in dengue fever occurrence was observed during the study period. Nearly half of all reported cases occurred during winter (53,788; 46.6%), followed by spring (34,240; 29.7%), whereas substantially lower proportions were recorded during summer (17,617; 15.3%) and autumn (9,736; 8.4%). Monthly analysis revealed that case numbers peaked in December (20,120; 17.4%), January (19,294; 16.7%), and November (14,374; 12.5%). Conversely, the lowest case counts were observed in August (2,401; 2.1%) and September (2,524; 2.2%) (Fig. 3).

Incidence rates of dengue fever by age, sex, and year

The overall incidence rate of DF was 302 per 10,000 population during the study period. The highest incidence rate was reported among males (362 per 10,000 population) and the age group 15–29 years (389 per 10,000 population), followed by those aged 30–44 years (342 per 10,000 population) and children aged less than 5 years (316 per 10,000 population). Marked variations in annual dengue incidence were observed throughout the study period. The highest incidence of dengue fever was recorded in 2020 (86 per 10,000 population), followed by 2019 (74 per 10,000 population) and 2022 (60 per 10,000 population). Thereafter, incidence rates declined considerably, reaching 25 cases per 10,000 population in both 2023 and 2025, while the lowest incidence rate was documented in 2024 (19 cases per 10,000 population) (Fig. 4).

Geographical distribution of dengue fever incidence rates by district

Marked spatial variation in dengue fever incidence was observed across the districts of the Al-Hodeidah Governorate. The highest incidence rates were recorded in Salif (1,842 per 10,000 population) and Kamaran (1,429 per 10,000 population), Al Hawak (790 per 10,000 population), Al Mina (703 per 10,000 population) and Al Qanawis (498 per 10,000 population), whereas the lowest rates were reported in Al-Khukhah (12 per 10,000 population), Bura (26 per 10,000 population) (Fig. 5).

Figure 5. Incidence rate of dengue fever by districts in Hodeidah Governorate, Yemen, 2019–2025 (n = 115,381).

Patient fatality rates of dengue fever by age, sex, and year

Among the 115,381 reported DF cases, 236 deaths were recorded, yielding an overall case fatality rate (CFR) of 0.2% during the study period. CFR was slightly higher among females (0.22%) than males (0.20%). In addition, the highest CFR was observed among individuals aged ≥ 60 years (0.45%), followed by children aged < 5 years (0.34%). The annual CFR was highest in 2019 (0.41%) and declined progressively thereafter, reaching its lowest levels in 2024 (0.03%) and 2025 (0.04%) (Fig. 6).

Figure 6. Case fatality rate of dengue fever by sex, age, and year of infection in Hodeidah Governorate, Yemen, 2019–2025 (n = 236).

Case fatality rate of dengue fever by district

Variation in CFR was observed across districts. The highest number of deaths was recorded in Bayt Al Faqih (44 deaths; CFR = 0.4%), followed by Zabid (28; 0.4%), Az Zuhrah (25; 0.7%), Al Hawak (24; 0.1%), and Al Jarrahi (21; 0.3%). Fewer deaths were observed in Az Zaydiah (18; 0.3%), As Sukhnah (19; 0.6%), Bajil (10; 0.3%), and At Tuhayta (7; 0.3%) (Fig. 7).

Clinical manifestations associated with dengue fever

Fever was reported in all dengue fever (DF) patients (100.0%). The most frequently reported clinical manifestations were headache (99.2%), joint pain (97.3%), and muscle pain (93.0%). More than three-quarters of the patients experienced retro-orbital pain or eye redness (76.4%), whereas general weakness was reported in 54.9% of the patients. The gastrointestinal manifestations included vomiting (34.2%) and abdominal pain (21.1%), whereas skin rash was reported in 18.4% of the patients. Less common manifestations included oliguria or anuria (3.4%), jaundice (3.3%), and watery diarrhea (1.0%). Severe clinical manifestations were uncommon and included coma (0.8%) and hemorrhagic signs (0.4%). (Table 2).

Table 2
Clinical manifestations associated with DF in Hodeidah governorate, Yemen, 2019–2025 (n = 115,381).

Clinical Manifestations	Frequency (n)	Percentage (%)
Fever	115,381	100.0
Headache	114,494	99.2
Joint Pain	112,304	97.3
Muscle Pain	107,318	93.0
Eye Redness or Pain Behind the Eyes	88,102	76.4
General Weakness	63,320	54.9
Vomiting	39,415	34.2
Abdominal Pain	24,370	21.1
Skin Rash	21,257	18.4
Oliguria or Anuria	3,919	3.4
Jaundice	3,794	3.3
Watery Diarrhea	1,206	1.0
Coma	943	0.8
Hemorrhagic Signs	446	0.4

Laboratory tests

Among the 115,381 suspected dengue cases reported during 2019–2025, a total of 82,979 samples (71.9%) underwent laboratory testing. Of these, 32,203 samples were laboratory-confirmed as dengue-positive, representing 38.8% (32,203/82,979) of tested samples and 27.9% (32,203/115,381) of all suspected cases. Diagnostic testing was performed using either rapid diagnostic tests (RDTs) (79,445 samples) or enzyme-linked immunosorbent assays (ELISA) (3,534 samples). The positivity rate was 39.7% (31,518/79,445) for RDT and 19.4% (685/3,534) for ELISA. Among RDT-positive samples, 26,985 (34.0%) were positive for NS1 antigen only, 3,159 (4.0%) were positive for IgM antibodies only, and 1,374 (1.7%) were positive for both NS1 antigen and IgM antibodies. Among ELISA-tested samples, 392 (11.1%) were NS1-positive and 293 (8.3%) were IgM-positive (Table 3).

