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Epidemiological and Clinical Insights into the Measles Outbreak in Diyala Province

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Abstract

Background: For more than sixty years, a safe and potent vaccine has been available; however, efforts to control measles through immunization are now endangered by a startling rise in cases both at home and abroad.

Objectives: To explore epidemiological and clinical characteristics of measles outbreak during 2023-2024 in Diyala province, Iraq.

Patients and Methods: This is a retrospective cross-sectional study that involved registering and following up the clinical case sheets of all measles cases admitted during the period from May 1st, 2023, to June 30th, 2024. A total of 5418 cases were included; among which 439 laboratory-confirmed cases. Clinical features were documented for a total of 652 cases.

Results: The majority (4612, 85.1%) of patients aged ≤10 years, followed by those >10 -20 years of age (347, 6.4%); the difference was highly significant ($p<0.001$). Additionally, 5328 (98.3%) of patients were not vaccinated versus 90 (1.7%) who were vaccinated. The difference was highly significant ($p<0.001$). Patients with cough were significantly more than those without cough (99.5% versus 0.5%, $p<0.001$). Similarly, patients with coryza were significantly more than those without coryza (97.2% versus 2.8%, $p<0.001$). Likewise, conjunctivitis appeared in 616 (94.5%) patients, accounting for a significantly higher percentage compared to those without conjunctivitis ($p<0.001$).

Conclusion: Unvaccinated people form an immunological gap that may act as an inlet for large measles outbreaks. Premarital screening of women for anti-measles IgG, adjusting the timing and number of measles vaccine doses, and increasing vaccination coverage plus initiation of an active surveillance system may reduce the rate of infection in the community.

Keywords: Measles, Measles outbreak, Measles vaccine, Diyala province.

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Introduction

The measles virus (MeV) belongs to the *Paramyxoviridae* family and is classified under the Morbillivirus genus. Although multiple genotypes exist, MeV isolates remain serologically identical, allowing polyclonal antibodies generated against vaccine strains to neutralize all other genotypes (1-4). The measles virus is extremely contagious in humans, producing a self-limiting febrile illness characterized by a maculopapular rash and transmitted via infectious aerosols. The virus initially infects alveolar macrophages and dendritic cells through the CD150 receptor (5). After this early infection, the virus spreads systemically with a marked preference for B and T lymphocytes, following an incubation period of 10 to 14 days. The prodromal stage is distinguished by the emergence of fever, cough, coryza, and/or conjunctivitis along with leukopenia, with rash usually appearing 3–5 days after the fever begins. Viral shedding commences during the prodrome, even before the rash is visible. Infected lymphocytes drive viremia, while the respiratory epithelium, invaded via nectin-4, sustains viral transmission through respiratory secretions (6). Individuals are contagious from 4 days before the appearance of the rash until 4 days after its appearance (7). Recovery from measles confers lifelong immunity (8). However, the immunosuppression induced by MeV frequently leads to secondary bacterial infections, such as pneumonia or gastrointestinal infections, which are the primary contributors to measles-associated morbidity and mortality. This heightened vulnerability to infections may persist for 2–3 years after measles (9). The first live attenuated measles vaccine was licensed in 1963 (10). Later, more attenuated vaccines, namely the Schwarz, Edmonston-Zagreb, AIK-C, and Moraten strains, all derived from the Edmonston lineage, were developed and remain in use today. Additionally, three others live-attenuated strains (CAM-70, Leningrad-16, and Shanghai-191) were derived from wild-type progenitors that do not belong to the Edmonston lineage (11). All current measles vaccines are classified as genotype A. Although vaccination elicits both humoral and cellular responses similar to those observed after natural infection, antibody titers are generally lower than those produced by infection (12). The prevalence of measles varies across World Health Organization (WHO) regions; notably, the African, Eastern Mediterranean, and European regions reported spikes in incidence during 2014-2015 due to significant outbreaks. The estimated global measles case burden exceeded 9.7 million cases in 2015 with an estimated total of 134,200 measles deaths (13). Between 2013 and 2018, coverage for both the first measles-containing vaccine (MCV1) and the second measles-containing vaccine (MCV2) in the East Mediterranean Region (EMR) showed improvement, yet they still fell short of the WHO's recommended target of ≥ 95% by 14% and 22%, respectively. The increase in measles cases in the EMR from 2015 to 2018 was largely driven by significant outbreaks in several countries within the region (14). Therefore, currently, the epidemiological situation of Iraq is drifting away from the elimination plan of measles endorsed by the WHO for the EMR, (15.16) that included the vaccine action plan which consists of 4 strategies: ensuring that every district in each country achieves at least a 95% vaccination rate with the first dose (MCV1) among children; attaining a minimum of 95% coverage with the second dose (MCV2) in every district; establishing robust, case-based surveillance systems across all countries; and providing optimal clinical management for measles cases (17). The Iraqi health authority has been following the WHO recommendation by administering the MCV1 at 9 months, as in other measles-endemic regions, and the MCV2 is given

