Epidemiological Analysis of Diphtheria Cases in Hodeida, Yemen:
A Review of Admission Records from 2018 to 2022

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Abstract: Diphtheria is a potentially fatal infectious disease caused by *Corynebacterium diphtheriae*, a non-encapsulated, gram-positive bacillus. The disease is primarily transmitted through close respiratory contact, leading to nasopharyngeal infections that may cause airway obstruction and, in severe cases, systemic involvement. Yemen had not previously experienced large-scale outbreaks until a major epidemic emerged between October 2017 and August 2018, during which 2,203 suspected cases were reported, resulting in 116 deaths. Objective: to conduct an epidemiological analysis of diphtheria cases in Hodeida, Yemen. Methodology: The study design was a descriptive, retrospective, cross-sectional hospital-based study. The sample size comprised the total number of diphtheria patients who attended Al-Thawra General Hospital in Hodeidah Governorate, Yemen, during the study period from 2018 to 2022; where their number reached 534 cases. Results: the results indicated that the prevalence of diphtheria in Hodeida governorate was 534 cases. The highest prevalence was in Al-Hawk District, with 129 cases, or 24% of the cases, followed by Al-Hali District, with 106 cases, or 19.8%. The study results showed that (63%) of the participants infected with diphtheria were females, while (37%) were males. The children aged 10 years and under were the most affected during this diphtheria outbreak (46.54%), compared to those in the older age group 11-20, which was 29.16% as well. The prevalence of diphtheria was highest among those with incomplete vaccination (7.9 %). Conclusion: the study found a significant increase in the prevalence of diphtheria in Hodeida governorate. As well as showing that incomplete vaccinations are associated with higher rates of several complications.

Keywords: Diphtheria, Prevalence, Epidemiology, Hodeida.

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التحليل الوبائي لحالات الدفتيريا في الحديدة، اليمن:
مراجعة لسجلات القبول من عام 2018 إلى عام 2022

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المستخلص: الخناق مرضٌ مُعدٍ قد يكون مميتًا، تُسبه بكتيريا الوتدية الخناقية، وهي عصبية موجبة الجرام غير مغلفة. ينتقل المرض بشكل رئيسي عن طريق التلامس التنفسي الوثيق، مما يؤدي إلى التهابات في البلعوم الأنفي قد تُسبب انسدادًا في مجرى الهواء، وفي الحالات الشديدة، إصابة جهازية. لم تشهد اليمن سابقًا تفشيًا واسع النطاق للمرض حتى ظهر وباءٌ كبيرٌ بين أكتوبر/تشرين الأول 2017 وأغسطس/آب 2018، حيث أُبلغ عن 2203 حالات مشتبه بها، مما أسفر عن 116 حالة وفاة. الهدف: إجراء تحليل وبائي لحالات الخناق في الحديدة، اليمن. المنهجية: اعتمد تصميم الدراسة على دراسة وصفية، رجعية، ومستعرضة، شملت المستشفيات. يتكون حجم العينة من العدد الإجمالي لمرضى الدفتيريا الذين حضروا مستشفى الثورة العام في اليمن خلال فترة الدراسة من 2018 إلى 2022 وعددهم 534 حالة. النتائج: أشارت النتائج إلى أن معدل انتشار الدفتيريا في محافظة الحديدة بلغ 534 حالة في الفترة التي تم البحث فيها. وكان أعلى معدل انتشار في مديرية الحوك حيث بلغ 129 حالة أو 24% من الحالات، تليها مديرية الحالي حيث بلغ 106 حالات أو 19.8%. وأظهرت نتائج الدراسة أن (63%) من المشاركين المصابين بالدفتيريا كانوا من الإناث بينما كان (37%) من الذكور. وكان المرضى الذين تبلغ أعمارهم 10 سنوات وأقل هم الأكثر تضررًا خلال تفشي الدفتيريا هذا (46.54%)، مقارنة بالفئة العمرية الأكبر سنًا من 11 إلى 20 عامًا والتي بلغت 29.16% أيضًا. وكان معدل انتشار الدفتيريا أعلى بين أولئك الذين لم يكتمل تطعيمهم (7.9 %). الاستنتاج: أظهرت الدراسة زيادة ملحوظة في معدل انتشار الدفتيريا في محافظة الحديدة. كما أظهرت أن عدم اكتمال التطعيمات يرتبط بارتفاع معدلات العديد من المضاعفات.

