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Impact of Measles Vaccination Coverage on Disease Severity Among Children Under Five Years of Age in Diyala Province, Iraq

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ABSTRACT

Background: Measles is one of the acute and very contagious diseases for children, but it can be successfully controlled by vaccination.
Objectives: To evaluate the impact of measles vaccination coverage on the severity of measles among children aged less than five years in Diyala Province, Iraq, during the year 2024 outbreak.
Materials and methods: A cross-sectional study was conducted from January to March 2024 at the Al-Batool Teaching Hospital, Baquba, Diyala, Iraq. Ninety-two children admitted with symptoms of measles underwent detailed clinical and serological examinations. We used descriptive, bivariate, and multiple logistic regression analyses to analyze the data. We set the statistical significance at a P-value of less than 0.05.
Results: The total number of cases were 92 children with a mean age of 26 ± 2.46 months, and 44.6% were below 1 year old. Most of the children were unvaccinated (84.8%), severely infected (80.4%), and complicated with pneumonia (70.7%), with positive IgM antibodies for measles (83.7%). Multiple logistic regression analysis showed that children below one year of age [Odds Ratio (OR) = 7.909, 95% CI: 1.610 to 38.860, P-value = 0.011], unvaccinated (OR = 6.300, 95% CI: 1.489 to 26.657, P-value = 0.012), and those with low-educated mothers (OR = 4.013, 95% CI: 1.982 to 16.389, P-value = 0.035) were significantly associated with severe illness.
Conclusion: During the year 2024 measles outbreak in Iraq, the severity of the illness was exacerbated among unvaccinated children aged below one year and those with low-educated mothers.
Keywords: Measles; Outbreak; Vaccine; Children, Severity.

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INTRODUCTION

Measles is classified as an extremely contagious disease. It is a highly communicable respiratory infection caused by an airborne virus [1]. The measles virus; also named "rubeola" or "red measles"; prefers to inhabit the upper respiratory system, especially the throat and the mucous tissue of the nose [1, 2]. Anybody can be a potential target for measles, but the most exposed groups to infection are children under five years, pregnant women, and those over the age of twenty years [3].

The danger of the measles virus lies in its ability to stay alive and infect others for nearly two hours after secretion in the air from an infected person [4]. Moreover, the virus can remain in an infected person's body for seven to twenty-one days while maintaining its infection capacity. Therefore, the report of the Center for Control and Prevention of Diseases (CDC) stressed the likelihood of spreading the infection among nine out of every ten exposed individuals if they were unvaccinated (https://emergency.cdc.gov/han/2024/han00504.asp).

Before John Enders and his colleagues discovered the measles vaccine in 1963, the disease was common in most regions of the world [5]. Global Medical Records referred to tens of millions of morbidities and deaths due to repeated measles outbreaks. Measles outbreaks often activate during a crisis and attack weak communities, especially at times of war, starvation, and other epidemics, such as the COVID-19 pandemic [6–8]. Measles brings death and burden to eco-

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nomic and health institutions due to increasing demand for hospitalization and prolonged lengths of stay, and sometimes the necessity to impose a quarantine to prevent the spread of infection [9, 10].

Several unpleasant complications might be part of the measles infection course such as ear infection and diarrhea (1/10 measles cases) [11]. The absence of a triple vaccine [measles, mumps, and rubella (MMR)] during pregnancy, or the neglect of mothers to vaccinate, may cause premature births or a child born with a weight less than normal [12].

Sixty years after the discovery of the measles vaccine, the world is currently witnessing one of the most violent waves of the epidemic.

During the first third of this year, the CDC registered the measles outbreak in more than sixty countries, including Iraq, which was listed third among the top ten countries with about 25,429 cases [7]. Iraq has witnessed three waves of measles outbreaks during the past thirty years, all of which coincided with crises such as the economic sanctions (1991-2003), the internal civil war (2006-2008), and the global health crisis due to the COVID-19 pandemic (2019-2022)[7, 13].

Recent data indicate that Iraq is experiencing one of the most severe waves of measles, with significant morbidity and mortality [7, 8]. There is a critical need for this study to address gaps in understanding the impact of vaccine coverage and sociodemographic factors on measles severity in Diyala province, Iraq. Therefore, this study investigates how measles vaccine coverage and various clinical and sociodemographic factors influence the severity of the current measles outbreak in Diyala province, Iraq. The primary objective was to examine the impact of vaccine coverage on disease severity. Secondary objectives were to identify sociodemographic factors linked to measles severity, compare clinical outcomes in vaccinated versus unvaccinated children and analyze the effect of maternal education and other socioeconomic factors on disease severity among children under five years of age.

