A Retrospective Study of Outbreak and Vaccination on Measles Inflammation

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Abstract

Background: Measles is a highly infectious viral disease as a significant global public health concern, particularly in low-income countries with inadequate healthcare facilities. This study determined the prevalence and risk factors of measles infection, vaccination rates, and surveillance effectiveness in Babylon and Karbala provinces of Iraq from 2020 to 2022. Method: Surveillance data on suspected and confirmed measles cases were collected and analyzed using descriptive statistics and multivariate logistic regression models. Results: Results showed that males, children aged 1-10 years, and residents of rural areas, particularly Ain Al-Tammr/Karbala, were more susceptible to measles. 93 confirmed measles cases were reported, with 13 in Babylon and 80 in Karbala. Non-vaccinated individuals had a significantly higher risk of infection. The study found 11 confirmed cases among vaccinated and unknown individuals, while 71 cases were among non-vaccinated individuals. Vaccine efficacy varied, indicating challenges in achieving effective community immunity. Poor vaccination coverage was attributed to administrative issues, inadequate resources, and vaccine hesitancy. Males were disproportionately affected compared to females. Conclusion: The study demonstrated the importance of strengthening vaccination programs, improving surveillance systems, and enhancing public awareness to combat measles outbreaks and reduce morbidity and mortality, especially among vulnerable populations. Improvements in vaccine coverage, proper vaccine handling, and prompt reporting of suspected cases are all necessary to eliminate measles from Iraq, with a special focus on the provinces of Babylon and Karbala.

Keywords: Measles, Vaccination, Public health, Iraq, Surveillance

Significance | Understanding risk factors, vaccination rates, and surveillance effectiveness is crucial for developing targeted strategies to prevent measles infections in Iraq.

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Introduction

The measles virus targets the respiratory system and is highly infectious (Jost et al., 2015). Highly contagious diseases are a significant contributor to sickness and mortality globally (Katz et al., 2010). Common symptoms of measles include fever, malaise, cough, cold, conjunctivitis, and skin rash (Shane et al., 2014). Typically, the rash appears on the head about fourteen days after encountering the virus and then spreads to the body and lower limbs (Kutty et al., 2013).

The measles virus belongs to the genus Morbillivirus and family Paramyxoviridae. Its genome comprises 15,894 nucleotides of non-segmented negative-sense RNA (Plattet et al., 2016). Measles primarily affects the respiratory system and is transmitted through respiratory droplets when an infected person coughs or sneezes.

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Humans are the primary natural host for measles, with no known occurrence in other animal species (Jost et al., 2015). There is speculation that measles infection may have either adverse or beneficial effects on atherosclerotic cardiovascular disease (CVD) (Jasem et al., 2012).

Measles is transmitted from person to person through direct contact with the nasal and throat secretions of infected individuals or through the air. Once infected, up to 90% of individuals are susceptible to contracting measles (CDC, 2013). The virus is primarily spread through coughing and sneezing, which release respiratory droplets containing the virus from infected individuals' lips or noses. Youngsters are the most commonly affected group.

The virus can remain active on contaminated surfaces or in the air for approximately two hours. Immunization is effective in preventing measles, and an infected individual can transmit the infection from four days before the rash appears to four days following the rash (Grelad et al., 2012).

Approximately 2.1 million individuals worldwide, including 1.4 million children under the age of five, passed away in 2002 from illnesses that may have been avoided with widespread vaccine use.As a consequence of these deaths, measles infections spread to almost 500,000 youngsters (WHO, 2005)..Measles infection is still a problem for public health, particularly in South Asia and Africa where the death rate is highest. The World Health Organization (WHO) reports that over 20 million people contract the measles annually, and that 95% of measles-related deaths occur in low-income nations with poor health infrastructure.In 2008, measles killed 164,000 people worldwide, most of them were children under the age of five. This translates to about 450 deaths every day and 18 deaths every hour(WHO, 2013).