الكلمات المفتاحية: الدفتيريا، الانتشار، علم الأوبئة، الحديدة.

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1- Introduction

Diphtheria is a potentially fatal infectious disease caused by *Corynebacterium diphtheriae*, a non-encapsulated, gram-positive bacillus. The disease is primarily transmitted through close respiratory contact, leading to nasopharyngeal infections that may cause airway obstruction and, in severe cases, systemic involvement. Clinically, diphtheria often presents as membranous pharyngitis, typically manifesting after an incubation period of 2 to 5 days [1].

Despite advancements in medical science and vaccination programs, diphtheria remains a significant public health issue, particularly in low-income countries with inadequate immunization coverage. Numerous outbreaks have occurred in sub-Saharan Africa, including in countries such as Nigeria and Madagascar (**WHO Disease Outbreak News (2023)**)[2]. Yemen had not previously experienced large-scale outbreaks until a major epidemic emerged between October 2017 and August 2018, during which 2,203 suspected cases were reported, resulting in 116 deaths. Alarmingly, the electronic surveillance system produced only a few alerts before the official declaration of the outbreak [3,4]. Diphtheria is a highly contagious and potentially fatal infectious disease caused by the gram-positive bacterium Corynebacterium diphtheriae. The disease primarily affects the upper respiratory tract, leading to the formation of a thick pseudomembrane over the throat and tonsils, which can cause severe breathing difficulties. In more severe cases, the diphtheria toxin may spread through the bloodstream, resulting in systemic complications such as myocarditis, neuritis, and kidney damage [5] (Centers for Disease Control and Prevention [CDC], 2022).

Currently, the highest burden of diphtheria in Asia is reported from India, Indonesia, and Nepal. Outbreaks have also been documented in countries with relatively robust immunization infrastructure, such as Thailand and Iran, which have recorded 157 and 513 cases, respectively, in recent years [4]. According to a recent World Health Organization (WHO) report, coverage of the diphtheria-pertussis-tetanus (DPT1) vaccine has shown a gradual decline, falling from 89% in 2015 to 88% in 2016 and further to 83% in 2017 [6].

Outbreaks of diphtheria have been reported in recent decades across various regions, including Southeast Asia, sub-Saharan Africa, and parts of Eastern Europe. These outbreaks are often associated with lapses in routine immunization, population movement, and inadequate disease surveillance. For example, recent resurgences in countries such as India, Indonesia, Nigeria, and Yemen highlight the vulnerability of certain populations to vaccine-preventable diseases in the absence of sustained public health interventions [7].

Diphtheria, especially in severe cases, requires hospitalization because of potentially serious complications such as respiratory failure, cardiac arrest, and even death if left untreated [8].

This study aims to contribute to the growing body of knowledge on the epidemiological trends of diphtheria in Hodeida, Yemen. It is expected to serve as a valuable reference for future research and to emphasize the importance of maintaining health through preventive measures. In addition, the study will offer updated insights into the current epidemiological situation of diphtheria in the region.

Significance of Study

This study holds considerable significance in advancing the understanding of diphtheria in Hodeida, Yemen, and in shaping effective public health interventions. It emphasizes the need for resilient healthcare systems, widespread vaccination coverage, and efficient disease surveillance to control and prevent outbreaks.

- It provides a comprehensive overview of the epidemiological profile of diphtheria in the region, including prevalence rates and affected demographic groups.
- It offers critical data on local vaccination coverage and identifies potential gaps and barriers in the immunization program.
- It helps raise awareness among the public and healthcare professionals regarding the risks of diphtheria and the essential role of vaccination.
- The findings can inform public health strategies, aid in resource allocation, and support the planning of vaccination campaigns and disease control initiatives.