MATERIALS AND METHODS

A cross-sectional study was conducted between January 1st and March 31st, 2024, at the Al-Batool Teaching Hospital, Baquba, Diyala, Iraq. A universal sampling technique was recruited to collect all children of both genders who were admitted with measles symptoms, such as skin rash, fever, cough, runny nose, and redness of the eyes, supported with parents' verbal and written consent forms were included in the study. The study was conducted following the approval of the scientific and ethical committees in the College of Medicine, University of Diyala. The code number is 2024AJM861.

We excluded several groups from the study for specific reasons. Newborn babies were excluded due to their unique health considerations and immune system immaturity. Children with congenital anomalies were excluded to avoid confounding variables related to their complex medical conditions. Additionally, children with other known chronic diseases were not included to prevent the interference of these conditions with the study outcomes. Lastly, we excluded children whose parents refused to sign the consent form, ensuring ethical compliance and respect for parental authority and decision-making.

Two milliliters of blood were drawn from each child via venipuncture and placed into sterile, labeled bottles containing an anticoagulant. The blood samples were centrifuged, and the plasma was stored at −20°C until further processing. Plasma samples were analyzed for measles-specific immunoglobulin M (IgM) antibodies using a measles IgM enzyme-linked immunosorbent assay (ELISA) test kit. Samples that yielded equivocal results were retested, and if they remained equivocal, they were classified as negative.

A semi-structured questionnaire was used to collect demographic and clinical information, such as the child's age, gender, measles vaccination history, mother's age and education level, and the family's place of residence.

The dependent variable in this study was the severity of the infection, categorized as severe and mild based on the World Health Organization (WHO) guidelines. The independent variables included sociodemographic factors, clinical characteristics, and mother-related factors. Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were presented in number and percentage. Bivariate analysis using the Chi-square test and multiple logistic regression analysis were performed to identify predictors of severity. A P-value of less than 0.05 was considered statistically significant. Data analysis was conducted using a statistical package for the Social Sciences (SPSS) for Windows, version 16.

RESULTS

The eligible sample consisted of ninety-two children. The mean age of children was 26.0 ± 2.46 months, with a range between 6 months to 5 years. Most of the children in the age group below one year 41 (44.6%). The male to female ratio was 1/1. Fifteen (15.2%) children had evidence of vaccination from their vaccine record. Most of the children had a severe infection (74, 80.4%), presented with pneumonia 65 (70.7%), and 77 (83.7%) tested positive for measles IgM antibodies. The mean age of mothers was 28 ± 5.28 with a range of 18-38 years, had secondary education (40.2%), and were resident in rural regions (62.0%), as shown in Table 1.

Table 2 revealed that only children who were aged less than one year old, (Chi-square test (χ^2) =29.946, P-value =0.0001),being female (χ^2 =4.420,P-value = 0.036), being measles unvaccinated χ^2=9.719,P-value = 0.002),complicated with pneumonia (χ^2 =3.874,P-value = 0.045)), and mothers aged less than 28 years old (χ^2 =5.879, P-value = 0.015) were significantly associated with the severe measles infection.

Children younger than 1 year old (OR = 7.909, 95% CI: 1.610 to 38.860, P-value = 0.011), children who had not been vaccinated (OR = 6.300, 95% CI: 1.489 to 26.657, P-value = 0.012), and mothers with only a primary school education (OR = 4.013, 95% CI: 1.982 to 16.389, P-value = 0.035) were all significantly linked to severe illness. Model adequacy was confirmed by the Hosmer and Lemeshow test, showing a good fit (P-value = 0.385). Additionally, the overall model was significant (P-value = 0.001) and explained 42.9% of the variance (Nagelkerke R square = 0.429).

DISCUSSION

It was not surprising to observe new measles cases in Iraq, which ranked third among the top ten countries affected by the 2024 measles outbreak. The number of registered cases at public healthcare facilities steadily increased from the beginning of January 2024 to cross the threshold of 25,000 by early May [7]. However, the tendency to seek care in the private sector [7] for reasons related to quality and satisfaction [14] likely underestimates the total number of measles cases.

Several studies have discussed the possible reasons for the emergence of the current measles epidemic, the most promi-

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Table 1. Sociodemographic and clinical characteristics of children and their mothers (n = 92).