The measles vaccination is a very efficacious live virus vaccine that significantly decreased the disease occurrence in USA. Nevertheless, it's a major factor contributing to the death of young children in numerous poor nations. Consequently, it can be regarded as one of the foremost causes of illness and death among children globally (Griffin et al, 2012).

Nevertheless, in individuals with malnutrition and weakened immune systems (such as immune-compromised patients), measles can lead to significant complications, such as otitis media, deafness, blindness, encephalitis, severe diarrhoea, pneumonia, and in rare cases, sub-acute sclerosing pan encephalitis (SSPE) and death (Mina et al, 2019).

The majority of measles-related fatalities, amounting to almost 95%, are concentrated in low-income nations that possess inadequate health infrastructures. Death resulting from acute measles virus infection, primarily affecting young children, is typically attributed to viral and bacterial secondary infections acquired during a period of immunological suppression caused by measles (Masrizal et al, 2018).

Measles virus (MeV) infection grants individuals with enduring protection. Moreover, the immunological response to measles is involved in the development of the disease, with the presence of humoral antibodies indicating immunity. Hence, cellular immunity is crucial in eradicating the virus and providing enduring defence [15-17]. Every child should receive two doses of the measles-containing vaccine (MCV) by the time they are 15 months old, according to the Iraqi standard immunization schedule. The first dose should be administered at 9 months of age, and the second dose should be administered at least one month later. When measles epidemics develop that disproportionately affect younger age groups, lowering the age at which the first dose of vaccine to six months is taken into consideration. The recommended MCV in Iraq is the measles, mumps, and rubella (MCV) vaccine (Jasem et al, 2012).

In a preceding investigation, a novel immune modulation mechanism was discovered involving the measles virus nucleoprotein. This mechanism fosters a regulatory T-cell response, and the study proposes that leveraging this property could be explored as a potential therapeutic approach for treating atherosclerosis (Akkaif et al, 2022; Akkaif et al, 2021). Mass immunity can be achieved through either natural infection or vaccination. Assuming that measles affects 95% of the human population, those who have successfully recovered from the disease develop adequate immunity that protects them against future reinfection. Only 5% of humans remain unprotected in this scenario, as they benefit from mass immunity (Bode et al, 2021; Feutz et al, 2022).

Achieving the herd immunity level necessary to stop measles outbreaks by reducing the population density of vulnerable people depends on adequate vaccination coverage.6 According to seroprevalence studies conducted in the United States and other industrialized nations, a population's herd immunity should vary from 90 to 95% in order to stop the measles from spreading.(Hutchins et al, 2001). In order to be reached and maintained in all districts or their administrative equivalents, as well as at the national level, the EMRO mandates that at least 95% coverage be obtained annually with both MCV1 and MCV2 (Akkaif et al, 2021). Improving measles monitoring, which combines laboratory and epidemiological data to provide the required sensitivity and specificity for identifying measles virus, is another important tactic for lowering measles mortality (Griffin et al, 2022). Effective district, provincial, and national surveillance systems are essential in Iraq because it is one of the nations targeted for elimination (Akkaif et al, 2021).

Between 2000 and 2018, the administration of Measles immunisation resulted in the preservation of around 23 million lives globally. Furthermore, there has been a significant 66% reduction in the occurrence of measles globally, accompanied by a substantial 73% decrease in the number of deaths caused by measles during the same time frame (Patel et al, 2020). Nevertheless, the World Health Organisation (WHO) documented a threefold surge in measles infections worldwide during the initial three months of 2019 in comparison to the corresponding time in 2018 (Gramigna et al, 2019).

The aim of this study is to identify the factors that increase the risk of measles and low vaccination rates, evaluate the effectiveness of monitoring measures, and analyze the rates of vaccine effectiveness and failure in the provinces of Babylon and Karbala in Iraq from 2020 to 2022. This study aims to estimate the prevalence of measles infection among children in Babylon Province, Iraq, in relation to their age and gender from 2020 to 2022, using descriptive statistics approaches to analyze the data.