General Objective

To conduct an epidemiological analysis of diphtheria cases in Hodeida, Yemen.

Specific Objectives

- To determine the prevalence of diphtheria in Hodeida, Yemen.

- To evaluate the risk factors among diagnosed patients.

- To describe the clinical manifestations observed in diagnosed cases.

- To examine the relationship between patients' demographic characteristics and their vaccination status.

2- Methodology

Study Design:

The study design was a descriptive, retrospective, cross-sectional hospital-based study.

Study setting:

This study was conducted at Al-Thawra General Hospital, Hodeidah, Yemen.

Study Population:

The study included all patients diagnosed with diphtheria at Al-Thawra General Hospital in Hodeidah Governorate, Yemen, between January 2018 and December 2022.

Sample Size:

The sample size was all diphtheria patients who attended Al-Thawra General Hospital, in Hodeidah Governorate, Yemen, during the study period. The total number of samples is 534 patients during this period.

Duration of Study:

The study was retrospective from January.

Data Collection Tool and Procedure: January 2018 to December 2022.

The data was collected from files by an Excel sheet, including

part I: year of diagnosis, sex, age, onset of symptoms, governorate of the patient, district of the patient, and zone of the patient.

part II: fever, sore throat, cough, presence of membrane, change of sound, swollen lymph gland, difficulty breathing, difficulty swallowing, admission, date of admission, outcome (recovery - death - referral - stone -under treatment), checkout date, sample collection, result of test, anti-toxin dose, cardiac complication, neurological complication, nephrology complication, liver complications, tracheostomy, routine vaccination and booster vaccination. Accordingly, diphtheria was diagnosed based on clinical symptoms and laboratory test results recorded in the patient's record.

Validity and Reliability of the Tool

The data collection sheet was based on official medical records in AlThawra hospital. The sheet included all key variables relevant to the study objectives (demographic characteristics, clinical manifestations, vaccination status, complications, and outcomes). to ensure content validity. The sheet was reviewed by three faculty members specialized in epidemiology and public health to confirm its comprehensiveness. To enhance reliability, data were double entered by two independent individuals and cross-checked for consistency, guaranteeing accuracy and trustworthiness of the data used in the study.

Data Analysis and Presentation:

Data were initially recorded in Excel spreadsheets, with two individuals independently entering the information for each sheet to minimize errors. Discrepancies between the two datasets were cross-checked against the original records. Statistical analysis was performed using SPSS version 24. Both descriptive and inferential statistics were applied. Categorical variables and differences in proportions were analyzed using Pearson's chi-square test, with statistical significance set at a p-value of less than 0.05. Demographic information was summarized using frequencies, percentages, and visualized with charts.

Ethical Considerations:

Ethical clearance was granted by the Faculty of Medicine and Health Sciences at Hodeidah University (Ethical Approval Code: 201/2024, dated 13/05/2024). Additional approval was obtained from the director of Al-Thawra General Hospital. To ensure participant anonymity, names were not recorded in the Excel database.

3- Result:

Figure 1: Distribution of Diphtheria Cases Admitted to Al-Thawra Hospital (2018–2022). Between 2018 and 2022, Al-Thawra Hospital recorded a total of 534 diphtheria cases. The highest number of admissions occurred in 2018, with 202 cases, followed by a significant drop in 2019 to just 31 cases. However, a sharp increase was observed again in 2020, reaching 157 cases. This was followed by a gradual decline in subsequent years, with 89 cases in 2021 and 55 in 2022.

Table 1: Socio-demographic characteristics of diphtheria cases (no. 534): shows that nearly two-thirds (63.1%) of patients were female. More than one quarter (26.2%) occurred in children aged 5 to <10 years and indicating that diphtheria predominantly affects school-aged children.

Regarding vaccination status, more than half (56%) of patients had been vaccinated, while two-thirds (33.5%) of the patients were unvaccinated.

