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ORIGINAL RESEARCH

Trend of Measles Outbreak in Yemen From January 2020 to August 2024

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Objective: The measles outbreak has recently recurred across the world despite the actions taken, and Yemen is among the worst-hit nations. There has been a lack of information regarding the status of the measles outbreak in Yemen. Therefore, this retrospective analysis aimed to determine the trend of the measles outbreak in Yemen from January 2020 to August 2024.

Methods: This retrospective analysis relied on the secondary data recorded between January 2020 and August 2024. The Ministry of Health and Population provided the necessary data in a soft copy format (Excel file), which was statistically analyzed.

Results: A total of 41135 suspected measles cases were reported between January 2020 and August 2024. A higher proportion was observed among males (54.72%), age groups of 0–4 years (69.34%), in 2023 (50.5%), Aden governorate (20.54%), and in the spring (32.25%). The overall incidence rate was 18.82 per 10,000 population, with a higher rate among males (19.8 cases), age groups of 0–4 years (93.87 cases), in 2023 (9.5 cases), and Abyan governorate (89.06 cases). The overall fatality rate cases were 424 (4.92%), with the highest rate among females (1.06%), aged 0–4 years (1.26%), in 2023 (1.32%), and the Al Hudaydah governorate (2.97%). Furthermore, 82.4% of suspected cases were among unvaccinated individuals and 10.2% among individuals vaccinated with one dose.

Conclusion: According to current findings, the alarming rise in measles cases in recent years poses a serious threat to Yemenis' lives if not addressed. Therefore, vaccination efforts should be strengthened, healthcare infrastructure needs to be improved, vaccine hesitancy must be addressed, and international collaboration must be cultivated to control and eliminate measles.

Keywords: Case Fatality Rate (CFR), incidence rate, measles, Yemen

Introduction

Measles is a highly contagious airborne disease caused by a virus of the genus *Morbillivirus* belonging to the family *Paramyxoviridae* that is characterized by RNA genome, single-stranded, negative-sense, and enveloped virus. Measles virus can be easily transmitted between individuals via airborne droplets resulting from an infected person coughing or sneezing.[1] The risk of measles infection increases in nations with damaged health infrastructure and a weak health system resulting from natural disasters or conflicts that interrupt routine immunizations, as well as crowded conditions in camps that make infections more likely.[2]

Symptoms of measles include a runny nose, high fever, cough, conjunctivitis/red eyes, and a maculopapular rash with small white spots all over the body. In some cases, the disease progresses to cause encephalitis, blindness, ear infections, breathing difficulty, including pneumonia, and severe diarrhea and dehydration.[1,2]

The measles virus was a major cause of morbidity and mortality worldwide before vaccines were introduced in 1963, accounting for over 2 million deaths and between 15,000 and 60,000 cases of blindness each year.[3] Furthermore, the measles vaccine has achieved outstanding success in preventing approximately 25 million deaths and reducing the

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number of deaths resulting from the measles virus from 761,000 in 2000 to 136,000 in 2022.[4] Additionally, measles can affect unvaccinated everyone, and it commonly infects young children, particularly those who are not immunized against measles, with weak immunity, malnutrition, or have chronic diseases.[2]

The measles virus continues to cause serious problems throughout the global health system, despite the availability of a safe and effective vaccine. The COVID-19 outbreak between 2020 and 2022 missed or postponed approximately 61 million doses of the measles vaccine, raising the possibility of higher global outbreaks.[5] Between 2016 and 2019, the number of measles cases worldwide increased from 132,490 in 2016 to 869,770 by 550%, with 207,500 deaths, the most reported cases since 1996.[6] The World Health Organization estimates that 9 million cases and 128,000 deaths result from measles globally in 2021.[5] Furthermore, the World Health Organization estimated that 136,000 measles deaths occurred in 2022, with the majority occurring in children under 5 years of age.[2]

Globally, an estimate of over 300,000 cases of measles were reported in 2023. During the first three months of 2024, 56,634 cases of measles were officially reported across 45 countries out of 53 within the WHO European Region.[7] Moreover, approximately 148,271 cases of measles were reported between 2019 and March 2024 in the Eastern Mediterranean Region.[8] In the African Region, the number of measles cases increased from 72,603 cases in 2017 to 618,595 cases in 2019 and then declined to 88,789 cases in 2021.[9] Furthermore, the measles burden was reported at 77210 cases in Afghanistan, 209 cases in Djibouti, 10620 cases in the Islamic Republic of Iran, 17737 cases in Pakistan, 17361 cases in Somalia, 3310 cases in Sudan, and 6309 cases in Syria.[10]

Yemen is classified among the poorest countries in the world and has faced a series of successive crises and pressing challenges that have exacerbated the severity of poverty and food shortages as a result of political instability.[11,12] Furthermore, the ongoing war since March 2015 has led to the destruction of the health and education system infrastructure, deterioration of the socio-economic situation, and high rates of food and water insecurity. These are important factors contributing to the spread of epidemics throughout the country.[13–15]

According to international reports, Yemen is ranked first among the top countries with the largest measles outbreaks in 2023.[16,17] There are 22,828 confirmed measles recorded in Yemen from 2018 to 2019, with a proportion in young children less than five years old (65%) and unvaccinated children (76%).[18] Moreover, the incidence rate of measles burden per 1,000,000 individuals has increased from 42.4 (1,162 cases) in 2019 to 142.3 (5,341 cases) in 2021 and subsequently rapidly increased to 710.0 (23,924 cases) in 2022.[19] In addition, more than 50,795 suspected measles cases and 568 deaths were reported in 2023.[20] To date, no report has described the epidemiology of measles outbreaks in Yemen. Therefore, this retrospective analysis aimed to determine the trend of measles outbreaks in Yemen from January 2020 to August 2024.

Materials and Methods

Study Design and Area

A descriptive retrospective analysis is based on the secondary data of measles burden in some Yemeni governorates during the period from January 2020 to August 2024. In 1977, the National Expanded Immunization Program was established in Yemen with support from the World Health Organization and UNICEF. The program included basic vaccines, and its activity was limited to the centers of the Sana'a, Taiz, and Al-Hudaydah governorates until 1982, when its activity expanded to most of the Yemeni governorate centers. In 2005, the pentavalent vaccine was introduced,[21] and in 2006, the program implemented the basic national campaign for children in all Yemeni governorates, and the coverage rate reached 68%.[22]

Furthermore, Yemen consists of 21 administrative governorates, and the data were only collected from the records of thirteen governorates, including Aden, Taiz, Hadramout, Abyan, Lahj, Al Dhale'e, Marib, Al Maharah, Shabwah, Al Hudaydah, Al Bayda, Socotra, and Al Jawf governorates. While we were not able to obtain data on the burden of measles cases in the rest of the governorates.