Materials and Method

Sample:

All documented cases were individuals from Iraq. Fortunately, no deaths or severe complications, such as pneumonia and encephalitis, were reported in connection with measles. The suspected instances included individuals ranging in age from less than 1 year old to 37 years old. Likewise, the confirmed cases encompassed individuals aged from under 1 year to 37 years.

The Public Health Department (PHD) of the Directorate General of Health (DGoH) of Babylon and Karbala provinces has received all reported cases of measles from primary health centers, private clinics, and hospitals. The Ministry of Health (MOH) utilizes standardized infectious notification forms to transmit reports of cases to the Infectious Disease Control Unit (CDCU) under the regional Public Health Department (PHD). At times, the attending physician will directly inform the health inspectors at the CDCU about probable cases of measles. The CDCU undertakes case-based epidemiological surveillance to study these cases.

This study utilized surveillance data on measles, which was acquired from the provinces of Babylon and Karbala between January 1, 2020, and December 31, 2022. The variables examined in the data include age, place of residence, gender, vaccination status, and investigation date for both suspected and confirmed cases of measles. Vaccination status was ascertained by examining the patient's immunization card or through verbal report. The surveillance data in Karbala were compiled in an Excel spreadsheet, while in Babylon they were collected as records.

The WHO's standard case definition guidelines were used to confirm or "discard" the reported measles cases. Any person in whom a clinician suspected infection with measles, or any person exhibiting fever, maculopapular rash, cough, coryza, or conjunctivitis, and occurring between January 1, 2020, and December 31, 2022, anywhere in Iraq, was classified as a suspected or clinically diagnosed case. A case is considered laboratory confirmed if it meets the clinical case definition and has measles-specific IgM antibodies present. A case that matched the clinical case criteria and was epidemiologically connected to a laboratory-confirmed case was referred to as an epidemiological case. Epidemiological linkage occurs when a case of measles is directly linked to another laboratory-confirmed case with rash onset happening 7–18 days prior to the current case. If a suspected case didn't fit the definitions in the laboratory or clinical settings, it was dropped.

Patient age, residence province, household location within or outside the province capital city, gender, immunization status, date of rash onset, date of specimen collection, date of specimen sent to the Central Laboratory in Babylon and Karbala, date of investigation, date of notification to the DgoH, date the sample was received by the Central Laboratory in Babylon and Karbala, and date of results reporting were among the surveillance data examined in this study. A verbal report from a relative or patient, as well as a study of the patient's immunization card, were used to ascertain the cases' vaccination status.

Statistical Analysis:

All surveillance data were imported into Microsoft Excel 2010 (Original Microsoft Office Software, Louisville, KY, USA) and subjected to PASW® Statistics GradPack 18 analysis using SPSS 18 for Windows and Mac. To determine the adjusted odds ratios (OR) and 95% confidence intervals (CI) for the outcomes of receiving at least one dose of MCV and receiving a confirmed diagnosis of measles separately, for each of the variables examined in the study, a series of multivariate binary logistic regression models was created. The significance threshold for the two-sided tests was set at 0.05.

Results

Between January 1, 2020, and December 31, 2022, a combined total of 286 suspected cases of measles were reported in the provinces of Babylon and Karbala in Iraq. Of these instances, 127 were in Babylon and 159 were in Karbala. Out of these, a total of 93 cases (13 and 80) were officially diagnosed as confirmed measles through laboratory testing, as depicted in Figure 1.

Table 1a & b display the trajectory of documented measles cases across the span of three years (2020—2022). The annual incidence of confirmed measles cases ranged from 2 to 6, with the largest number of cases (4) occurring in April 2022. The overall low infection rate can be attributed to high vaccination coverage (Table 1a). In Table 1b, the incidence of confirmed measles cases varied from 0 to 2 per year, except in 2020 when the number of cases ranged from 1 to 78, indicating an epidemic. In March 2020, the Ain Al-Tammr region in Karbala saw a measles outbreak, resulting in 37 confirmed cases, marking the highest infection ratio.