Table 3. Laboratory diagnostic results of dengue infection in Hodeidah governorate, Yemen, 2019–2025 (n = 82,979).

Diagnostic Test	RDT	ELISA
Total Samples Tested	79,445	3,534
Overall Positive n (%)	31,518 (39.7)	685 (19.4)
NS1 Ag Positive n (%)	26,985 (34.0)	392 (11.1)
IgM Positive n (%)	3,159 (4.0)	293 (8.3)
Positive (NS1 + IgM) n (%)	1,374 (1.7)	NA

Abbreviations: RDT = Rapid Diagnostic Test; ELISA = Enzyme-Linked Immunosorbent Assay; NS1 = Non-Structural Protein 1 Antigen; NA: not available

Discussion

Dengue fever (DF) continues to represent a major public health challenge worldwide, particularly in low- and middle-income countries, where the disease imposes a substantial burden on healthcare systems and public health resources (38). The rising number of dengue cases around the world is due to a complicated mix of factors, such as climate change, rapid urbanization, population growth, more people moving around, and the spread of Aedes mosquito vectors to new areas (38-40). Yemen is among the countries where dengue fever remains endemic, with recurrent outbreaks reported in several governorates over recent decades (18, 21, 27, 40). In this context, the present study presents an in-depth analysis of the epidemiological characteristics, temporal trends, seasonal patterns, clinical manifestations, and case fatality rates of dengue fever in Hodeidah Governorate between 2019 and 2025.

The present study recorded a total of 115,381 suspected DF cases over the seven-year study period (2019-2025). This finding aligns with previous studies from Yemen that documented recurrent outbreaks and sustained dengue transmission in several governorates. A recent study conducted in the southern governorates of Yemen reported 104,562 DF cases between 2020 and 2024 (21), whereas another study from Hajjah Governorate reported 10,617 suspected cases during the same period (27). Moreover, previous studies from Yemen reported 59,486 suspected cases in 2019 (41). Similarly, the WHO reported a major dengue outbreak in Yemen in 2019, with 71,688 reported cases nationwide (18) . Other dengue-endemic countries have also reported similar findings. For example, a retrospective study conducted in Bangladesh reported 281,698 dengue cases in 2019, reflecting the substantial burden of dengue in the region (42).

The high burden of dengue fever observed in this study could be attributed to a combination of factors, including ongoing armed conflict, deterioration of public health infrastructure, population displacement, and limited vector-control activities. Furthermore, environmental conditions favorable for mosquito breeding, coupled with inadequate water management and sanitation services, may have facilitated the sustained transmission of the dengue virus in the study area. Therefore, enhancing vector-control

programs and fostering collaboration between national health authorities and international health organizations are essential to improve dengue prevention and control efforts in Yemen.

The study reveals that males reported the highest incidence rate. This finding is consistent with previous studies conducted in Yemen (21, 27) and other countries, including Saudi Arabia Saudi Arabia (43), and Italy (44), which observed a higher incidence of dengue infection among males than among females. In contrast, a global analysis reported higher infection rates among females than among males (38). Differences in exposure patterns, occupational activities, healthcare-seeking behavior, and sociocultural factors may partly explain these variations across settings (27).

The present study revealed that the individual age group of 15–29 years had the highest incidence rate of dengue fever, followed by those aged 30–44 years. This finding is in agreement with previous studies conducted in Yemen (21, 27) and other countries, including and Saudi Arabia (43, 45) and Ethiopia (46). The predominance of dengue infection among adolescents and young adults may reflect their greater involvement in occupational, educational, and social interactions that increase exposure to mosquito bites. Furthermore, increased mobility and outdoor activities may place these age groups at greater risk of contact with infected Aedes aegypti mosquitoes (47, 48).

The present study found that 2020 had the highest incidence rate of dengue fever, followed by 2019. Thereafter, incidence rates declined considerably, reaching 25 cases per 10,000 population in both 2023 and 2025, while the lowest incidence rate was documented in 2024. These findings are consistent with previous studies conducted in Yemen (21, 27) that documented substantial year-to-year fluctuations in dengue incidence in Yemen, as well as with global reports highlighting the dynamic nature of dengue transmission (49). The increased dengue incidence during (2019-2020) may be attributed to a combination of factors, including disruptions to routine surveillance and vector-control activities during the COVID-19 pandemic, as well as environmental conditions favorable to Aedes mosquito breeding. The subsequent decline in dengue incidence after 2022 may be partly explained by increased surveillance sensitivity and activities. In addition to the implementation coordinated multisectoral integrated interventions compared with previous periods. These interventions included case-based surveillance conducted by rapid response teams, vector control measures, and community engagement initiatives. They also involved household visits conducted by trained health volunteers in collaboration with rapid response teams to identify and eliminate mosquito breeding sites, thereby strengthening household-level vector control.

The present study found that nearly half of the dengue fever (DF) cases occurred in the winter season, followed by spring and autumn. Moreover, the highest proportion of DF cases was observed in December (17.4%), followed by January (16.7%) and November (12.5%), and the lowest proportions of cases were recorded in August and September. A recent study in Yemen (21) reported a significant increase in DF cases during autumn and summer, which contradicts these results. However, a study conducted in Hajjah Governorate similarly reported that dengue cases were concentrated predominantly during autumn and winter, accounting for 46.6% and 40.6% of cases, respectively, whereas substantially lower

proportions were observed during spring and summer (27). Previous studies have shown that dengue transmission is strongly influenced by climatic and environmental factors, particularly temperature, rainfall, and humidity, which affect the breeding, survival, and distribution of Aedes mosquitoes (50, 51).