Case Classification

The measles cases were classified based on the WHO guidelines[23] into the following categories:

1 – Laboratory confirmed Case: Any person who meets the definition of a clinical case and has laboratory confirmation of measles virus infection.

2 – Epidemiologically Linked Case: A case that meets the clinical case definition and has contact with a laboratory-confirmed measles case.

3 – Clinically Compatible Case: Any person who meets the definition of a clinical case for whom a laboratory examination has not been performed.

4 – Death Case: The death of any person infected with measles that has been confirmed (clinically, laboratory, or epidemiologically) and is not the result of other causes.[23]

Data Collection and Analysis

The measles case data (laboratory-confirmed, epidemiologically linked, and clinically compatible) were collected by surveillance staff and recorded electronically in the database of the Ministry of Public Health and Population in Aden. Measles cases were classified in health institutions of the subjected governorates according to WHO guidelines.[23] In addition, the measles cases were laboratory confirmed by the detection of anti-measles IgM antibody using the enzyme-linked immunosorbent assay (ELISA). Office administrators and health workers received a clear explanation of the concept and purpose of this investigation. Then, the required data in an Excel sheet format (soft copy) was obtained from the surveillance center. Moreover, the variables that were extracted from the databases included the date of onset (epidemiological weeks, month, and year), demographic characteristics (sex, age, governorates), case classification (laboratory-confirmed, epidemiologically linked, and clinically compatible), vaccination information (unvaccinated, one dose, two doses, ≥ three doses), and outcome of cases. The cases were categorized by age groups into subgroups as follows: 0–4 years, 5–9 years, 10–14 years, 15–19 years, 20–24 years, and ≥25 years.

Complete information on measles cases registered in the surveillance center's database from January 2020 to August 2024 was included from this analysis. Conversely, incomplete data or data recorded before January 2020 and after August 2024 were excluded.

The measles incidence rate per 10,000 people was calculated by dividing the number of recorded measles cases by the total population at risk. The population size was obtained from the UNOCHA[24] database. The Case Fatality Rate (CFR) of measles cases was calculated by dividing the total measles-related deaths by the total measles cases. In addition, the overall incidence rate and overall case fatality rate were calculated. The denominator for incidence rates was the population size at risk. Microsoft Excel was used to extract the measles surveillance database. In addition, the obtained data were categorized into quantitative variables and presented as frequencies and percentages in tables and figures. The Statistical Package for Social Sciences (SPSS) (Version 26, IBM®, US) program was also used to look at the differences between subgroups of variables. A probability (*P*) value of 0.05 or less was considered statistically significant.

Results

Characterization of the Suspected Measles Cases

Between January 2020 and August 2024, a total of 41135 suspected measles cases enrolled in this retrospective analysis. Male individuals were exposed to a higher proportion of measles cases compared to female individuals (54.72% males versus 45.28% females). Moreover, the age groups of 0–4 years reported the highest proportion of measles burden (69.34%), followed by those of 5–9 (22.0%), 10–14 years (5.08%), and the lowest was in those aged 20–24 years (0.76%). Furthermore, 2023 reported the half number of total measles cases at 20769 (50.5%) cases, followed by 2022 with 9122 (22.2%) cases and 2024 with 8440 (20.5%), while the lower cases were recorded in 2020 at 1301 (3.2%). Additionally, the Aden governorate was reported to have the largest number of measles cases at 8450 (20.54%), followed by Lahj at 6462 (15.71%), and Hadramout at 5525 (13.43%), while the lowest cases were documented in Al Jawf governorate at 11 (0.03%). Additionally, of the 41135 suspected cases, 1747 (4.25%) were classified as laboratory-confirmed, 37352 (90.8%) as epidemiologically linked, and 2036 (4.95%) as clinically compatible, as summarized in Table 1.

Table 1 Characterization of Suspected Measles Cases in Some Yemeni Governorate Between Jan 2020 and Aug 2024

Variables		Total Cases	Lab- Confirmed (n=1747)	Epid-linked (n=37352)	Clinically Compatible (n=2036)	*P* value
Sex	Male	22510	886	20.511	1113	0.002
	Female	18625	861	16.841	923	
Age group	0–4	28.521	1186	26.026	1309	0.000
	5–9	9048	422	8093	533	
	10–14	2091	82	1877	132	
	15–19	434	17	394	23	
	20–24	312	11	292	9	
	≥ 25	729	29	670	30	
Year	2020	1301	16	1153	132	0.000
	2021	1503	75	1161	267	
	2022	9122	241	8598	283	
	2023	20.769	1103	18.788	878	
	2024	8440	312	7652	476	
Governorate name	Aden	8450	559	7363	528	0.001
	Taiz	5449	296	4716	437	
	Hadramaut	5525	493	4287	745	
	Abyan	5512	100	5386	26	
	Lahj	6462	132	6264	66	
	Al Dhale'e	2545	24	2510	11	
	Marib	1669	21	1588	60	
	Al Maharah	694	28	628	38	
	Shabwah	2659	69	2465	125	
	Al Hudaydah	1447	25	1422	0	
	Al Bayda	694	0	694	0	
	Socotra	18	0	18	0	
	Al Jawf	11	0	11	0	

Note: P value ≤ 0.05 (statistically significant).

Weekly Epidemiological Trends of Measles Cases

Figure 1 shows that the largest number of measles cases were recorded in week 19 (627 cases) in 2023, followed by week 22 in 2022 (476 cases), weeks 7 and 12 in 2024 (357 cases each), week 2 (71 cases) in 2020, and week 52 in 2021 (61 cases).