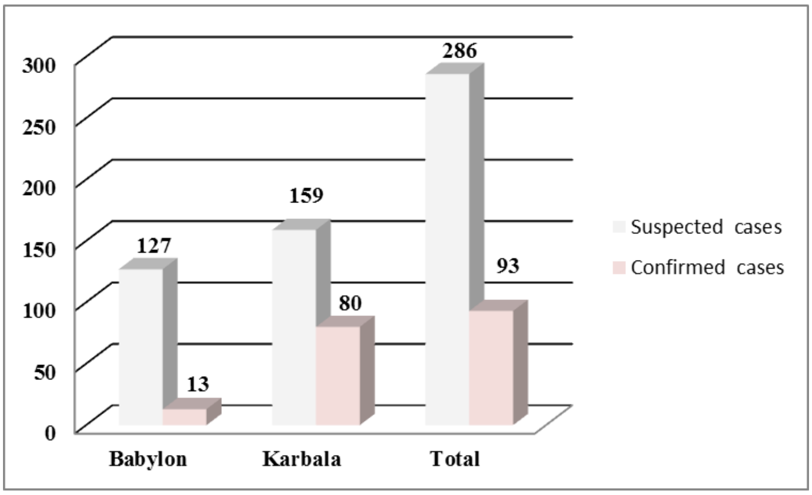

Figure 1. The number of suspected and confirmed cases in Babylon and Karbala provinces from 2020-2022.

Table 1a. Suspected and confirmed measles cases according to months, Babylon province, Iraq, during 2020-2022.

No.	Months	2020		2021		2022	
		S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
1	Jan	9	0	3	1	1	1
2	Feb	22	3	0	0	0	0
3	Mar	24	2	0	0	2	0
4	Apr	22	0	1	0	5	4
5	May	6	0	2	0	5	0
6	Jun	0	0	4	0	4	0
7	Jul	0	0	0	0	0	0
8	Aug	0	0	1	0	0	0
9	Sept	1	0	0	0	1	0
10	Oct	0	0	3	0	1	1
11	Nov	1	0	2	1	3	0
12	Dec	3	0	1	0	0	0
Totally		88	5	17	2	22	6

* Suspected cases, ** Confirmed cases

Table 1b. Suspected and confirmed measles cases according to months, Karbala province, Iraq, during 2020-2022

No.	Months	2020		2021		2022	
		S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
1	Jan	17	10	1	1	1	0
2	Feb	46	28	0	0	0	0
3	Mar	48	37	2	0	1	0
4	Apr	18	2	0	0	1	0
5	May	2	1	0	0	1	0
6	Jun	0	0	0	0	2	0
7	Jul	0	0	0	0	2	0
8	Aug	0	0	0	0	1	0
9	Sept	0	0	0	0	0	0
10	Oct	0	0	4	0	2	0
11	Nov	1	0	1	1	4	0
12	Dec	0	0	0	0	4	0
Totally		132	78	8	2	19	0

* Suspected cases, ** Confirmed cases

Table 2a. Suspected and confirmed measles cases according to gender, Babylon province, Iraq, during 2020-2022.

Gender	2020		2021		2022	
	S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
Male	45	2	10	2	8	3
Female	43	3	7	0	14	3

* Suspected cases, ** Confirmed cases

Table 2b. Suspected and confirmed measles cases according to gender, Karbala province, Iraq, during 2020-2022.

Gender	2020		2021		2022	
	S.c.*	C.c.**	S.c.*	C.c.**	S.c.*	C.c.**
Male	67	43	4	2	7	0
Female	65	35	4	0	12	0

* Suspected cases, ** Confirmed cases

Table 3a. Suspected and confirmed measles cases according to age, Babylon province/ Iraq, during 2020-2022.