The present study found that nearly half of the dengue fever (DF) cases occurred in the winter season, followed by spring and autumn. Moreover, the highest proportion of DF cases was observed in December (17.4%), followed by January (16.7%) and November (12.5%), and the lowest proportions of cases were recorded in August and September. A recent study conducted in Yemen (21) reported a significant increase in DF cases during the autumn and summer seasons, which differs from the findings of the present study. In contrast, the seasonal pattern observed in the present study is consistent with findings from Hajjah Governorate, Yemen, where dengue fever cases were predominantly reported during autumn (46.6%) and winter (40.6%), with the highest monthly frequencies occurring in October, November, and December (27). The similarity between these findings may be attributed to comparable climatic and ecological conditions in the Tihama region, which provide favorable environments for Aedes mosquito breeding and dengue virus transmission during the post-rainfall and winter periods. Dengue transmission is strongly influenced by climatic and environmental factors, particularly temperature, rainfall, and humidity, which affect the breeding, survival, abundance, and distribution of Aedes mosquitoes, the primary vectors of dengue virus (50, 51). In particular, the Red Sea coastal plain is characterized by relatively warm temperatures, high humidity, and the accumulation of standing water following seasonal rainfall, all of which support mosquito proliferation. In addition, the lagged effects of rainfall on mosquito population dynamics may contribute to increased dengue incidence during subsequent winter months.

According to the district, the highest incidence rates were recorded in Salif, Kamaran, Al Hawak, Al Mina, and Al Qanawis, whereas the lowest rates were reported in Al-Khukhah, Bura, Jabal Ras, and Al-Mighlaf. Salif and Kamaran, despite their small population sizes, exhibited the highest incidence rates. Coastal districts such as Salif and Kamaran may provide favorable breeding conditions for Aedes mosquitoes due to warm temperatures, high humidity, and the presence of stagnant or brackish water environments. In contrast, Al Hawak and Al Mina are among the largest urbanized districts and are characterized by high temperatures and humidity, rapid urban expansion, and high population density. These densely populated areas are likely to experience increased human–vector contact, thereby facilitating more efficient viral transmission. Furthermore, rapid urbanization, population growth, inadequate water management, poor waste disposal practices, and the widespread presence of artificial water-holding containers may contribute to the proliferation of Aedes mosquitoes and the transmission of dengue in these districts.

The overall case fatality rate (CFR) of dengue fever in this study was 236 deaths (0.2%). These results are consistent with a recent study from southern Yemen reporting an overall case fatality rate (CFR) of 0.21% (21). However, this rate is lower than previous estimates from Yemen, which reported CFRs of 0.4–0.5% during the 2019 outbreak (52) and 1.9% in Hadhramout from 2005 to 2009 (53). Higher fatality rates have also been reported in other dengue-endemic settings, including Ethiopia (1.0%) (46) and Bangladesh (0.5%) (42).

The case fatality rate (CFR) was slightly higher among females (0.22%) than among males (0.20%). This finding is consistent with reports from Yemen (21) and Bangladesh (42), which also reported higher mortality rates among females. However, it contrasts with global trends, where dengue-related mortality is generally reported to be higher among males (38, 54),as well as with a recent study conducted in Hajjah Governorate, Yemen, which reported higher mortality rates among males than females (27). The higher CFR observed among females may be related to disparities in healthcare access, nutritional status, and sex-related physiological and immunological factors that could influence disease severity and outcomes, as previously suggested in Yemen (21).

The highest CFR was observed among individuals aged ≥60 years (0.45%), followed by children aged <5 years (0.34%). This finding is consistent with a previous study from Yemen (21) and with global reports indicating that older adults are at increased risk of dengue-related mortality (55, 56). However, another study from Yemen reported the highest mortality rate among children aged <5 years, followed by individuals aged 45–59 years, with no deaths recorded among those aged ≥60 years (27). Advanced age, age-related physiological decline, immunological impairment, and the presence of chronic comorbidities may increase the risk of fatal outcomes among elderly dengue patients (57, 58).

Strengths and limitations

This study provides the first comprehensive assessment of the epidemiological patterns of dengue fever across all districts of Al-Hodeidah Governorate during the study period. The analysis offers valuable insights into the temporal, demographic, and geographic distribution of dengue cases, including seasonal trends and variations in incidence across districts. This analysis is strengthened by laboratory diagnostic data and clinical diagnosis based on clinical manifestations. However, several limitations should be considered. First, the study relied on routinely collected surveillance data and secondary data obtained from governmental health offices, which may be subject to underreporting, incomplete records, and inconsistencies in data quality across districts. Consequently, the reported number of dengue cases may underestimate the true burden of disease in the study area. Second, variations in reporting practices, diagnostic capacity, case definitions, and access to healthcare services across health facilities and districts may have affected the dataset's accuracy and completeness. Finally, the study did not incorporate entomological, environmental, climatic, virological, or socioeconomic data, which could have added insight into the factors driving the observed spatial and temporal patterns of dengue transmission. Despite these limitations, the study provides valuable epidemiological evidence on dengue fever in Al-Hodeidah Governorate and establishes a baseline for future surveillance, research, and disease control efforts.