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at school entry (11). Research shows that a single measles vaccine dose administered at 9 months results in 85% of children achieving protective immunity, whereas delaying the first dose until 12 months increases protection to 95% (10). Consequently, a regimen of two vaccine doses is recommended to achieve 95% immunization coverage within a community, thereby establishing herd immunity necessary to halt the spread of this highly contagious virus (8). In Iraq, a study on measles outbreak in Iraq, listed a number of factors that may contribute to the upsurge of measles cases, recommending the Iraqi Ministry of Health to provide a standardized method to eliminate measles by increasing the vaccination coverage rate of children (15). In a national retrospective cross-sectional study on measles cases reported from January 2023 to August 2024 in Iraq, the incidence was found to have increased significantly from 22.1 to 69.3 cases / 100,000 population, notably among infants < 9 months (12% to 16.7%) and > 15 years (6.4% to 12.1%). The rate of unknown vaccination status rose from 42.5% to 50.2% (18). A study on measles cases in Thi-Qare province (2023-2024) found that half of measles cases were in the age group of 1-5 years, constituting (50.35%) of total cases, followed by age groups 6-10 (10.5%) year. Measles cases peaked in winter and early spring (37.2% and 47.97% of cases were reported in January and February, respectively) (19). Another study exploring the impact of measles vaccination in Diyala province found that the lack of vaccination in the majority of infected children led to severe infections, particularly those complicated by pneumonia. Infants under one year of age, along with unvaccinated children and those whose mothers had lower educational levels, were at a higher risk of experiencing severe measles infections compared to other groups (20). A narrative review that tracked the 2024 measles outbreak in Iraq concluded that Iraq's placement as the third-ranked country for measles outbreaks in 2024, with approximately 25,429 reported cases according to the Centers for Disease Control and Prevention (CDC), underscores the urgent need for strengthened healthcare systems and vaccination campaigns (21). The current study aimed to explore epidemiological and clinical characteristics of the measles outbreak during 2023-2024 within Diyala province, Iraq.

Patients and Methods

Study design: This study utilized a retrospective cross-sectional design to gain insights into the epidemiological and clinical characteristics of measles cases in Diyala province, Iraq over a specified period of time.

Study setting: This study employed data collected by the Communicable Diseases Division of the Public Health Department of the Diyala Directorate of Health, Diyala, Iraq. Data were collected during the outbreak that plagued the province from May 1st, 2023, to June 30th, 2024.

Source of data: Data were obtained from measles case report forms and patient case sheets collected from all healthcare facilities, including hospitals, consultative clinics, and primary health care centers across Diyala province. These data are routinely reported to the province's Public Health Department as part of the communicable disease surveillance system.

Inclusion and exclusion criteria: The study included all reported measles cases in Diyala province who consented to have their data gathered and to participate in the study, from May 1st, 2023, to June 30th, 2024, given that they have met at least one of the WHO measles case definitions (22):

- Clinical measles case: Any person in whom a clinician suspects measles infection; or Any person with fever and maculopapular rash (i.e., non-vesicular) and: cough, or coryza (i.e., runny nose) or conjunctivitis (i.e., red eyes).

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• Laboratory-confirmed measles case: A suspected case of measles that has been confirmed positive by testing in a proficient laboratory, and vaccine-associated illness has been ruled out.