Age group (years)		1>-10			11-20			21-30			31- < 40		
		F	M	T	F	M	T	F	M	T	F	M	T
2020	S.c.*	31	31	62	3	6	9	6	4	10	3	4	7
	C.c.**	1	2	3	0	0	0	1	0	1	1	0	1
2021	S.c.*	6	8	14	0	1	1	1	0	1	0	1	1
	C.c.**	0	2	2	0	0	0	0	0	0	0	0	0
2022	S.c.*	11	7	18	2	1	3	1	0	1	0	0	0
	C.c.**	2	2	4	1	1	2	0	0	0	0	0	0

* Suspected cases, ** Confirmed cases, M: Male, F: Female, T: Total

Table 3b. Suspected and confirmed measles cases according to age, Karbala province Iraq, during 2020-2022.

Age group (years)		1>-10			11-20			21-30			31- < 40		
		F	M	T	F	M	T	F	M	T	F	M	T
2020	S.c.*	45	72	117	2	4	6	3	5	8	0	1	1
	C.c.**	26	45	71	1	2	3	1	2	3	0	1	1
2021	S.c.*	1	3	4	3	1	4	0	0	0	0	0	0
	C.c.**	0	2	2	0	0	0	0	0	0	0	0	0
2022	S.c.*	11	7	18	1	0	1	0	0	0	0	0	0
	C.c.**	0	0	0	0	0	0	0	0	0	0	0	0

* Suspected cases, ** Confirmed cases, M: Male, F: Female, T: Total.

Table 4a. Suspected and confirmed measles cases according to the geographic district, Babylon province Iraq, during 2020-2022.

Geographic district	2020		2021		2022	
	S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
Rural	14	0	4	0	6	4
Urban	74	5	13	2	16	2

* Suspected cases, ** Confirmed cases

Table 4b. Suspected and confirmed measles cases according to the geographic district, Karbala province Iraq, during 2020-2022.

Geographic district	2020		2021		2022	
	S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
Rural	84	51	1	0	8	0
Urban	48	27	7	2	11	0

* Suspected cases, ** Confirmed cases

Table 5a. Suspected and confirmed measles cases according to vaccination status, Babylon province Iraq, during 2020-2022.

Vaccination status	2020		2021		2022	
	S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
Vaccinated	3	1	3	0	0	0
Non-vaccinated	11	2	1	1	0	0
Unknown	74	2	13	1	22	6

* Suspected cases, ** Confirmed cases

Table 5b. Suspected and confirmed measles cases according to vaccination status, Karbala province Iraq, during 2020-2022.

Vaccination status	2020		2021		2022	
	S.C.*	C.C.**	S.C.*	C.C.**	S.C.*	C.C.**
Vaccinated	3		1	1	1	0
Non-vaccinated	02	7	7	1	18	0
Unknown	7		0	0	0	0

* Suspected cases, ** Confirmed cases

Table 2a presents the number of confirmed cases, suspected cases, and infection ratio categorized by gender. The greatest infection ratio, which was 37.5%, was observed among males in 2022. Table 2b displays the number of confirmed cases, suspected cases, and infection ratio categorized by gender. It is seen that the highest infection ratio in 2020 was among males, reaching 64.1%. These results show a significant increase in infection among male individuals compared to female individuals.

Table 3a displays the number of confirmed cases, suspected cases, and infection ratio categorized by age group. The age group with the highest number of confirmed cases was 1-10 years, with a total of 48 cases. Individuals aged between 1-10 are at a higher risk of being infected by measles than adults.

Table 4a & b display the number of suspected and confirmed cases of measles categorized by geographic district. Rural areas had a higher number of instances compared to urban areas, with 51 cases in rural areas and 5 cases in urban areas. The residency report displays the pattern of confirmed measles cases and suspected cases among different geographic districts, namely Rural and Urban. Urban districts had the highest number of confirmed cases, with a total of five. The rural areas had the highest number of confirmed cases, with 51 cases reported in the Ain Al-Tammr region/Karbala due to a measles outbreak, as shown in Table 4b.