Conclusion

Dengue fever remains a significant public health concern across all districts of Al-Hodeidah Governorate. The highest incidence was observed among males and individuals aged 15–29 years. Dengue transmission exhibited a clear seasonal pattern, with nearly half of all reported cases occurring during

the winter season and incidence peaking between November and January. The highest incidence rates were recorded in 2020, while substantial geographic variation was observed across districts. These findings emphasize the need to strengthen dengue surveillance and early warning systems, improve early detection and case management, enhance vector control interventions, and prioritize preventive measures in high-incidence districts and population groups with the highest reported incidence. We highly recommend strengthening coordination among relevant sectors, actively involving the community in dengue control activities, and increasing public awareness of dengue prevention. Local health authorities should implement community awareness campaigns, promote preventive practices, improve water storage and solid waste management practices to reduce mosquito breeding habitats, and provide continuous training for healthcare workers to enhance dengue prevention, diagnosis, and clinical management. Further epidemiological, entomological, and molecular studies are warranted to better understand dengue transmission dynamics, identify circulating dengue virus serotypes and genotypes, and support evidence-based prevention and control strategies in Al-Hodeidah Governorate.

Abbreviations

DF
Dengue fever
DENV
Dengue virus
WHO
World Health Organization
eIDEWS
Electronic Integrated Disease Early Warning System
RDTs
Rapid Diagnostic Tests
NS1
Nonstructural protein 1
IgM
Immunoglobulin M
CFR
Case fatality rate
ELISA
Enzyme-Linked Immunosorbent Assay
MoPHP
Ministry of Public Health and Population (Yemen)
COVID-19
Coronavirus Disease 2019
UNOCHA
United Nations Office for the Coordination of Humanitarian Affairs

SPSS
Statistical Package for the Social Sciences

Declarations

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Author contributions

Mohammed Hajjam contributed to study conception and design, data analysis, interpretation of results, and manuscript drafting and revision. Mohammed Al-Muniri contributed to methodology, data collection, and manuscript revision. Basem Moamen and Munir Ma’jam contributed to drafting the introduction, while Munir Ma’jam and Ameen Shabah contributed to drafting the discussion and interpreting the results. Ameen Shabah and Hashem Ma’mar also contributed to data collection and manuscript revision. Reema Al-Yousifi and Tarik Ghaleb performed the final critical review of the manuscript. All authors revised and approved the final manuscript and agree to be accountable for all aspects of the work. Mohammed Hajjam is the corresponding author and guarantor of the manuscript..

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Data availability

This published article includes the datasets generated during this study. The corresponding author (Mohammed Hajjam) will provide any relevant data upon reasonable request.

Ethics approval and consent to participate

Ethical approval was granted by the Health Office Ethics Committee (Ref. No.: 2212, dated 1 January 2026). The study was also approved by the District Health Office. The research was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments, as

well as in compliance with national and institutional ethical guidelines and Yemeni public health laws and regulations. Given the retrospective nature of the study, permission was obtained from the Ministry of Public Health and Population (MoPHP) for the use of routine database data for research purposes in accordance with Article 51 of the Yemeni Public Health Law No. (4) of 2009. No personal identifiers were used, and data confidentiality was strictly maintained. All data were anonymized prior to analysis