Frequency of Measles Cases According to Seasons and Months

The current outcome showed the spring season had the highest number of measles at 13264 (32.25%), followed by summer at 12069 (29.34%), winter 8723 (21.21%), and the lowest was in autumn 7079 (17.21%). In addition, March

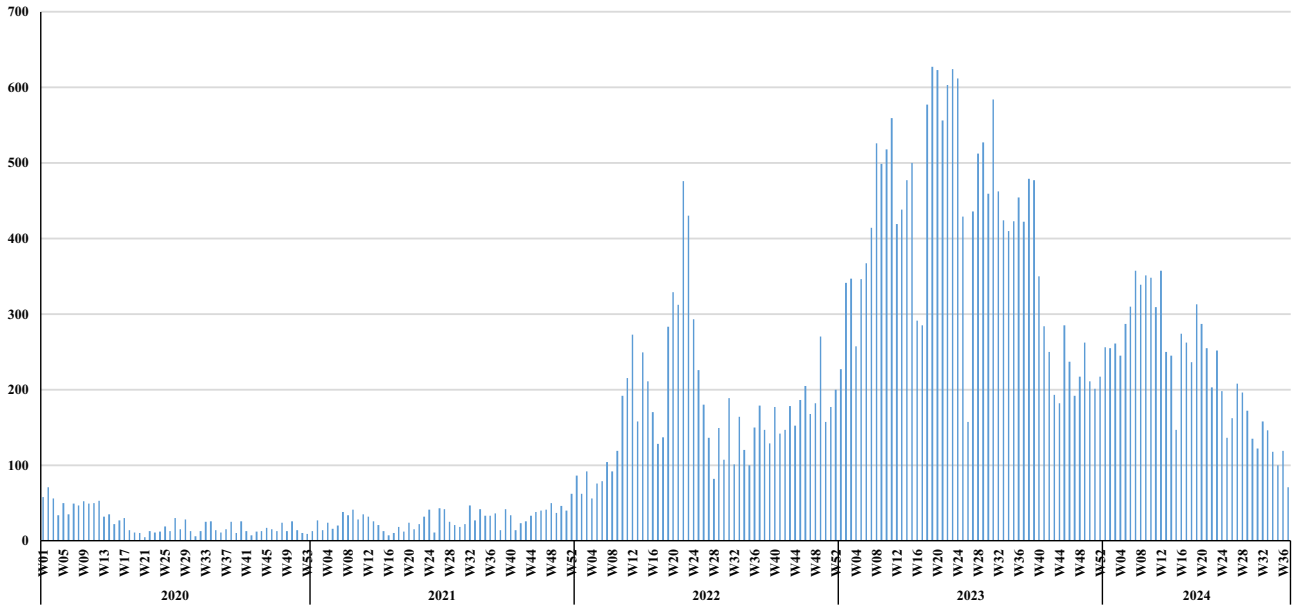

Figure 1 Weekly epidemiological trends of measles cases in some Yemeni governorate, Jan 2020 and Aug 2024.

reported the highest measles cases (5035; 12.24%), followed by June (4869; 12.08%), May (4846; 11.78%), and August (3770; 9.16%), while December showed the lowest number of measles cases (1952; 4.75%), with statistical significance ($P < 0.05$) (Figure 2).

Incidence Rate of Measles Cases

This analysis revealed that the overall incidence rate of measles infection per 10,000 people in the studied governorate was 18.82. Moreover, males had experienced a higher incidence rate of measles infection, with 19.8 per 10,000

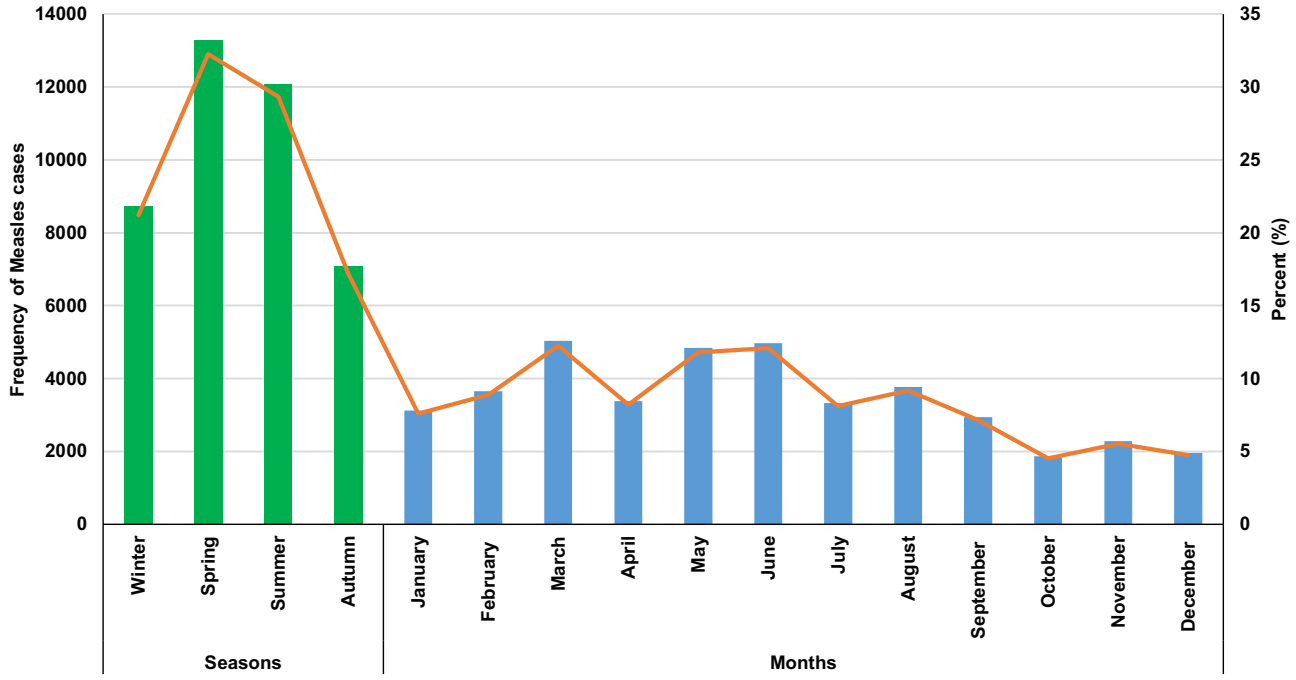

Figure 2 Frequency of measles cases concerning seasons and months.