• Epidemiologically linked measles case: A clinical case of measles that has not been confirmed by a laboratory, but was geographically and temporally related, with dates of rash onset occurring 7–21 days apart from a laboratory-confirmed case or another epidemiologically linked measles case.

Excluded cases were those who tested negative for measles by laboratory confirmation and those who refused to have their data collected to participate in the study. A total of 5543 cases were reported to the Public Health Department in Diyala (all met the WHO clinical measles case definition) and initially considered to be included in the study, 564 cases were sent for laboratory confirmation, 439 cases were proved to be laboratory-confirmed measles cases according to the WHO definition, including 17 cases who tested positive for both measles and rubella; however, the remaining 125 cases tested negative for measles, and hence were excluded from the study (including 3 cases who tested positive for rubella only). The rest of the cases (4979) that did not undergo laboratory confirmation all met the WHO definition of epidemiologically linked measles case, summing to a grand total of 5418 cases (4979 clinically diagnosed cases and 439 laboratory-confirmed cases) who were included in the study and underwent statistical analysis. Moreover, the investigated spread of disease met the WHO definition of laboratory-confirmed measles outbreak: "Two or more laboratory-confirmed measles cases that are temporally related (with dates of rash onset occurring 7–21 days apart) and epidemiologically or virologically linked, or both" (22).

Data collection and definition of variables: Data collection focused on the admission date, sociodemographic information, clinical and laboratory diagnosis, and patients' outcomes. Sociodemographic information included age (≤10, >10-20, >20-30, >30-40, and >40-50 years), gender, occupation (pre-school child, student, employee, medical staff, military, and others), location (according to district of residence), vaccination status (vaccinated or not), contact with measles case (yes or no), and hospitalization (hospitalized or home isolated). The clinical features investigated included fever, rash, cough, coryza, conjunctivitis, lymph node swelling, and arthralgia and/or arthritis, along with the time (in days) from the start of fever till the appearance of rash. Clinical features were documented for a total of 652 cases.

Calculation of incidence: The incidence rate of measles cases in Diyala province was calculated using the following equation:

$$Diyala\ incidence = \frac{\text{Number of measles cases in Diyala}}{\text{Total population of Diyala}} \times 100{,}000$$

The incidence rate of measles cases in districts of Diyala province was calculated using the following equation:

$$District\ incidence = \frac{\text{Number of measles cases in a specific distric}}{\text{Total population of that district}} \times 100{,}000$$

Statistical Analysis

Data analysis was executed using the Statistical Package for the Social Sciences (SPSS) software version 29 for statistical investigation along with Microsoft Excel for data preparation. The incidence of measles was calculated per 100,000 population. Descriptive statistical analysis included the calculation of frequency and percentage for categorical variables, along with the mean, standard deviation and range for age (as a quantitative variable). The Chi-square test was used to compare and evaluate the association of categorical variables, with p-values ≤0.05 regarded as statistically significant.

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Results

Epidemiological trends and incidence rates: In this study, the annual incidence rates of measles (per 100,000 population) were calculated for 2023 and 2024 for each district separately and for the entire Diyala province. All districts, and hence the province, showed an increase in the incidence rate in 2024 compared to 2023. In 2023 , Baqubah had the highest incidence rate (122.5) among districts, followed by Baladrooz (77.4), whereas Mansoriya had the lowest incidence rate (1.5). In 2024, Baqubah had the highest incidence rate (325.6), followed by Almuqdadiya (190.5). This time around, Mansoriya remained as the district with the lowest incidence rate (18.2). Across the province, the incidence rate increased from 72.7 in 2023 to 213.2 in 2024, as shown in Table 1.

Table 1. Annual incidence rates of measles (per 100,000 population) in Diyala province and its districts.

District	Total population (2023)*	Total population (2024)*	Cases (2023)	Cases (2024)	Incidence (2023)**	Incidence (2024)**
Baqubah	733052	780497	898	2541	122.5	325.6
Baladrooz	186054	182933	144	253	77.4	138.3
Almuqdadiya	254893	239387	24	456	9.4	190.5
Alkhalis	297686	314386	222	458	74.6	145.7
Jaloalaa	173029	186099	48	280	27.7	150.5
Mansoriya	130237	120722	2	22	1.5	18.2
Khanaqin	85585	83346	14	56	16.4	67.2
Total (Diyala)	1860536	1907370	1352	4066	72.7	213.2

*Mid-year population obtained from the Public Health Department in Diyala province, Iraq.
** Incidence rate per 100,000 population.