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

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Figures

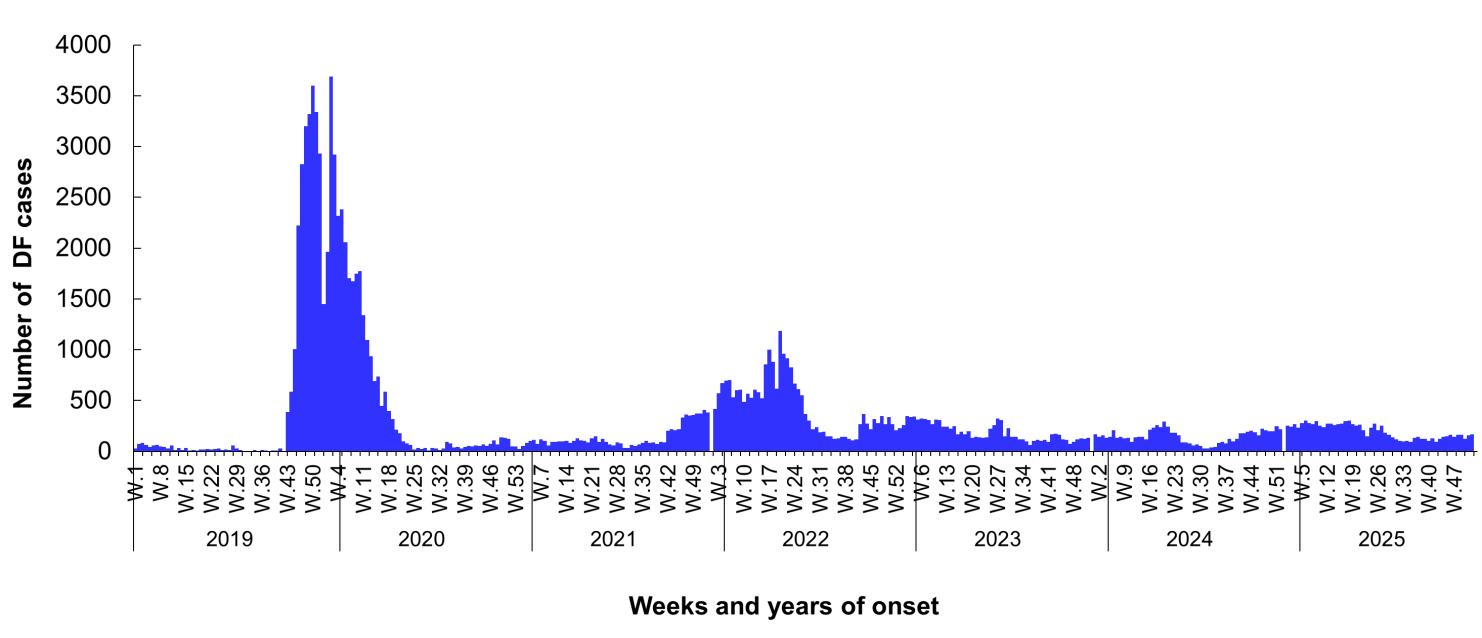


Figure 1

Weekly pattern of dengue fever cases by epidemiological week in Hodeidah Governorate, Yemen, 2019–2025. (n = 115,381)

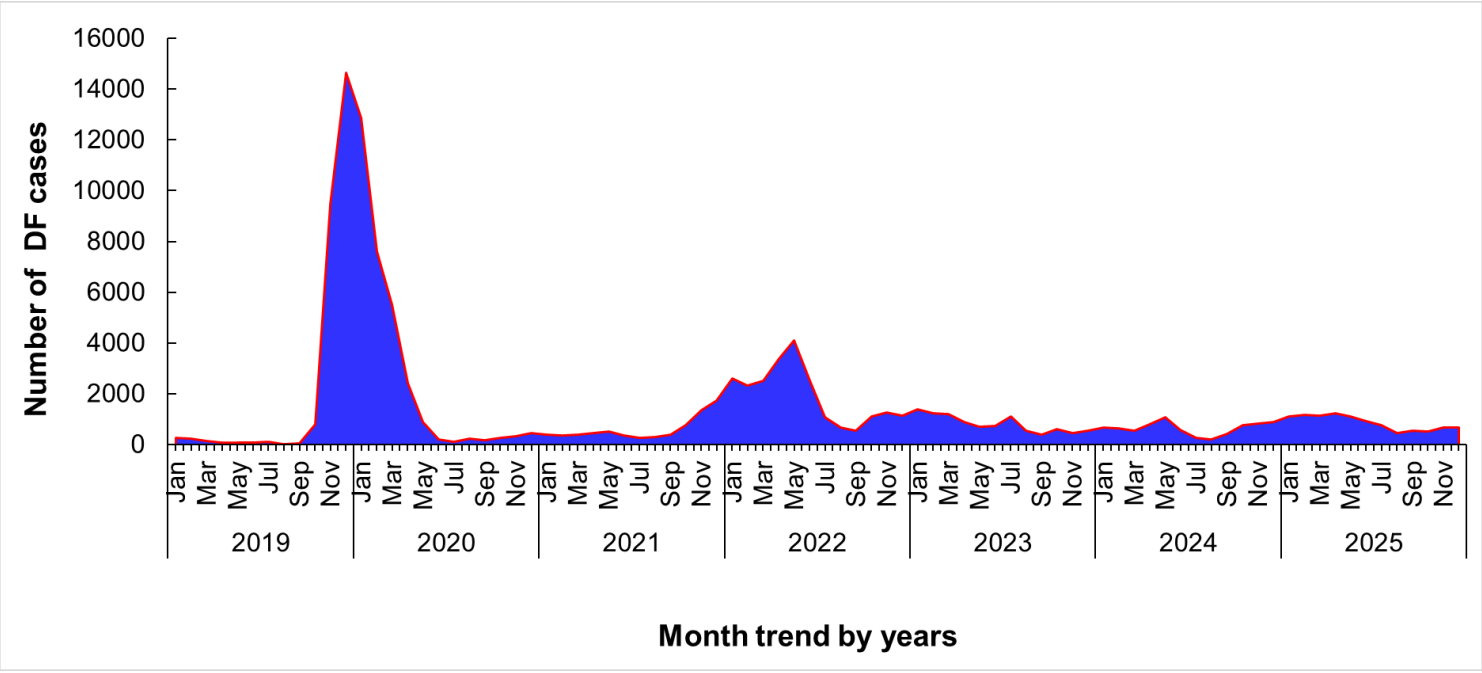


Figure 2

Monthly epidemiological trends of dengue fever (DF) cases in Hodeidah Governorate, Yemen, 2019–2025. (n = 115,381)