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populations compared to 17.75 per 10,000 individuals among females. The analysis also revealed that the age group of 0–4 years had the highest incidence rate at 93.87 per 10,000 people, followed by the age group of 5–9 years with 36.63 per 10,000 people, with statistical significance ($P < 0.05$). The incidence rate significantly dropped to 8 per 10,000 people in the age group of 10–14 years, and the age group under 25 years had the lowest incidence rate at 0.87 per 10,000 people. Furthermore, a higher rate of measles incidence was reported at 9.5 per 10,000 persons in 2023, followed by 4.17 per 10,000 people in 2022, 3.86 per 10,000 individuals in 2024, and the lowest was recorded at 0.6 per 10,000 people in 2020, with statistical significance ($P < 0.05$). Additionally, the Abyan governorate had the highest measles incidence rate at 89.06 per 10,000 individuals, followed by Aden at 80.21 per 10,000, Lahj at 60.04 per 10,000, Al Maharah at 39.52 per 10,000, and Shabwah at 39.31 per 10,000. The Al Jawf governorate had the lowest measles incidence rate of 0.17 per 10,000 individuals, with statistical significance ($P < 0.05$) (Figure 3).

Case Fatality Rate of Measles Cases

The present findings revealed that the general fatality rate was reported at 424 (4.92%) in the studied governorate during the study period. Moreover, the females showed a slightly higher fatality rate than the males (1.06% vs 1.01%). In addition, the age group of 0–4 years had a higher fatality rate with 1.26%, followed by age groups of 9–14 years (0.67%), 5–9 years (0.53%), and 19–24 years (0.32%). While the age group of ≥25 years had the lowest rate of fatality cases (0.27%). Furthermore, the highest rate of measles fatality was reported in 2023 (1.32%), and the lowest rate was in 2021 (0.6%). Regarding governorates, the Al Hudaydah governorate exhibited the highest rate of measles fatality (2.97%), followed by Taiz (1.27%), Lahj (1.16%), Abyan (1.11%), Aden (1.09%), and Shabwah (1.02%), whereas the remaining districts had less than 0.99% of fatality rates, with statistical significance ($P < 0.05$) (Figure 4).

Vaccination Status of Cases

Of the 41,135 suspected cases of measles, 33,896 (82.4%) were found to be among unvaccinated individuals, while 7,239 (17.6%) cases were recorded among individuals who were vaccinated with at least one dose of a measles-containing vaccine, with statistical significance ($P < 0.05$). Furthermore, approximately 4,212 (10.2%) suspected cases were reported among individuals vaccinated with one dose, 2,262 (5.5%) were reported among individuals vaccinated with two doses, and 765 (1.9%) cases were reported among individuals vaccinated with ≥ three doses, with statistical

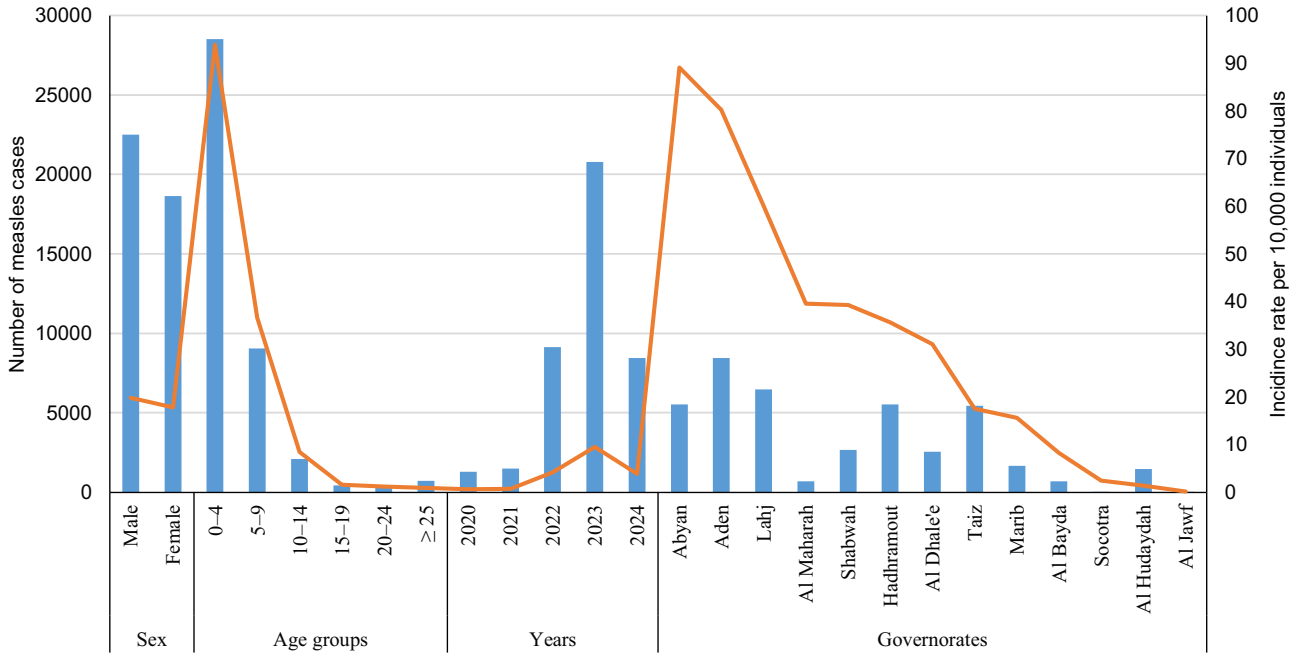

Figure 3 Incidence rate of measles cases based on demographic characterization.