According to the Anti-toxin dose, the majority (82%)of patients.

Table 2 Clinical Signs and Symptoms of Diphtheria cases (no. 534): show indicates that the most observed clinical symptoms among diphtheria cases were sore throat (95.3%), presence of a membrane (93.6%), cough (89.0%), difficulty swallowing (85.6%), fever (84.1%), and nasal discharge (77.7%).

Table 3, Distribution of diphtheria cases with case fatality rate by districts in 2018- 2022, Yemen (no. 534), illustrates significant variation in diphtheria incidence across different districts. Al Hawak District reported the highest incidence rate at 49 cases per 100,000 population, followed by Al Munirah (40.8/100,000) and Al Hali (37.5/100,000). The case fatality rate (CFR) was highest in Al Mansuriyah District at 100%, with Zabid District showing a notably high CFR of 30%.

Table 4 Association between vaccination status of cases and sociodemographic (no. 534) indicates that there is no statistically significant association between vaccination status and gender, as evidenced by a p-value of 0.79. In contrast, there is a highly significant relationship between vaccination status and different age groups, with a p-value of 0.001.

Discussion:

This study presents an epidemiological analysis of diphtheria cases admitted to Al-Thawra General Hospital in Hodeidah, Yemen, from 2018 to 2022. A total of 534 cases were documented during this period, with the highest number of admissions occurring in 2018. The sharp decline in 2019, followed by a resurgence in 2020, may reflect disruptions in healthcare services, population displacement, or fluctuations in surveillance and reporting due to the ongoing conflict in Yemen.

The demographic analysis revealed that diphtheria disproportionately affected females (63.1%) and children aged 5 to <10 years (26.2%)[9]. This agreement with Sameer Shedaiwah, 2024) Who said in his research that diphtheria cases affect females more than males[10] and aligns with global trends showing school-aged children as a high-risk group, likely due to increased exposure in school environments and lapses in booster vaccination coverage. The prevalence among females, while not statistically associated with vaccination status, may be influenced by social and cultural factors affecting healthcare access and care-seeking behavior. This finding aligns with a previous study conducted in Sana'a, Yemen, which reported the highest incidence of diphtheria among individuals under 15 years of age (11 per 100,000), while those aged 15 and above had the lowest incidence (5 per 100,000) [8]. Similarly, a 2016 study in the Lao People's Democratic Republic found that 69% of diphtheria cases occurred in children younger than 15 years [8]. A comparable pattern was also observed during the recent diphtheria outbreak among Rohingya refugees in Bangladesh, where 13% of the cases involved children under the age of five [11].

In our study, diphtheria was most prevalent among individuals with incomplete vaccination, accounting for 35.7% of cases. This is in line with a case-control study conducted in Laos, which found that around 34% of diphtheria patients had not received any doses of the DPT vaccine [11, 12]. These findings reinforce the observed trend that unvaccinated individuals are at significantly higher risk, a pattern also reflected in studies from India and Indonesia, where over 70% of diphtheria-related deaths occurred among those who

had not completed their immunization schedules [13, 14]. Furthermore, our study revealed that 95.33% of diphtheria cases presented with sore throat, a symptom strongly associated with the disease. This finding is supported by a meta-analysis of two studies conducted in Georgia, which identified recent sore throat as a significant risk factor for developing diphtheria [15].

Conclusion:

This study highlights the continued public health threat posed by diphtheria in Hodeidah, Yemen, particularly in the context of a fragile healthcare system impacted by conflict. The analysis of 534 cases between 2018 and 2022 reveals that diphtheria predominantly affects children under 15 years, especially those aged 5 to <10, and is more frequently observed among females. A significant proportion of cases occurred among individuals with incomplete or no vaccination, reinforcing the critical role of immunization in preventing diphtheria. The high prevalence of sore throat as a presenting symptom further supports its value as a clinical indicator for early diagnosis. The study also indicates there are no statistical differences between gender and vaccination cases, while there are highly statistically significant differences between age groups and vaccination cases.