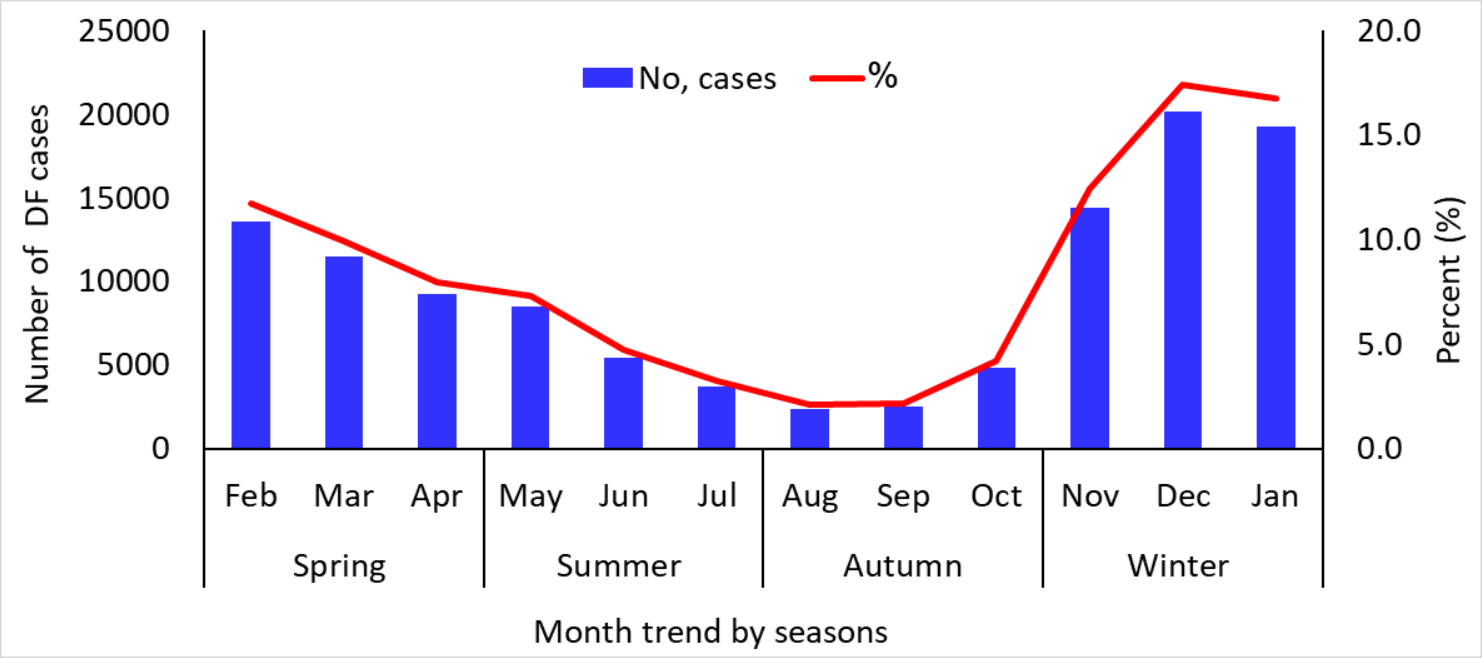


Figure 3

Seasonal and monthly distributions of reported dengue fever cases in Hodeidah Governorate, Yemen, 2019–2025 (n = 115,381).

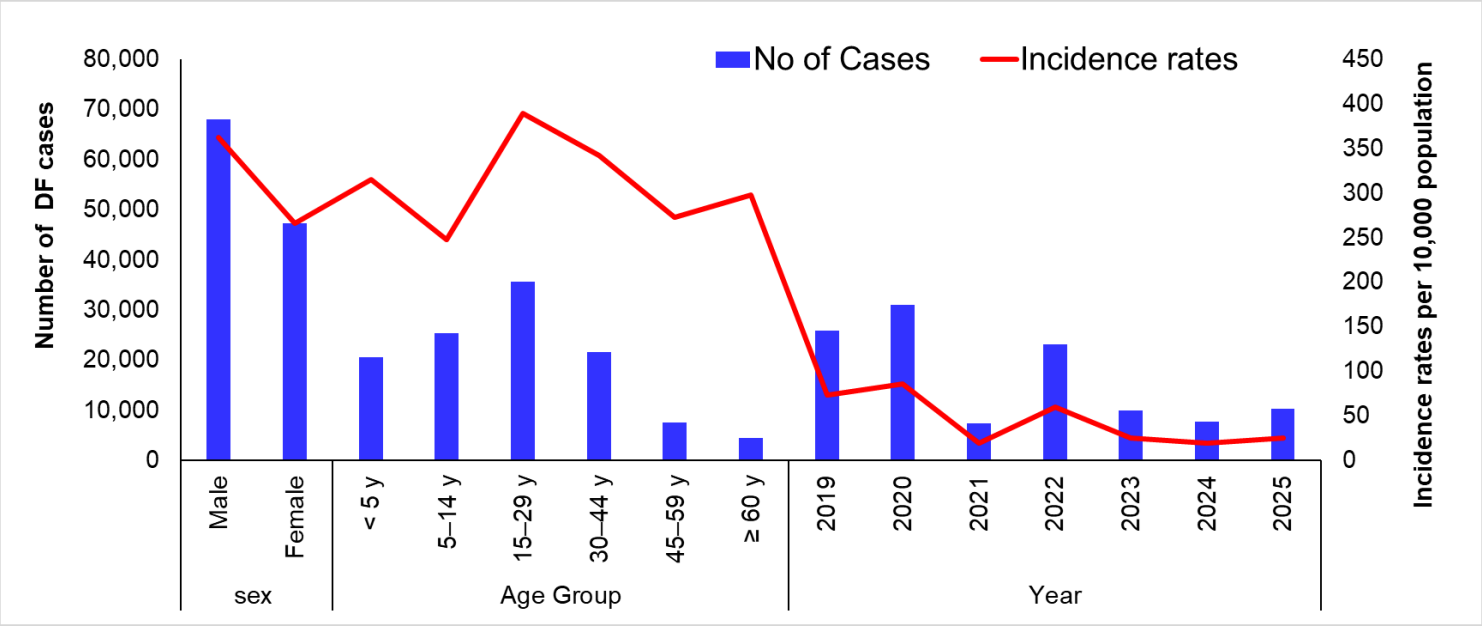


Figure 4

Incidence rate of dengue fever by age, sex, and year in Hodeidah Governorate, Yemen, 2019–2025 (n = 115,381).