In the current study, patients' mean age ± SD was 5.88 ± 9.32 years, ranging from 3 days to 50 years. Measles prevalence in the province during the study period was 0.284%. A total of 8 cases died (all met the WHO definition of acute measles-related death) [15], with a case fatality rate of 0.147% (very close to 1.5 deaths per 1000 cases). Based on the month of diagnosis, the number of diagnosed measles cases assumed the shape of a bell, typical for an outbreak, as the number of cases started with only 5 cases in May 2023, and increased gradually to a total of 971 cases in January 2024, after which it peaked at 1023 cases in February 2024, followed by a drop to 910 cases in March 2024, then gradually decreased to 133 cases in June 2024. Distribution of patients according to the month of diagnosis is illustrated in Figure 1.

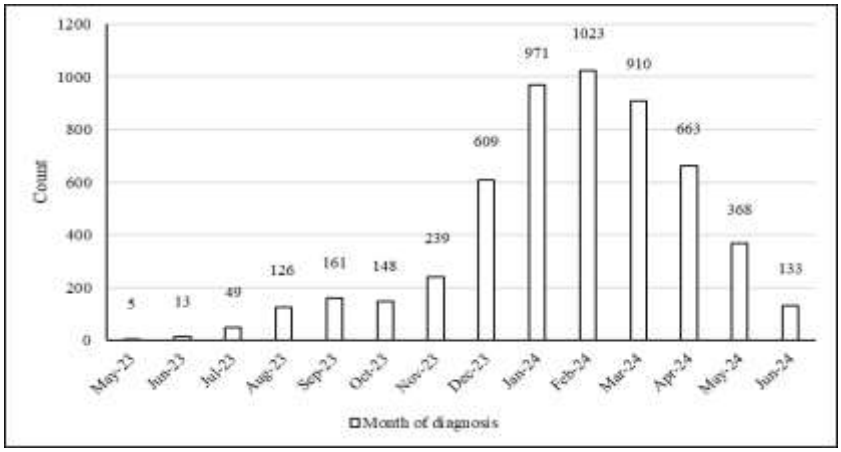

Figure 1. Distribution of measles patients according to the month of diagnosis.

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Demographic characteristics of cases: A total of 5418 patients were included in this study. Of them, 4979 (91.9%) were clinically diagnosed with measles, and 439 (8.1%) were laboratory confirmed. The difference between the two groups was highly significant (p<0.001). Patients included 2825 (52.1%) males and 2593 (47.9%) females. Thus, males were significantly more than females (p = 0.002). The majority of patients (4186, 77.2%) were pre-school children; again, are the difference in patients' occupations was statistically highly significant (p<0.001)—details provided in Table 2. The results of this study showed that the majority (4612, 85.1%) of patients were aged ≤10 years, followed by those more than 10 to 20 years of age (347, 6.4%), while the age group of more than 40 to 50 years of age contained the fewest number of patients (50, 0.9%). The difference was highly significant (p<0.001) (Table 3).

Table 2. Distribution of measles patients according to diagnosis, gender, and occupation.

Variable		Measles patients No. (%)	p-value*
Diagnosis	Clinically diagnosed	4979 (91.9%)	<0.001**
	Laboratory confirmed	439 (8.1%)	
	Total	5418 (100%)	
Gender	Male	2825 (52.1%)	0.002**
	Female	2593 (47.9%)	
	Total	5418 (100%)	
Occupation	Pre-school child	4186 (77.2%)	<0.001**
	Student	736 (13.6%)	
	Employee	27 (0.5%)	
	Medical staff	10 (0.2%)	
	Military	12 (0.2%)	
	Others	447 (8.3%)	
	Total	5418 (100%)	

*Difference among proportions using Pearson's Chi-square test at 0.05 level.
**Statistically significant difference.

Table 3. Distribution of measles patients according to age groups.