These findings underscore the urgent need for strengthening vaccination coverage, improving public awareness, and enhancing disease surveillance and healthcare access, particularly for high-risk and underserved populations.

Recommendation:

Based on our results, we recommend the following:

1. Given the significant role of vaccination in preventing diphtheria, it is recommended to strengthen the existing vaccination programs. This could include increasing the accessibility and coverage of vaccination, especially in remote and underserved areas.
2. Implement public health awareness campaigns about the importance of vaccination and the risks associated with diphtheria. This could help to increase the acceptance and uptake of vaccination.
3. Conduct further research to understand the reasons behind the prevalence of diphtheria in Hodeidah. This could include studies on socio-economic factors, healthcare access, vaccination rates, and public health practices.
4. Collaborate with international health organizations to gain technical support and resources for diphtheria prevention and control.

Conflicts of interest:

The authors declare that they have no conflicts of interest.

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Figure 1: Distribution of Diphtheria cases admitted to the AL-Thwra hospital during the period between 2018 and 2022 (no.534)

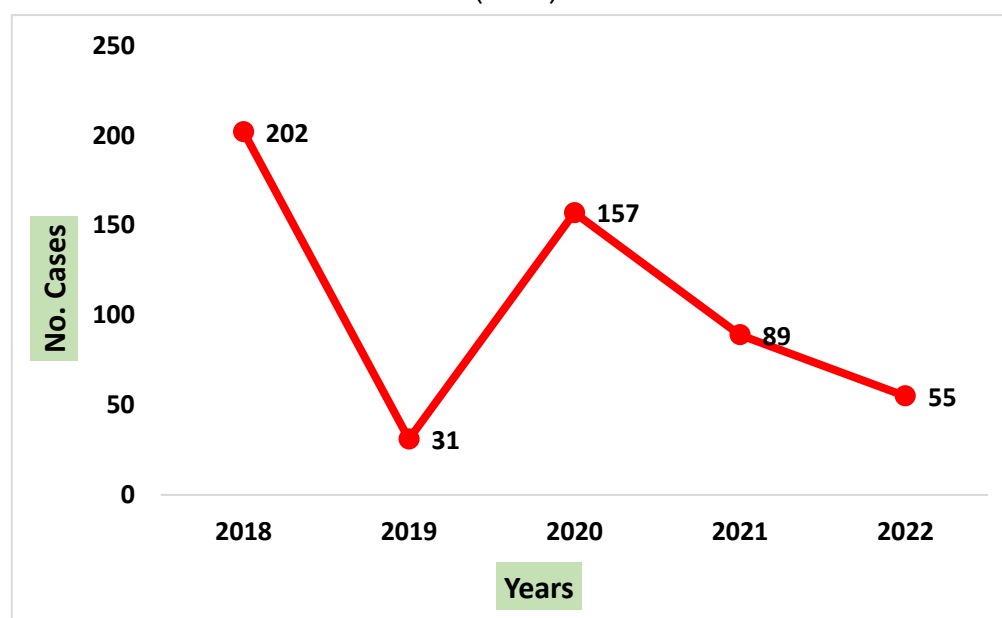**Table 1: Socio-demographic characteristics of diphtheria cases (no. 534)**

Variable		Frequency	Percent
Gender	**Male**	197	36.9
	Female	337	63.1
Age groups	< 5	75	14.0
	5 - < 10	140	26.2

Variable		Frequency	Percent
	10 - < 15	126	23.6
	15 - < 20	47	8.8
	20 - < 25	56	10.5
	25 - < 30	29	5.4
	≥ 30	61	11.4
Vaccination status	Vaccinated	299	56.0
	Un Vaccinated	179	33.5
	Un complete	42	7.9
	Un known	14	2.6
Booster Vaccination	Yes	76	14.23
	No	458	85.77
Anti-toxin dose	Yes	438	82.0
	No	96	18.0
Outcome of cases	Death	28	5.24
	Recovery	460	86.14%
	Referral	18	3.37%
	Desiring	28	5.24%
Complication	Yes	217	41%
	No	317	59%