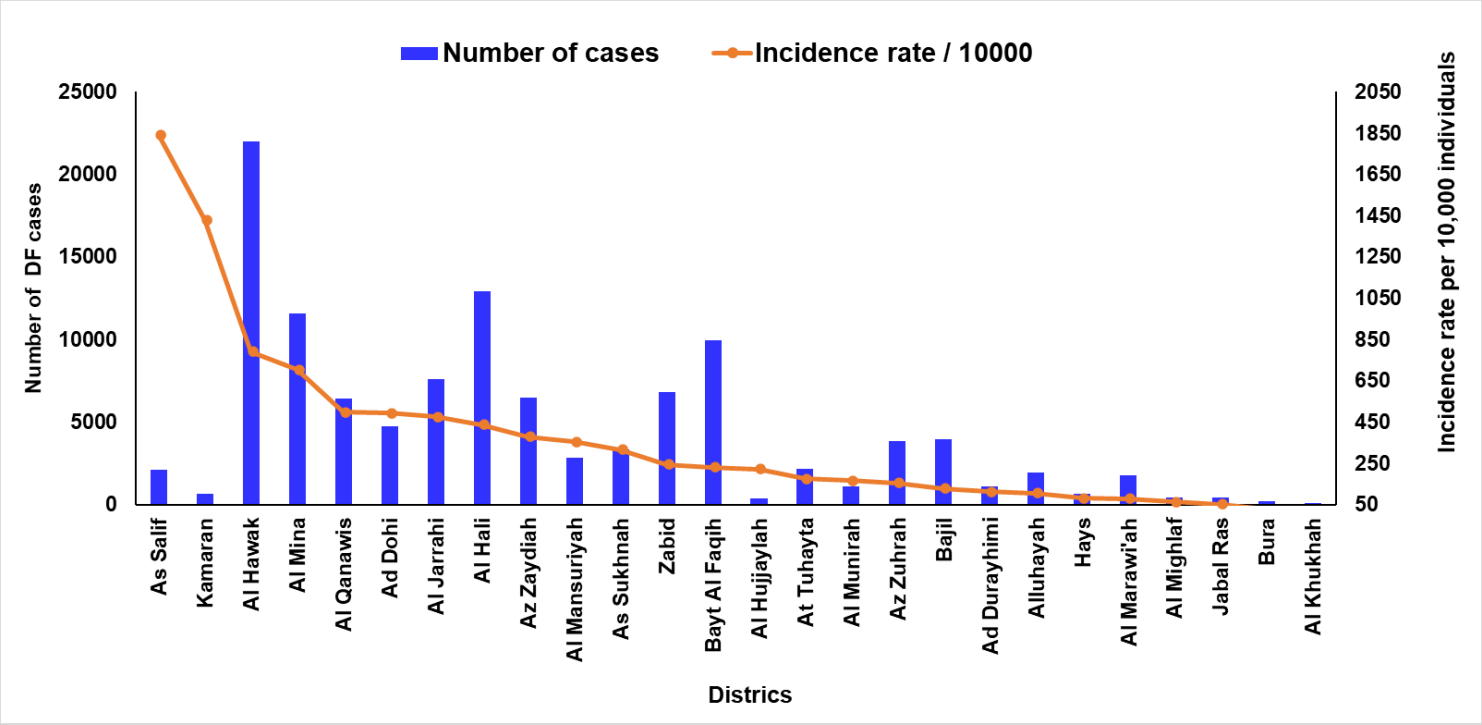


Figure 5

Incidence rate of dengue fever by districts in Hodeidah Governorate, Yemen, 2019–2025 (n = 115,381).