Variable		Measles patients No. (%)	p-value*
Age (years)	≤10	4612 (85.1%)	<0.001**
	>10-20	347 (6.4%)	
	>20-30	164 (3.1%)	
	>30-40	245 (4.5%)	
	>40-50	50 (0.9%)	
	Total	5418 (100%)	

*Difference among proportions using Pearson's Chi-square test at 0.05 level.
**Statistically significant difference.

Geographic distribution: The results in Table 4 reveal that the bulk of patients were from Baqubah district (3439, 63.5%), followed by those from Alkhalis district (680, 12.6%) and Almuqdadiya district (480, 8.9%). In contrast, Mansoriya district was the home for the fewest number of patients (24, 0.4%). The difference among the districts was highly significant (p<0.001).

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Table 4. Distribution of measles patients according to location (districts).

Variable		Measles patients No. (%)	p-value*
Location	Baqubah	3439 (63.5%)	<0.001**
	Baladrooz	397 (7.3%)	
	Almuqdadiya	480 (8.9%)	
	Alkhalis	680 (12.6%)	
	Jaloalaa	328 (6%)	
	Mansoriya	24 (0.4%)	
	Khanaqin	70 (1.3%)	
	Total	5418 (100%)	

*Difference among proportions using Pearson's Chi-square test at 0.05 level.
**Statistically significant difference.

Vaccination status and exposure history: Regarding measles vaccination status, 5328 (98.3%) patients were unvaccinated, whereas 90 (1.7%) were vaccinated. The difference was highly significant (p<0.001). The results also reveal that only 76 (1.4%) patients reported contact with a positive measles case, whereas 5342 (98.6%) denied any contact. The difference was highly significant (p<0.001). Furthermore, a total of 4609 (85.1%) cases were admitted to the hospital (91 of those chose to self-discharge), and the remaining 809 (14.9%) were not hospitalized; instead, they were advised to isolate at home. The difference was highly significant (p<0.001) (Table 5).

Table 5. Distribution of measles patients according to location (districts).

Variable		Measles patients No. (%)	p-value*
Vaccination status	Not vaccinated	5328 (98.3%)	<0.001**
	Vaccinated	90 (1.7%)	
	Total	5418 (100%)	
Contact with measles case	No	5342 (98.6%)	<0.001**
	Yes	76 (1.4%)	
	Total	5418 (100%)	
Hospitalization	No (home isolation)	809 (14.9%)	<0.001**
	Yes	4609 (85.1%)	
	Total	5418 (100%)	

*Difference among proportions using Pearson's Chi-square test at 0.05 level.
**Statistically significant difference.

Clinical presentation and symptomatology: The distribution of patients by observable clinical features included 652 patients registered only during the first 6 months of 2024, as shown in Table 6. Regarding the duration from the onset of fever to the appearance of a skin rash, it took 0-2 days in most patients (388; 59.5%), a significantly higher proportion than other durations (p<0.001). Patients with cough were considerably more than those without cough (99.5% versus 0.5%, p<0.001). Similarly, patients with coryza were significantly more than those without coryza (97.2% versus 2.8%, p<0.001). Likewise, conjunctivitis was present in 616 (94.5%) patients, a significantly higher proportion than in those without conjunctivitis (p<0.001). Furthermore, lymph node (LN) swelling was recorded in 267 (41%) patients, significantly fewer than in those without lymph node swelling (p<0.001). Arthralgia and/or

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arthritis was reported in 62 (9.5%) patients, making them significantly fewer than the 590 (90.5%) patients without arthralgia (p<0.001).

Table 6. Distribution of measles patients according to clinical features.

Clinical feature		Measles patients No. (%)	p-value*
Fever to rash (days)	0-2 days	388 (59.5%)	<0.001**
	3-5 days	229 (35.1%)	
	More than 5 days	35 (5.4%)	
	Total	652 (100%)	
Cough	Absent	3 (0.5%)	<0.001**
	Present	649 (99.5%)	
	Total	652 (100%)	
Coryza	Absent	18 (2.8%)	<0.001**
	Present	634 (97.2%)	
	Total	652 (100%)	
Conjunctivitis	Absent	36 (5.5%)	<0.001**
	Present	616 (94.5%)	
	Total	652 (100%)	
Lymph node swelling	Absent	385 (59%)	<0.001**
	Present	267 (41%)	
	Total	652 (100%)	
Arthralgia and/or arthritis	Absent	590 (90.5%)	<0.001**
	Present	62 (9.5%)	
	Total	652 (100%)	

*Difference among proportions using Pearson's Chi-square test at 0.05 level.
**Statistically significant difference.