Figure (2): Socio-demographic characteristics of diphtheria cases according the age

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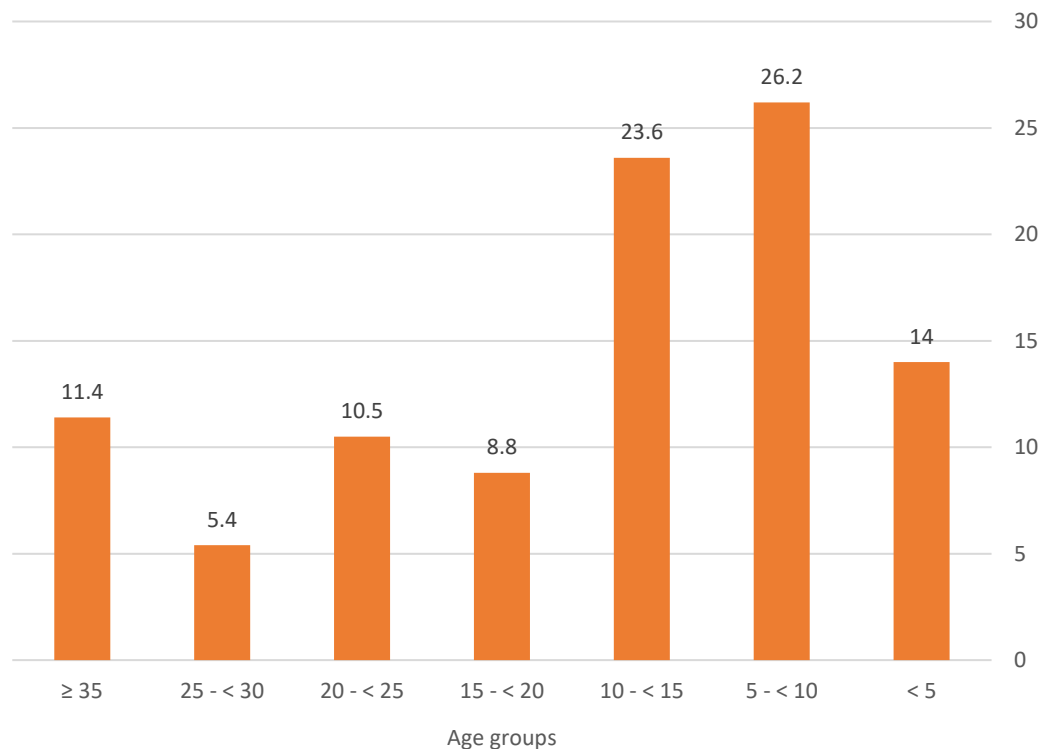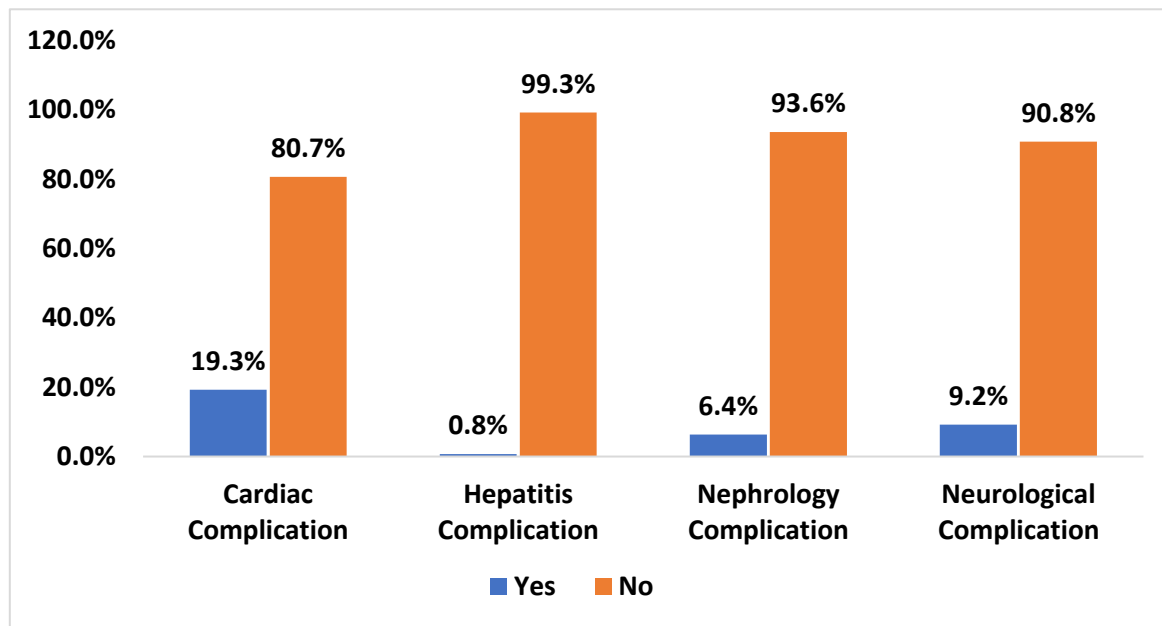
figure (3): Complications among Diphtheria Case