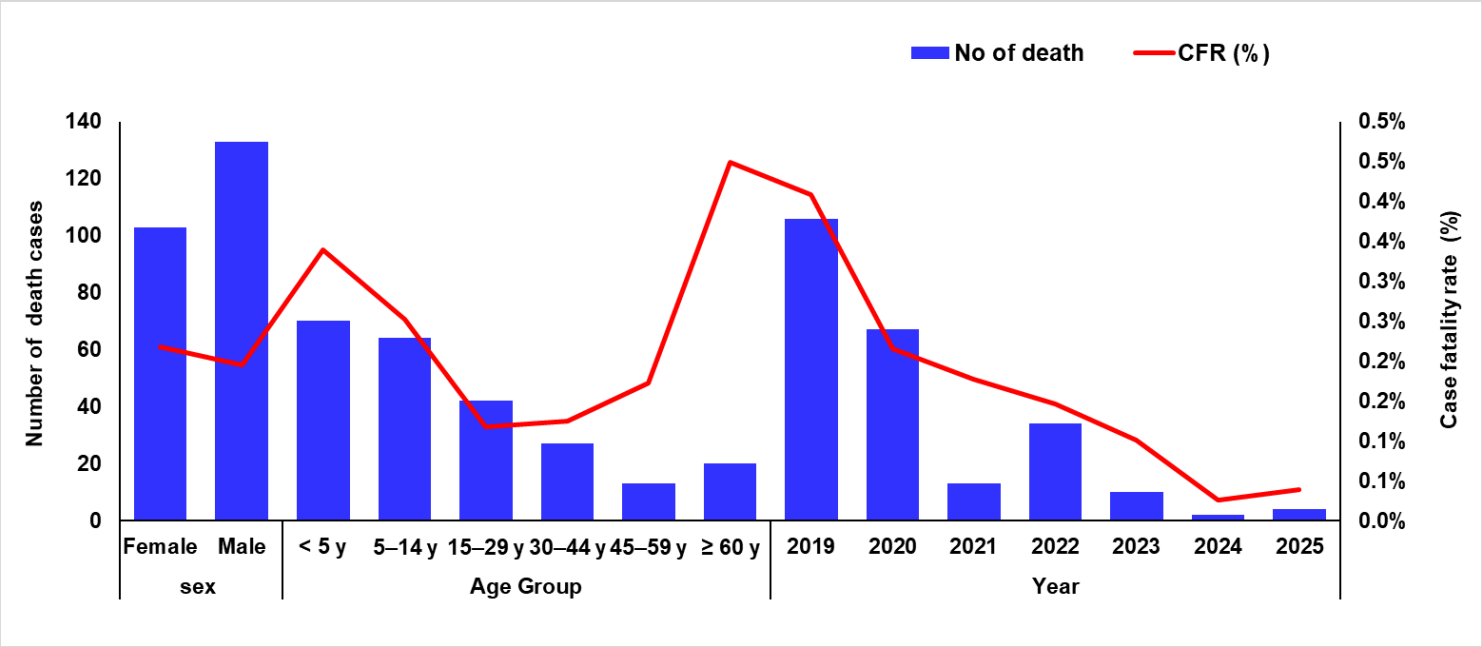


Figure 6

Case fatality rate of dengue fever by sex, age, and year of infection inHodeidah Governorate, Yemen, 2019–2025 (n = 236).

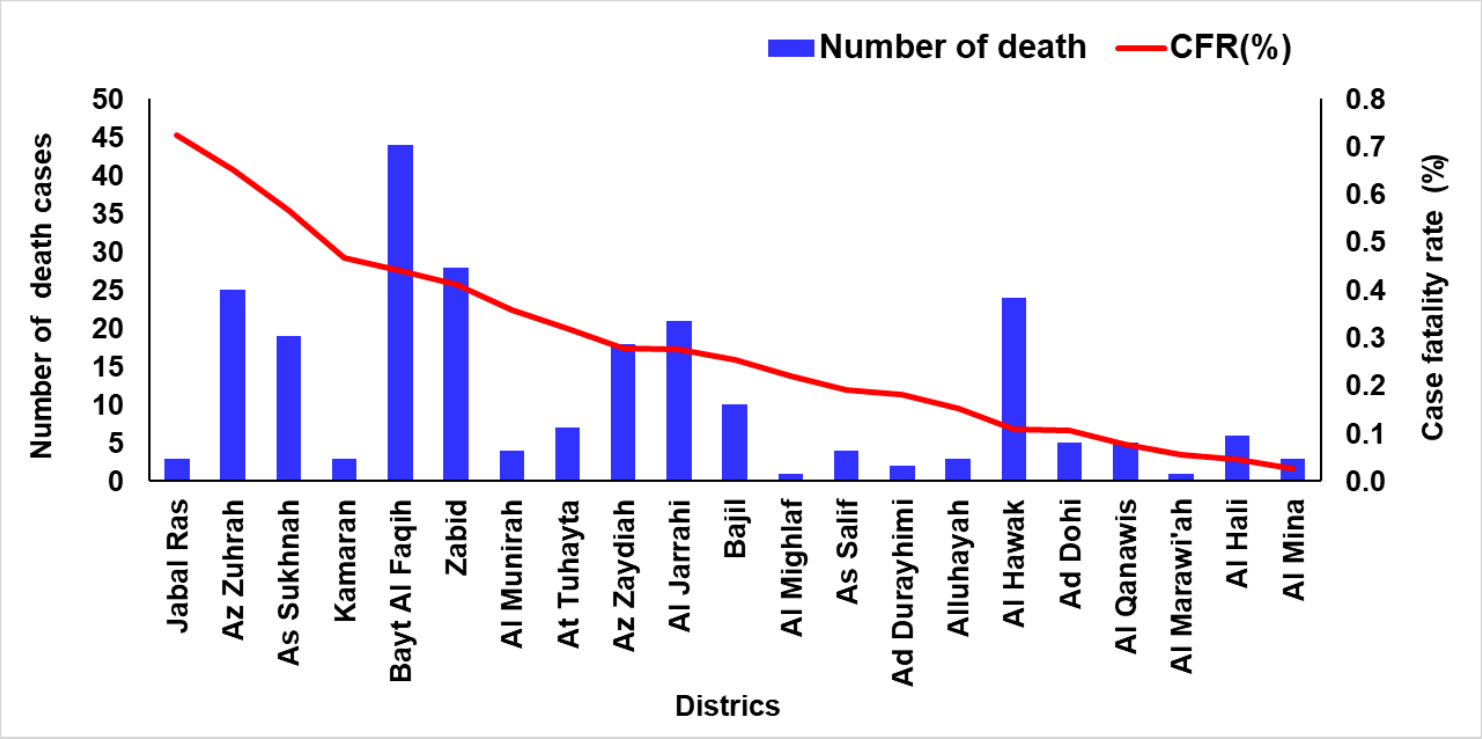


Figure 7

Case fatality rate of dengue fever by districts in Hodeidah Governorate, Yemen, 2019–2025 (n = 236)