Discussion

Admittedly, there was a redundant up swinging of measles cases globally (14), even in most developed countries (23) as well as in the World Health Organization East Mediterranean Region (WHO-EMR) (24). In Diyala province, Iraq, there was a gradual increase in measles cases among children with fever and skin rash since 2019 (18,25). These observations suggested that measles has become an endemic disease, especially among high-risk groups, and that the province may witness a larger outbreak of measles. This is what actually occurred during 2023-2024. Since this area is under high endemicity, supported by the results of the current study, the first dose is better to be given as early as 6 months, a subsequent booster is administered between 9 and 12 months of age, besides, a third booster dose before school entry regardless of the anti-measles IgG status (26). In this study, the measles incidence rate in Diyala province increased from 72.7 in 2023 to 213.2 in 2024. This result is in line with the result obtained by a national study on measles outbreak 2023-2024 in Iraq (18). Moreover, in the current study, measles cases reached their peak in February 2024 (1023 cases), followed by January 2024 (971 cases). This trend is very similar to that found in a study that explored the measles outbreak in Thi-Qare province in 2023-2024 in which the number of cases reached its peak in February 2024 (47.97% of cases) followed by January 2024 (37.2% of cases) (19). In the present study, a significantly greater prevalence of measles infection was observed among individuals aged 10 years or younger (85.1% of cases) which is consistent with previous studies in Iraq, including one study at the national level in which 81.6% of cases were in the age group of 10 years or younger (18), and a second study in Thi-Qare province in which the age group of 10 years or younger represented 83.5% of cases (19).

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Research indicates that newborns possess higher anti-measles antibody titers at birth compared to their mothers. One study revealed that 91.2% of young infants attained protective levels of measles antibodies, in contrast to only 84.8% of their mothers (27). That means that the protective levels of maternal antibody in infants are largely dependent on the seropositivity and antibody titer of mothers during pregnancy (28). Moreover, since maternal antibodies in infants decay rapidly with a half-life of 25 to 48 days, the antibody levels can quickly fall beneath protective thresholds (29). Thus, for children <1 year of age, their protective status is completely dependent on maternal status unless they receive the MCV1, while the protective status in children >1year old is surely dependent on vaccination status. Therefore, any breakthrough measles infection during this age is probably related to either maternal or child's vaccination status. Measles cases were additionally reported across all age groups, even those 40-50 years old. Epidemiologically, this is an important finding that denotes protection infirmity. In a previous study to explore the measles vaccine efficacy in Iraq, it was found that the protection rate was 92.6% among those 6-14 years old (12). Therefore, measles infection during adulthood may either be due to no vaccination for any reason along with no natural infection during childhood, or these individuals might have previous protection, but as time passed, the levels of anti-measles IgG fell down, and they became susceptible again. The third weakly acceptable probability is infection by genetically modified strain of MeV. In this regard, according to viral N protein, among the 24 identified MeV genotypes, six, specifically B3, D4, D8, D9, G3, and H1, continue to circulate globally (30). Furthermore, 98.3% patients in this study were non-vaccinated or partially vaccinated against measles. Therefore, the picture is now becoming clear, and the defect was recognized as lack of vaccination, and the logical question here is: why? The presence of unvaccinated or partially vaccinated people in the community forms an immunological gap from where the virus may enter., since the MeV is highly contagious and quickly transmitted by infectious aerosols (6). More critically, individuals with measles are contagious starting from 4 days before the appearance of the rash and remain so until 4 days after its onset, with the straightforward progression of the illness spanning 17 to 21 days from the initial fever (8). This extended infectious period allows ample opportunity for the measles virus to be shed and disseminated. Additionally, when immunocompromised individuals contract MeV, they may present with atypical clinical features of measles and frequently endure severe, lingering complications, most notably pneumonia (31). From an epidemiological point of view, these patients are more dangerous for disseminating MeV in the community. Scientifically, lack of vaccination is either due to failure of vaccine or failure of vaccination. Failure of measles vaccine in a country like Iraq which is suffering from deterioration of all infrastructures including healthcare services as a result of wars, may be due to intermittent shortage of vaccine availability for any reason. Furthermore, partial or complete vaccine failure may because of cold-chain insufficiency due to frequent electric power outages, an aspect that has become a chronic obstacle in the country. On the vaccination failure side, a lot of reasons come to mind, starting with shortage in healthcare providers and other facilities in healthcare centers or due to low performance of unqualified or badly trained healthcare workers. Moreover, low vaccine coverage rate may be due to insufficient or neglected vaccination campaigns. Additionally, people may refuse to vaccinate their babies due to the public acceptance hesitancy of vaccines, a public phenomenon that has risen after COVID-19 vaccine adverse effects (32). The