Variable	Groups	Frequency(%)
Age of children 26 ± 2.46 months (Range 6-60)		
Age groups (years)	< 1 years	41 (44.6)
	1− < 3 years	22 (23.9)
	3− < 5 years	29 (31.5)
Gender	Male	46(50.0)
	Female	46 (50.0)
Vaccination history	Unvaccinated	78 (84.8)
	Vaccinated	15 (15.2)
Severity of infection	Severe	74 (80.4)
	Mild	18 (19.6)
Type of infections in severe measles (n = 74)	Pneumonia	54(58.7)
	Acute enteritis	5(5.4)
	Viral meningitis	4(4.3)
	Pneumonia+ acute enteritis	11(12.0)
IgM test	Negative	15(16.3)
	Positive	77 (83.7)
Age of mothers 28 ± 5.28 years (18-38)	18-28	44 (47.8)
	> 28	48 (52.2)
Mother education	Primary	35 (38.1)
	Secondary	37 (40.2)
	Graduated	20 (21.7)
Residency	Rural	57 (62.0)
	Urban	35 (38.0)

nent of which was the COVID-19 pandemic and its consequences [7, 15]. In his review of the resurgence of measles, Parums DV [16] highlighted that vaccine hesitancy fueled by misinformation about side effects, decreased vaccine uptake during and post-COVID-19 pandemic, and a lack of awareness about the severe consequences of measles have all contributed to low vaccination rates, leaving communities vulnerable.

There is near-international consensus that the COVID-19 pandemic (2020 to 2022) directly affected all vaccination programs, including measles vaccination, leaving nearly 25 million children unvaccinated or under vaccinated worldwide. Moreover, measles-containing vaccine dose 1 (MCV1) coverage decreased from 86.0% in 2018 to 83.0% in 2022 [15–18]. Similarly, the results of our study found that most of the infected children were less than three years old (63, 68.5%), unvaccinated (78, 84.8%), and about 80.4% developed severe infection. The severity of measles infection was significantly associated with being unvaccinated (χ^2 = 9.719, P- value = 0.002). According to van Dam et al. [19], measles is less linked to complications and/or hospitalization among children who received two doses of measles vaccines compared to unvaccinated children. Furthermore, in the multivariate analysis, unvaccinated children were 6.300 times more likely to have severe infection (95% CI: 1.489 to 26.657, P-value = 0.012) compared to vaccinated children. Similarly, Hassan et al, conducted an earlier study [20] reported that unvaccinated Somali children were much younger, with a higher death rate and longer hospital stays compared to vaccinated children.

The speed of response and containment to measles outbreaks often evaluates the efficiency of national vaccination programs. Therefore, some countries have adopted mandatory vaccination legislation, and broad health education campaigns are necessary to address health literacy issues related to immunization [21].

In the present study, mothers with primary education or less were 4.013 times more likely to have severely infected, unvaccinated children compared to mothers with secondary education or higher (95% CI: 1.982 to 16.389, P-value = 0.035). According to Kibrab et al. [22], the likelihood of full vaccination is higher in children with educated mothers than in children with uneducated mothers. Findings of the systematic review and the meta-analysis conducted by Forshaw et al. [23] to investigate the global influence of mothers' education level on full vaccination for children, showed that the possibilities of full childhood vaccination were 2.3 times higher in children whose mothers received a secondary or higher education compared to children whose mothers did not have education.

Measles is often associated with upper respiratory tract infections, particularly pneumonia and otitis media [24]. In this study, pneumonia was the main determinant of measles severity,the most common complication among the severe cases in the bivariate analysis (P-value = 0.045). Turaiche et al. [24] noted that pneumonia is one of the most prominent risk factors related to measles, especially among older children compared to younger age groups. This may explain why pneumonia did not emerge as a predictor in the multivariate analysis, as most of the children in this study were under three years old.

Measles is a vaccine-preventable disease, but high population immunity is required to interrupt viral transmission. Since 2008, measles vaccine coverage has been fluctuating, reaching its lowest rates during the COVID-19 pandemic years (2019-2022). The number of new measles cases and countries experiencing large outbreaks escalated during 2021-2022, with only 50% of affected countries performing adequate measles surveillance [25]. Several studies have strongly predicted the possibility of measles outbreaks during and after the COVID-19 pandemic [13, 26, 27], but the response to these predictions was insufficient to protect the population, given that the risk of contracting COVID-19 is less severe. The opportunity was favorable at the local and international levels during 2023 to decrease the severity of the expected measles outbreak through a set of urgent and expected measures, including redoubling efforts to increase routine childhood immunization coverage, reducing the potential risks of importing cases from other outbreak-affected countries, and enhancing outbreak response capacity through public health, healthcare, and education sectors [28].