Table 2: Clinical Signs and Symptoms of Diphtheria Cases (no. 534)

Variable		Frequency	Percent
Fever	Yes	449	84.1%
	No	85	15.9%
Cough	Yes	475	89.0%
	No	59	11.1%
Presence of Membrane	Yes	500	93.6%
	No	34	6.4%
Difficulty Breathing	Yes	144	27.0%
	No	390	73.0%
Difficulty Swallowing	Yes	457	85.6%
	No	77	14.4%
Sore throat	Yes	509	95.3%
	No	25	4.7%
Swollen Lymph Gland	Yes	123	23.0%
	No	411	77.0%
Nasal discharge	Yes	415	77.7%
	No	119	22.3%
Change of Sound	Yes	145	27.2%
	No	389	72.9%

Table 3: Distribution of diphtheria cases with case fatality rate by districts in 2018- 2022, Yemen (no. 534)

Districts	Population	No. case	Death	No. CFR%	Icidance
A Hali	282429	106	2	2	37.5
Ad Dahi	90561	6	1	17	6.6
Ad Durayhimi	92836	7	0	0	7.5
AL Garrahi	150891	8	2	25	5.3
AL Hawak	262628	129	1	1	49.1
AL Lohia	175773	1	0	0	0.6

Districts	Population	No. case	Death	No. CFR%	Icidance
Al Mighlaf	68051	6	1	17	8.8
AL Mina	155305	45	0	0	29.0
Al Munirah	63655	26	3	12	40.8
Al Murawaea	216467	71	7	10	32.8
AL Qanaws	121347	5	0	0	4.1
Al sukhna	99834	10	1	10	10.0
Almansuriyah	74767	1	1	100	1.3
As Salif	10766	1	0	0	9.3
Az Zaydiyah	161042	11	0	0	6.8
Az Zuhrah	232368	9	0	0	3.9
Bait AL Faqih	407108	45	1	2	11.1
Bajal	291612	27	4	15	9.3
Bura	76460	6	0	0	7.8
Hays	75727	4	1	25	5.3
Zabid	268142	10	3	30	3.7
Total	3377770	534	28	5	15.1

Table 4: relationship between vaccination status of cases and sociodemographic (no. 534)

Variable		Vaccinated	Un Vaccinated	Un complete	unknown	(P value)
Gender	Male	114()	61	16	6	0.790
	Female	185	118	26	8	
Age group	< 5	40	25	9	1	<0.001*
	5 - < 10	85	39	14	2	
	10 - < 15	76	38	12	0	
	15 - < 20	30	11	3	3	
	20 - < 25	36	17	1	2	
	25 - < 30	15	10	2	2	
	≥ 35	17	39	1	4	

Significant p-value < 0.05