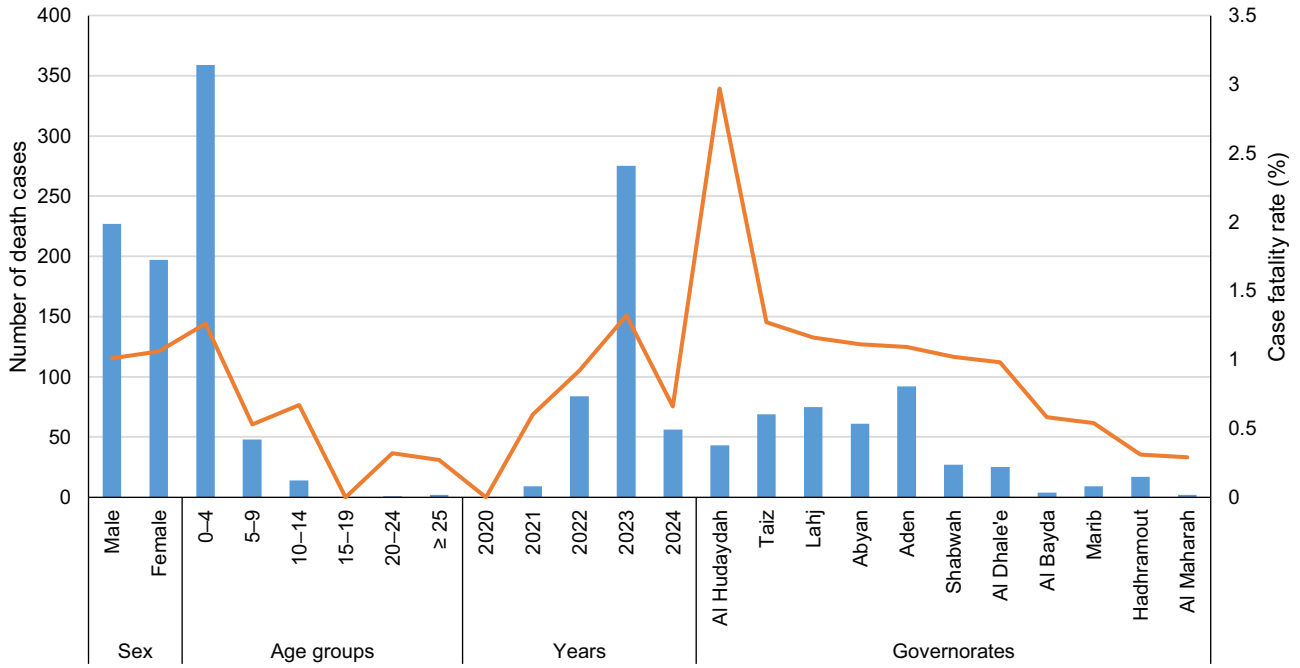

Figure 4 Case fatality rate of measles in some Yemeni governorates between 2020 and 2024.

significance ($P < 0.05$). The largest proportion of reported unvaccinated cases was in 2023 (85.8%), while the lowest was in 2020 (53.5%), as listed in Table 2.

Discussion

To date, no WHO region has been able to eliminate measles from its territory. Recently, the measles deaths have globally increased 43% between 2021 and 2022, from 95,000 to 136,200.[4] Yemen reported with an overall burden of measles cases at 41135 during five years, and this is similar to previous studies.[25–32] Therefore, collaboration between national and international governments is needed to develop and implement effective prevention strategies.

Table 2 Measles Cases by Vaccination Status Between Jan 2020 and Aug 2024 in Yemen

Variables		Total Cases No. (%)	Vaccination Status				*P* value
			Unvaccinated No. (%)	1 Dose No. (%)	2 Doses No. (%)	≥ 3 Doses No. (%)	
Sex	Male	22510 (54.7)	18.552 (82.4)	2308 (10.2)	1209 (5.4)	441 (2.0)	0.006
	Female	18625 (45.3)	15.344 (82.4)	1904 (10.2)	1011 (5.4)	366 (2.0)	
Age group	0–4	28.521 (69.2)	23.941 (83.9)	2308 (8.2)	1807 (6.3)	465 (1.6)	0.038
	5–9	9048 (22.0)	7113 (78.6)	1347 (14.9)	324 (3.6)	264 (2.9)	
	10–14	2091 (5.1)	1610 (77.0)	353 (16.9)	67 (3.2)	61 (2.9)	
	15–19	434 (1.1)	345 (79.5)	72 (16.6)	10 (2.3)	7 (1.6)	
	20–24	312 (0.8)	255 (81.7)	42 (13.5)	6 (1.9)	9 (2.9)	
	≥ 25	729 (1.8)	632 (86.7)	85 (11.7)	6 (0.8)	6 (0.8)	

(*Continued*)

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Table 2 (Continued).

Variables		Total Cases No. (%)	Vaccination Status				*P* value
			Unvaccinated No. (%)	1 Dose No. (%)	2 Doses No. (%)	≥ 3 Doses No. (%)	
Year	2020	1301 (3.1)	696 (53.5)	488 (37.5)	93 (7.2)	24 (1.8)	0.013
	2021	1503 (3.7)	932 (62.0)	275 (18.4)	169 (11.2)	127 (8.4)	
	2022	9122 (22.2)	7453 (81.7)	1051 (11.5)	473 (5.2)	145 (1.6)	
	2023	20,769 (50.5)	17.810 (85.8)	1664 (8.0)	1076 (5.1)	219 (1.1)	
	2024	8440 (20.5)	7005 (83.0)	734 (8.7)	451 (5.3)	250 (3.0)	

Note: *P* value ≤ 0.05 (statistically significant).
Abbreviations: EU, European Countries; CDC, Centers for Disease Control and Prevention; CFR, Case Fatality Rate; ECDC, European Centre for Disease Prevention and Control; EMR, Eastern Mediterranean Region; MMR, Measles Mumps and Rubella; WHO, World Health Organization.

Furthermore, a higher proportion of measles was observed in age groups of 0–4 years. The results are in consonance with those of other investigators who reported that the children under 5 years are most affected by measles.[28–30,32–34] In 2015, more than 230,000 children under the age of five did not receive routine vaccinations against the measles virus due to ongoing conflict in Yemen, as reported by WHO.[31] Children under the age of five are more susceptible to measles because their immune systems and organ systems are still developing. The measles virus also suppresses the immune system and causes the body to forget how to fight infections, which leaves children extremely vulnerable. Children who receive two doses before the age of six have current levels of protection against measles of 97%.[1]

There appears to be a lack of immunization due to logistical barriers, such as the restrictions on humanitarian imports, the lack of health facilities capable of providing vaccinations, and the lack of health education to highlight the importance of vaccines in protecting against diseases such as measles. To address this health crisis, comprehensive and coordinated measures are needed to protect Yemeni children from measles, as well as community engagement and enhanced case management.

The trend of measles burden in Yemen has increased from 1301 (3.2%) cases in 2020 to 20769 (50.5%) cases in 2023. A report by Musa et al[19] documented that the measles cases in all regions of Yemen increased 20-fold between 2019 and 2022 from 1,162 cases to 23,924 cases. The significant increase in the number of measles cases in Yemen recently compared to previous years will hinder the progress achieved to date and expose Yemen to the risk of delaying the goal of achieving control and elimination of measles.[35] Therefore, using national strategies, building partnerships with multiple sectors to support comprehensive immunization efforts by launching health awareness campaigns and encouraging families to vaccinate their children, especially in hard-to-reach areas.