The strength of the study lies in its timing. It was conducted during the measles epidemic that swept Iraq in the first quarter of 2024, allowing for the in-depth examination of different covariates to control their impact on the relationship between the severity of infection and measles immunization. However, the small sample size collected from a single-center limits the possibility of generalizing the results to the entire population in Iraq. The study's design (cross-sectional) that excludes the causal relationship is considered another limitation to the study. Also, the information about childhood vaccination was obtained from mothers, which increases the possibility of recall bias.

Table 2. Results of bivariate analysis on the severity of measles infection (n = 92).

Variables	Groups	Severe 74 (80.4)	Mild 18 (19.6)	Total 92(100)	Chi-square	P-value
Age of child	< 1 years	39(52.7)	2(11.1)	41 (44.6)	29.946	0.0001
	1− < 3 years	18 (24.3)	4(22.2)	22 (23.9)		
	3− < 5 years	13 (17.6)	2 (11.1)	15 (16.3)		
	≥ 5 years	4 (5.4)	10 (55.6)	14 (15.2)		
Gender	Female	33 (44.6)	13 (72.2)	46 (50.0)	4.420	0.036
	Male	41 (55.4)	5 (27.8)	46(50.0)		
Measles vaccination	Unvaccinated	67 (90.5)	11 (61.1)	78 (84.8)	9.719	0.002
	Vaccinated	7 (9.5)	7 (38.9)	14 (15.2)		
IgM test	Negative	10 (13.5)	5 (27.8)	15 (16.3)	2.159	0.142
	Positive	64 (86.5)	13 (72.)	77 (83.7)		
Disease with measles	Pneumonia	65 (87.8)	0 (0.0)	65 (70.7)	3.874	0.045
	Others	9 (12.2)	18 (100)	27 (29.3)		
Age of mothers (years)	18–28	40 (54.1)	4 (22.2)	44 (47.8)	5.879	0.015
	> 28	34 (45.9)	14 (77.8)	48 (52.2)		
Mother education	Primary	31 (41.9)	4 (22.2)	35 (38.1)	2.956	0.228
	Secondary	29(39.2)	8(44.5)	37 (40.2)		
	Graduated	14 (18.9)	6 (33.3)	20 (21.7)		
Residency	Rural	46 (62.2)	11 (61.1)	57 (62.0)	2.123	0.247
	Urban	28 (37.8)	7 (38.9)	35 (38.0)		

Table 3. Factors associated with severe measles infection in multiple logistic regression (n = 92).

Variables	Groups	*B*	SE	Wald	P-value	OR	95% CI
Age of children	< 1 year	2.068	0.812	6.428	0.011	7.909	1.610–38.860
	≥ 1 year				Reference		
Vaccination coverage	Unvaccinated	1.841	0.736	6.255	0.012	6.300	1.489–26.657
	Vaccinated				Reference		
Education of mothers	Primary school	1.389	0.718	3.746	0.035	4.013	1.982–16.389
	Secondary and more				Reference		

CONCLUSION

The lack of vaccination in the majority of the 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. These results underscore the importance of strengthening routine measles vaccination programs, especially in high-risk areas. Therefore, there is an increasing need for a comprehensive and more strict study to address these restrictions. Furthermore, the concurrent qualitative study may help to understand the reasons for some mothers' inability to complete the vaccination program for their children. Implementing targeted interventions to improve vaccine acceptance and coverage, and enhancing maternal education and community-based health promotion activities may also help mitigate the impact of future measles outbreaks. Furthermore, continued surveillance and research are necessary to monitor the evolving epidemiology of measles and guide evidence-based public health strategies.

ETHICAL DECLARATIONS

Acknowledgments

None.

Ethics Approval and Consent to Participate

The study was conducted following the approval of the scientific and ethical committees in the College of Medicine, University of Diyala, Diyala, Iraq. The code number is 2024AJM861. Informed consent was obtained from the parents.

Consent for Publication

Not applicable (no individual personal data included).

Availability of Data and Material

Data generated during this study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that there is no conflict of interest.

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Authors' Contributions

All of the listed authors were significantly, directly, and intellectually contributed to the work. The authors read and approved the final version of the manuscript.

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