The results showed the pattern of confirmed measles cases and suspected cases based on vaccination status. The non-vaccinated group had the largest number of confirmed cases, with a total of 2 cases. Table 5b displays the pattern of confirmed measles cases and suspected instances based on vaccination status. The non-vaccinated group had the highest number of confirmed cases, totaling 67.

The WHO's suggested cut-off threshold of 80% was used to compare a set of performance metrics with the measles surveillance system in Iraq (WHO, 2010). The percentage of suspected cases with adequate specimens collected within 28 days of rash onset, the percentage of suspected case serum/dried blood specimens that arrived at the Central Laboratory within 7 days of collection, the percentage of results reported within 7 days of specimen receipt, and the percentage of suspected cases notified ≤48 h after rash onset were among the information provided. However, there was no information available regarding the proportion of weekly reports that the PHD received.

Measuring the percentage of cases among the population that received vaccinations, the vaccine failure rate was determined (Al-Ghamdi et al., 2011). The formula PCV = PPV − (PCV × VE)/1 − (PCV × VE) was used to calculate vaccine efficacy (VE), where PCV stands for the proportion of cases among vaccinated individuals, PPV for the proportion of vaccinated individuals, and VE for vaccine effectiveness.

The overall results show that individuals aged 1 to 10 exhibited the highest level of susceptibility. The prevalence of measles in rural areas was greater than in urban areas, particularly in Ain Al-Tammr/Karbala. Males exhibited a higher elevation compared to females. The findings revealed that there were 11 confirmed cases in vaccinated and unknown persons, compared to 71 cases among non-vaccinated individuals.

Discussion

Despite the existence of a reliable vaccination, measles is an acute infectious viral disease that affects children worldwide and can result in pediatric morbidity and mortality. In Iraq, measles remains a major cause of infectious morbidity. Cases of measles typically peak in the winter and spring and then decline toward the end of summer (Figure: 3-1). In temperate climates, measles outbreaks typically follow this seasonal pattern. These outbreaks are probably caused by children congregating at school, people congregating at homes and places of business during the winter, and conducive environmental conditions that facilitate the spread of viruses (Nelson et al, 2007; Al-Arabi et al, 2011).

Table (1a & b) presents the incidence of infections categorized by the months of the year. The month with the largest number of confirmed cases was March, with a total of 37 cases. Conversely, the months from May to December had the lowest number of confirmed cases, with just 1 case reported.

Furthermore, it was found that both genders had been affected by measles virus infection, but males(n:43) were seemed to be more susceptible to measles infection than their female (n: 35) counterparts and the association between the measles virus infection and the gender of children wassignificant statistically at p-value <0.005. Previous study in Malawi, 2010, were stated that equallydistributed between male and female patients without any preference regarding gender (Nelson et al, 2020). The findings of Atabani *et al.* (2000) revealed that the immune response to measles vaccines, specifically the MeV-specific antibody-dependent cellular cytotoxicity (ADCC) and antibody response, differed among Gambian children aged 3-65 years who were immunized with either Edmonston-Zagreb medium-titer (EZ) or Schwarz standard vaccines during infancy. These variations in immune response were found to be responsible for the higher mortality rate among females.

The observation indicating that children aged 1 to 10 years old accounted for the majority of measles cases reported (Table: 3a,b) is anticipated in communities where vaccine coverage is rather low (Nelson et al, 2007). This is probable because there is a notably elevated quantity of suspected cases reported for the given age range of 1-10 years. The age range of the infected individuals varied from 1 to over 40 years. The majority of confirmed cases, totaling 45, were found in the age group between 1 and 10 years. The illustration of this can be seen in Table (3a,b).

The data further revealed that those residing outside the provincial capital city had a higher likelihood of contracting measles. The finding presented here contradicts the commonly accepted notion that measles rates are greater in urban areas (Jasem et al, 2012). This finding aligns with our observation of vaccination occurring outside the main city of the province, as seen in Table (3-4a & b).