According to this finding, 4.25% of cases were classified as laboratory-confirmed, 90.8% epidemiologically linked, and 4.95% as clinically compatible cases. This is similar to reports performed in Yemen by Shamsan,[36] in Southeast Ethiopia by Tsegaye et al,[28] and in Nigeria by Ibrahim et al.[37] On the other hand, the proportion of cases laboratory-confirmed in this finding is significantly lower when compared with reported previously at 35% in Kenya[31] and 68% in the WHO European Region.[32,33] This indicates that laboratory confirmation of measles remains extremely low in Yemen, where all suspected cases of measles are considered to be subject to laboratory confirmation. This is due to the limited resources, adequate equipment, and qualified staff to detect the measles virus in the various governorates of Yemen.

Although measles is not a seasonal disease, an increase has been observed during travel times, such as spring break, or when unvaccinated people are in close quarters, such as summer camps.[38] Our results, which showed a higher number of cases reported in spring and summer, as well as between March and May, are in compliance with the previous reports.[28,35,37,39,40] The majority of people in Yemen practice their daily activities more in the spring and summer, and this explains the reason for the increase in the number of measles cases in this study. Therefore, more efforts are required

to raise awareness among the general public about the danger of infectious organisms and preventive measures in the spring and summer.

The overall rate of measles incidence was reported at 18.82 cases per 10,000 population. This finding is higher than reported in China,[39] Canada,[26] Taiwan,[27] Southeast Ethiopia,[28] Ethiopia,[41] and EU countries.[33] The effectiveness and efficiency of the strategies and programs implemented by some countries to eradicate measles outbreaks may be the reason for the difference in the incidence rate of measles burden between countries. Therefore, health institutions and relevant organizations should make more efforts to strengthen disease surveillance systems that help identify and track measles cases.

This finding revealed that a higher incidence rate of measles infection was among males at 19.8 per 10,000 individuals compared to females at 17.75. This result is consistent with earlier reports.[28,33,42] Moreover, the highest incidence rate of measles was 93.87 per 10,000 people in the 0–4 years age group. Our results agree with those of other studies in Syria,[43] Lebanon,[44] Saudi Arabia,[45] Kenya,[31] Canada,[26] and Nigeria.[36] Further, preventing future outbreaks could be achieved by implementing several policies, such as ensuring that vaccines are offered at school entrance to facilitate the delivery of MMR, increasing vaccination requirements for healthcare workers, identifying areas with low vaccination coverage based on available data, and proactively addressing them.

The trend of measles incidence increased from 0.6 per 10,000 people in 2020 to 9.5 per 10,000 persons in 2023. This finding is consistent with a global report that documented the increase in measles cases by 556% between 2017 and 2019.[6] The increase in the number of measles cases in this study is mainly due to the Covid-19 pandemic between 2020 and 2022, which led to a delay or cessation of measles vaccine supplies, exposing millions of children to the risk of contracting infectious diseases.[5] In addition, the continuation of the war in Yemen since 2015 and the blockade and restrictions imposed on Yemen have affected the supply of vaccines.[46,47] A variation in the incidence rates of measles from one year to the next might be the result of differences in the duration of the measles outbreak, low vaccine coverage, accumulation of measles susceptibility, and clusters of non-immune persons.

This outcome revealed that the Abyan governorate reported the highest incidence rate of measles. According to a study conducted in Yemen, the Abyan was found to be the governorate most affected by measles.[36] Several factors could be responsible for the resurgence and increase in measles burden in these affected areas, including population density, economic situation, timing of vaccination, and absence or quality of vaccine. A further study is needed to confirm the possible causes of this outbreak: missing immunization, lack of vaccine, misconception about the measles vaccine and autism, vaccine-induced disease, and unvaccinated immigrants.

The overall fatality rate of the measles burden in this analysis was 4.92%, which was higher than that reported in Yemen in 2011[36] and between 2018 and 2019.[14] Moreover, this is similar to previous studies.[26–28,33,40] Worldwide, 36 measles cases per one million people are annually reported. For every 1,000 children infected with measles, one or two children die from it.[48] Furthermore, 2023 (1.32%) reported the highest rate of measles fatality cases, and this finding is in agreement with the reported studies.[4,32,33] Therefore, increasing immunization coverage and participation in routine childhood vaccinations, as well as catch-up vaccination campaigns for adolescents and adults who have missed previous vaccinations, is essential for achieving the measles elimination goal.

Measles outbreaks and measles-related deaths are more likely to occur in communities with a high proportion of undervaccinated and unvaccinated children. According to an estimation by the WHO, the coverage of measles immunization ranged from 37% in 2015 to 45% in 2023, which means more than half of Yemeni children are vulnerable to measles infection and other infectious diseases.[49] The current findings showed a significantly higher measles burden among unvaccinated individuals compared to vaccinated individuals. This outcome aligns with previous reports.[26,33,40,45] Consequently, it is important to implement strong systems and create a national database to document and monitor the implementation of vaccination programs in all regions of Yemen, which will contribute to identifying and reaching unvaccinated or partially vaccinated people.

Strength and Limitations

The study is the first comprehensive study on the measles outbreak in Yemen to be published. Furthermore, this finding of this analysis will provide health institutions and decision markers in Yemen with essential information for establishing

effective strategies for monitoring and controlling the measles outbreak. Despite these positive attributes, this report has several limitations. Measles epidemiology in Yemen cannot be accurately presented because of the absence of data on measles burden in some governorates governed by the Sana'a government. In addition, the measles surveillance program relies primarily on cases reported from health institutions and may lead to unreported cases in some areas where there are no health services; this can lead to incorrect estimates. Moreover, the inability to obtain information related with clinical signs and symptoms of cases, which will add great importance to this study.

Conclusion

It can be concluded that the trend of measles cases has been continuously increasing from year to year in the study area. Moreover, the age groups under 5 years, males, and the governorates of Aden and Abyan were found to be the most affected by measles infection. Unstudied factors could have significantly contributed to the increase in measles outbreaks. Therefore, a continuous, high-quality surveillance program and epidemiological investigations are key to closely monitoring the epidemiology of measles in Yemen and identifying immunization gaps. Measles elimination requires international collaboration and assistance in implementing effective prevention strategies to combat and eliminate measles epidemics in Yemen. Moreover, it is necessary to implement campaigns to raise awareness among the general population regarding the importance and role of vaccines in reducing morbidity and mortality rates. Additionally, further studies are needed to determine the associated risk factors, such as sociodemographic, educational, and behavioral factors, which contribute to increasing the burden of measles.