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concept "fear of vaccines" is furthermore augmented by the public ill-confidence in health services which is a part of poor confidence in the whole governmental system. Of note, there are no legislations that obligate people to accept vaccination. In addition to that, children malnutrition, particularly vitamin A deficiency, as well as other causes of immunosuppression, all reduce the efficacy of measles vaccine (33). This study reinforces the idea that attaining measles elimination objectives depends on case-based surveillance, which includes the laboratory confirmation of suspected cases through standardized methods (15,34). Moreover, integrating molecular surveillance with conventional epidemiological data allows for the tracking of transmission pathways and serves as evidence to verify measles elimination (30). In this study, as with other worldwide studies, it is almost certain that there was underreporting in outbreak and non-outbreak settings of measles cases (35,36). Moreover, the current data denote that some measles patients self-discharged from hospital while others were instructed to home-isolate without any surveillance rather than being admitted to hospital for unknown reasons. All these practices may work against disease control and elimination. Clinically, the current study's results showed that cough, coryza, and conjunctivitis all were present in a significantly higher percentage of patients, with the duration from the start of fever till the appearance of the maculopapular skin rash taking 0-2 days in 59.5% of the patients, which is a significantly higher percentage compared to other durations. These signs typically meet the definition of measles according to the WHO case definition (22). It is interesting to mention that measles or what is historically called "Hasbah" in the Iraqi local cultural heritage was a well-known disease of childhood since antiquity. Moreover, in the pre-vaccine era, measles was a popularly well-known disease that occurs once in a lifetime, and thus, every child had to pass this "challenge". The current results additionally found that 8 measles patients died, with a case fatality rate (CFR) of around 1.5 deaths per 1000 cases, which is consistent with the case fatality rate reported by a study conducted in Thi-Qare province (1.2 deaths per 1000 cases) (19). It is estimated that the measles case fatality rate ranges from 0% to 40.16%, with a median of 1.0%, and it greatly varies among localities and is inversely correlated with economic development. In high-income regions such as North America and Europe, the case fatality rate for measles is exceptionally low: about 0.1 to 0.3 deaths per 1,000 cases. In middle-income areas, including parts of Latin America and Asia, measles CFRs rise to roughly 1 to 5 deaths per 1,000 cases (which is consistent with the present study). In low-income countries, particularly across sub-Saharan Africa, the CFRs are around 5 to 10 deaths per 1,000 cases. Finally, during large outbreaks or in humanitarian-crisis settings, such as refugee camps, localized CFRs can spike to 10-30 deaths per 1,000 cases (37).

Conclusion

This study provides critical epidemiological and clinical insights into the 2023-2024 measles outbreak in Diyala province, Iraq, revealing a concerning surge in incidence from 72.7 to 213.2 cases per 100,000 population. The overwhelming majority of cases (85.1%) occurred in children ≤10 years, with near-universal under-vaccination (98.3% unvaccinated) acting as the primary driver of transmission. The predominance of classical symptoms, cough (99.5%), coryza (97.2%), and conjunctivitis (94.5%), confirms measles' distinctive clinical footprint, while the peak incidence in winter months (January and February 2024) aligns with regional transmission patterns. The findings underscore measles' endemic resurgence in Diyala, fueled by critical gaps in herd immunity. The significant case burden among preschool-aged children highlights vulnerabilities in routine immunization delivery,