The vaccination status was assessed by examining the measles vaccination status, and the findings are presented in Table (5a & b). The results indicated that there were 11 confirmed cases in both the vaccinated and unknown groups, whereas there were 71 cases in the non-vaccinated group.

Insufficient administrative practices, inadequate management of the cold chain, improper handling of vaccinations, and maybe additional factors connected to the host and vaccine all contribute to an elevated rate of vaccine failure. However, the proportion of vaccinated individuals who acquired effective immunity was referred to as vaccine efficacy, which exhibited variation (Fine et al, 1994; Rota et al, 2006).

The primary reason for the insufficient level of community immunity is the failure to vaccinate persons who are at a higher risk. In addition, inadequate vaccination rates can stem from a lack of political determination, insufficient resources, challenges in reaching vulnerable people (such as travelers, inhabitants of unstable regions, and internally displaced families), and apprehension regarding potential negative consequences (Nelson et al, 2007).

Furthermore, a decline in vaccination rates among Iraqi children has been shown (Kadim et al, 2022). In the Province of Babylon, specifically, only 74 out of 277 patients received immunization, and they exhibited a higher rate of recovery compared to the 203 individuals who were not vaccinated (Mohammed et al, 2022). In a study conducted by Jawad *et al.* (2021) in Al Najaf Al Ashraf province, it was discovered that the coverage of measles vaccine was low among the 418 reported cases. This low coverage increases the risk of outbreaks. Similarly, in the governorate of Diyala, the evaluation of the vaccination program was found to be inadequate, specifically in terms of vaccine and cold chain management (Abd et al, 2021).

According to a study conducted by Taniguchi *et al.* (2000) it was shown that caregivers face challenges in ensuring measles vaccination for children, particularly when they reside in volatile regions, have limited access to others, or are experiencing financial difficulties.

Between 2000 and 2030, the measles vaccination rate is projected to decline or remain unchanged in all Iraqi governorates except ThiQur and Anbar. These two governorates have a substantial decrease in coverage in 2018 and 2030, as compared to 2000. Furthermore, by 2030, they will have the lowest coverage among all governorates (Taniguchi et al, 2000).

The number of infected individuals—of which men composed the bulk of the sample—was the basis for this study's conclusions. The findings of a lab study address various measles-specific innate and cell-mediated mechanisms. According to their findings, there was a significant difference in gender between males and females with infection ($p<0.001$, $p<0.002$, $p<0.04$, respectively) (Benjamin et al, 2012).

This report outlines several limitations and provides information on tracking cases of measles in the past.The method of obtaining the vaccination case from the instances was not disclosed, as we relied on secondary surveillance data.Consequently, the case of the vaccination has not been established.The number of cases and classification used in this analysis were based on available surveillance data that may not be as representative due to the lack of sensitivity in measles surveillance.No risk factors resulting in childhood vaccination were found in the Babylon Governorate since risk determinants were absent from the data.Vaccine cold chain quality could not be achieved because secondary monitoring data was used.

Conclusion

Human measles infections persist as a significant concern, particularly among young individuals and those with limited healthcare access. Our study highlights a higher reporting rate of measles among male infants under one year, escalating over time. Strengthening routine immunization programs, ensuring comprehensive vaccination monitoring, and improving data quality are imperative. Infection prevalence is notably higher among unvaccinated males aged 1-10 years in rural regions like Karbala (Ain Al-Tamur), warranting focused eradication efforts. Broadening vaccine distribution, enhancing public awareness, and prompt case notification are essential strategies. Additionally, all susceptible individuals, including those with HIV/AIDS, should receive measles vaccination, considering programmatic variables for optimal vaccination age.

Author contribution

H.S.A.O., A.J.M. conceptualized, performed analysis, L.A.I.K.A.K., D.A.A., Y.A.K.A.K analyzed data, and prepared the manuscript.

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Competing financial interests

The authors have no conflict of interest.

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