Data Sharing Statement

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

Ethical Statement

This study was conducted in accordance with the laws and regulations of public health in Yemen and with the Declaration of Helsinki. Moreover, an official letter was written by the Faculty of Applied Sciences to the Ministry of Health and the Environment for approval to provide data related to this study. Furthermore, owing to the retrospective nature of the study, the research committee granted permission to use the database data for research purposes in accordance with Article 51 of the Yemeni Public Health Law number (4) of 2009, without the need for updated approval. To preserve the personal identity of the patients, symbols were used during data collection, and the analysis was performed anonymously.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Gastanaduy P, Haber P, Rota AP, Patel M. Chapter 13: measles; in the book; epidemiology and prevention of vaccine-preventable diseases 14th edition. *CDC Epidemiology and Prevention of Vaccine-Preventable Dise Series*. 2021.
2. World Health Organization. Measles. https://www.who.int/news-room/fact-sheets/detail/measles. Available from: Accessed July 12, 2024.
3. World Health Organization. *Global Measles and Rubella Strategic Plan: 2012-20*. Available from:. https://apps.who.int/iris/bitstream/handle/10665/44855/9789241503396_eng.pdf. Accessed February 27, 2025.
4. Minta AA, Ferrari M, Antoni S, et al. Progress toward measles elimination — worldwide, 2000–2022. *MMWR Morb Mortal Wkly Rep*. 2023;72:1262–1268. doi:10.15585/mmwr.mm7246a3
5. World Health Organization. Nearly 40 million children are dangerously susceptible to growing measles threat. Available from: https://www.who.int/news/item/23-11-2022-nearly-40-million-children-are-dangerously-susceptible-to-growing-measles-threat. Accessed 23, November 2024.
6. Patel MK, Goodson JL, Jp A, et al. Progress toward regional measles elimination - worldwide, 2000-2019. *MMWR Morb Mortal Wkly Rep*. 2020;69(45):1700–1705. doi:10.15585/mmwr.mm6945a6

7. World Health Organization. Joint press release from WHO and UNICEF: measles cases across Europe continue to surge, putting millions of children at risk. Copenhagen/Geneva. Available from: https://www.who.int/europe/news/item/28-05-2024-joint-press-release-from-who-and-unicef–measles-cases-across-europe-continue-to-surge–putting-millions-of-children-at-risk. Assedded May28, 2024.
8. Al-Tawfiq JA, Memish ZA. Measles outbreaks in the Eastern Mediterranean Region: urgent need for strengthened vaccination efforts. *J Epidemiol Glob Health* 2024;14(2):252–254. doi:10.1007/s44197-024-00227-3
9. Masresha BG, Hatcher C, Lebo E, et al. Progress toward measles elimination-African region, 2017–2021. *MMWR Morb Mortal Wkly Rep*. 2023;72:985–991. doi:10.15585/mmwr.mm7236a3
10. World Health Organization. Infectious disease outbreaks reported in the Eastern Mediterranean Region in 2022. *World Health Organization East Mediterr Health J*. https://www.emro.who.int/pandemic-epidemic-diseases/information-resources/infectious-disease-outbreaks-reported-in-the-eastern-mediterranean-region-in-2022.html.
11. Edrees WH, Al-Awar SM. Bacterial contamination of mobile phones of medical laboratory workers at Sana'a city, Yemen and their antimicrobial susceptibility. *JPPRes*. 2020;8(6):591–599. doi:10.56499/jppres20.862_8.6.591
12. Al-Aomary NM, Edrees WH, Al-Ofairi BA, Thabit JM. Nasal carriage of *Staphylococcus aureus* and its antibacterial susceptibility profiles among food handlers in Sana'a restaurants, Yemen. *Israa Univ J Appl Sci*. 2024;7(2):55–70. doi:10.52865/DDHP5456
13. UNICEF. Yemen crisis. Available from: https://www.unicef.org/emergencies/yemen-crisis. Accessed August 19, 2024.
14. Edrees WH, Abdullah QY, Al-Shehari WA, Alrahabi LM, Khardesh AAF. COVID-19 pandemic in Taiz Governorate, Yemen, between 2020 and 2023. *BMC Infect Dis*. 2024;24(1). doi:10.1186/s12879-024-09650-0
15. Ali M, Edrees WH, Al-Shehari WA, et al. Antifungal susceptibility pattern of *Candida* species isolated from pregnant Women. *Front Cell Infect Microbiol*. 2024;14:1434677. doi:10.3389/fcimb.2024.1434677
16. Centers for Disease Control and Prevention. Global measles outbreaks. *CDC*. 2024. https://www.cdc.gov/global-measles-vaccination/data-research/global-measles-outbreaks/index.html.
17. MSK library guides: public health: global measles outbreaks. Available from: https://libguides.mskcc.org/publichealth/MeaslesOutbreaksGlobal. Accessed February 25, 2025.
18. Al-Marrani WH, Yasser Ghaleb Y, Shikh D, et al. *Measles Cases in Conflict Areas, Yemen, 2018–2019. 10th TEPHINET Bi-Regional*; 2021. Taiwan. https://www.tephinet.org/learning/fead/measles-cases-conflict-areas-yemen-2018-2019.
19. Musa N, Ghoniem A, Hsu CH, et al. Progress toward measles elimination — world Health Organization Eastern Mediterranean Region, 2019–2022. *MMWR Morb Mortal Wkly Rep*. 2024;73:139–144. doi:10.15585/mmwr.mm7307a1
20. Yemen humanitarian update: issue 10 [EN/AR] - Yemen. reliefweb. published December 17, 2023. Available from: https://reliefweb.int/report/yemen/yemen-humanitarian-update-issue-10-enar. Accessed February 27, 2025.
21. World Health Organization. Available from: https://www.emro.who.int/ar/2024-arabic/people-saw-the-deadly-impact-of-diseases-with-their-own-eyes-so-they-would-come-to-get-vaccinated.html. Accessed February 25, 2025.
22. Ministry of health and population. Annual statistical Health Report 2006. Available from: https://moh.gov.ye/storage/965/20210127121240 44Report2006.pdf. Accessed February 25, 2025.
23. World Health Organization. *Measles and Rubella Surveillance and Outbreak Investigation Guidelines*; Regional Office for South-East Asia. https://iris.who.int/bitstream/handle/10665/205481/B4314.pdf?sequence=1.
24. United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). Yemen. Humanitarian Needs. 2024. https://data.humdata.org/dataset/yemen-humanitarian-needs.
25. Alreshidi FS, Alrasheedi A. Measles trends in the Kingdom of Saudi Arabia, 2002–2012. *Preprints www preprints org*. doi:10.20944/preprints202401.0871.v1
26. De Serres G, Desai S, Shane A, Hiebert J, Ouakki M, Severini A. Measles in Canada between 2002 and 2013. *Open Forum Infect Dis*. 2015;2(2):ofv048. doi:10.1093/ofid/ofv048
27. Yu C-P, Chen B-C, Chou Y-C, Hsieh C-J, Lin F-H. Epidemiological features and risk factors for measles and rubella in Taiwan during 2011 to 2020. *Medicine*. 2022;101(43):e31254. doi:10.1097/MD.0000000000031254
28. Tsegaye G, Gezahagn Y, Bedada S, Berhanu N, Gudina G, Mulatu G. Epidemiology of measles in Bale Zone, Southeast Ethiopia: analysis of surveillance data from 2013 to 2019. *Risk Manag Healthc Policy*. 2021(14):4093–4103. doi:10.2147/RMHP.S325173
29. Yousif M, Hong H, Malfeld S, et al. Measles incidence in South Africa: a six-year review, 2015—2020. *BMC Public Health*. 2022;22(1). doi:10.1186/s12889-022-14069-w
30. Idé HA, Yanogo PK, Barry D, Togola OB, Adehossi E, Meda N. Epidemiological profile of measles in Niger: analysis of measles case-based surveillance data from 2010 to 2019. *Pan Afr Med J*. 2022;43. doi:10.11604/pamj.2022.43.18.33443
31. Kisangau N, Sergon K, Ibrahim Y, et al. Progress towards elimination of measles in Kenya, 2003-2016. *Pan Afr Med J*. 2018;31:65. doi:10.11604/pamj.2018.31.65.16309
32. Muscat M, Mamou MB, Kat CRD, et al. Progress and challenges in measles and rubella elimination in the WHO European region. *Vaccines*. 2024;12(6):696. doi:10.3390/vaccines12060696
33. European Centre for Disease Prevention and Control. Annual epidemiological report for 2023. Stockholm: ECDC; 2024. Available at: https://www.ecdc.europa.eu/en/publications-data/measles-annual-epidemiological-report-2023. Accessed February 25, 2025.
34. Nassar AH, Amad MA A, Qasim M, et al. Risk factors for measles outbreak in Ataq and Habban districts, Shabwah governorate, Yemen. *BMC Infect Dis*. 2021;21:551. doi:10.1186/s12879-021-06207-3
35. Edrees WH, Al-Shehari WA. A retrospective analysis of the malaria trend in Yemen over the sixteen-years, from 2006 to 2021. *BMC Public Health*. 2025;25(239). doi:10.1186/s12889-025-21466-4
36. Shamsan F. Measles outbreak report in Sa'adah Governorate, Yemen, 2012. 1st. *BMC Infect Dis*. http://www.youblisher.com/p/1465957-First-National-YFETP-Conference-Book-Feb-2014-1/.
37. Ibrahim BS, Usman R, Mohammed Y, et al. Burden of measles in Nigeria: a five-year review of casebased surveillance data, 2012-2016. *Pan Afr Med J*. 2019;32(1):5. doi:10.11604/pamj.supp.2019.32.1.13564
38. Centers for Disease Control and Prevention. Measles cases and outbreak. CDC. https://www.cdc.gov/measles/data-research/index.html. Accessed November 1, 2024.