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exacerbated by systemic challenges including vaccine hesitancy, cold-chain failures, and insufficient coverage. Notably, cases across all age groups, including adults >40 years, signal waning immunity and historical gaps in vaccination programs. With a case fatality rate of 1.5 per 1,000 cases, the outbreak reflects broader failures in meeting WHO elimination targets for the Eastern Mediterranean Region. To curb transmission and accelerate elimination efforts need to be made to adhere to the WHO recommendations, and goals need to be set and followed-up closely to achieve that. Without these interventions, Diyala, and Iraq broadly, will remain susceptible to recurrent outbreaks, jeopardizing regional elimination goals.

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Ethical clearance: All participants or their legal guardians provided informed consent at the time of data collection, and all information was anonymized to ensure privacy protection. This study was conducted with the approval of the Diyala Directorate of Health (No. 8782) and in strict adherence to the ethical guidelines outlined in the Declaration of the Directorate's Ethical Committee.

Conflict of interest: None.

Use of Artificial Intelligence (AI): The authors state they did not use any generative AI tools for creating or editing the manuscript's language.

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الرؤى الوبائية والسريرية لتفشي مرض الحصبة في محافظة ديالى

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الملخص

الخلفية: لأكثر من ستين عامًا، كان لقاح آمن وفعّال متاحًا؛ إلا أن الجهود المبذولة للسيطرة على مرض الحصبة عبر التحصين أصبحت مهددة حاليًا بسبب الارتفاع المقلق في عدد الحالات محليًا وعالميًا.

الأهداف: استكشاف الخصائص الوبائية والسريرية لتفشي مرض الحصبة خلال عامي ٢٠٢٣–٢٠٢٤ في محافظة ديالى، العراق.

المرضى والطرق: دراسة مقطعية استعادية شملت تسجيل ومتابعة السجلات السريرية لجميع حالات الحصبة المُدخلة خلال الفترة من ١ أيار ٢٠٢٣ إلى ٣٠ حزيران ٢٠٢٤. بلغ العدد الكلي للحالات ٥٤١٨ حالة، منها ٤٣٩ حالة مؤكدة مختبريًا. وتم توثيق السمات السريرية لـ ٦٥٢ حالة.

النتائج: كانت الغالبية العظمى من المرضى (٤٦١٢، بنسبة ٨٥,١٪) بعمر ≥١٠ سنوات، تلاهم من هم بعمر <١٠–٢٠ سنة (٣٤٧، بنسبة ٦,٤٪)، وكان الفرق ذا دلالة إحصائية عالية ($p<0.001$). إضافة إلى ذلك، كان ٥٣٢٨ مريضًا (٩٨,٣٪) غير مُطعّمين مقابل ٩٠ مريضًا (١,٧٪) مُطعّمين، مع فرق ذي دلالة إحصائية عالية ($p<0.001$). كما كان عدد المرضى المصابين بالسعال أعلى بكثير من غير المصابين (٩٩,٥٪ مقابل ٠,٥٪، $p<0.001$). وبالمثل، كان وجود الزكام أعلى بشكل ملحوظ (٩٧,٢٪ مقابل ٢,٨٪، $p<0.001$). كذلك ظهرت التهاب الملتحمة لدى ٦١٦ مريضًا (٩٤,٥٪)، بنسبة أعلى دلالةً إحصائيًا مقارنةً بغير المصابين ($p<0.001$).

الاستنتاج: يُشكّل غير المُطعّمين فجوة مناعية قد تعمل كمدخل لحدوث فاشيات كبيرة لمرض الحصبة. إن فحص النساء قبل الزواج للكشف عن الأجسام المضادة IgG للحصبة، وتعديل توقيت وعدد جرعات لقاح الحصبة، وزيادة التغطية التلقيحية، فضلًا عن استحداث نظام ترصّد فعّال، قد تسهم في خفض معدل الإصابة في المجتمع.

الكلمات المفتاحية: الحصبة، تفشي الحصبة، لقاح الحصبة، محافظة ديالى.

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