39. Liu S, Xu E, Zhang X, et al. The epidemiological characteristics of measles and difficulties of measles elimination in Hang Zhou China. *Hum Vaccin Immunother*. 2013;9(6):1296–1302. doi:10.4161/hv.24032
40. Filia A, Tavilla A, Bella A, et al. Measles in Italy. *Euro Surveill*. 2011;16(29):pii=19925.
41. Eshetu D, Tosisa W, Regassa BT, et al. Epidemiology of measles outbreaks, incidence and associated risk factors in Ethiopia from 2000 to 2023: a systematic review and meta-analysis. *BMC Infect Dis*. 2024;24:914. doi:10.1186/s12879-024-09828-6
42. Wang R, Jing W, Liu M, Liu J. Trends of the global, regional, and national incidence of measles, vaccine coverage, and risk factors in 204 countries from 1990 to 2019. *Front Med*. 2022;8:798031. doi:10.3389/fmed.2021.798031
43. Mehtar S, AlMhawish N, Shobak K, et al.Measles in conflict-affected northern Syria: results from an ongoing outbreak surveillance program. *Confl Health*. 2021;15:95. doi:10.1186/s13031-021-00430-0
44. Helou M, Mouawad Y, El Ters F, Husni R. Measles outbreak in. *Disaster Med Public Health Prep*. 2024;18:e49. doi:10.1017/dmp.2024.42
45. Alruqaie N, Al Qadrah B, Almansour S, et al. A measles outbreak in Riyadh in 2023: clinical and epidemiological characteristics. *Cureus*. 2023;15 (11):e48171. doi:10.7759/cureus.48171
46. Mustafa B, Hussain A, Nawaz A, et al. Measles outbreak in Yemen amidst a humanitarian crisis: key challenges and recommendations. *Int J Surg Global Health*. 2023;6(6). doi:10.1097/GH9.0000000000000364
47. Edrees WH, Al-Shehari WA, Al-Haddad AM, et al. Dengue fever in Yemen: a five-year review, 2020–2024. *BMC Infect Dis*. 2025;25(28). doi:10.1186/s12879-024-10429-6
48. Centers for Disease Control and Prevention. Measles.CDC Archives. Available from: https://www.cdc.gov/globalhealth/newsroom/topics/measles/index.htmlGoogleScholar. Accessed February 25, 2025.
49. World Health Organization. Measles vaccination coverage. Yemen. Available from: https://immunizationdata.who.int/global/wiise-detail-page/measles-vaccination-coverage?CODE=YEM&ANTIGEN=&YEAR=. Accessed February 25, 2025.