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Measles vaccination coverage and associated factors among children aged 6 to 60 months presenting with measles in major public hospitals in war torn regions of Sana a city Yemen a cross sectional study

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Abstract

Background: Measles remains a critical public health crisis in conflict-affected regions like Yemen, where severely compromised healthcare infrastructure underpins declining immunization rates and recurrent outbreaks. Consequently, this study aimed to evaluate measles-containing vaccine (MCV) coverage and delineate the socioeconomic and clinical determinants of unvaccinated status among children aged 6–60 months presenting with measles in Sana'a City.

Methods: To achieve this objective, a facility-based cross-sectional survey was executed between March 1 and July 28, 2024, across seven prominent public hospitals. Structured questionnaires were administered to caregivers of 350 clinically diagnosed pediatric patients. Ultimately, data spanning demographics, vaccination histories, and barriers to immunization were evaluated using descriptive statistics and multivariable logistic regression.

Results: Building upon this methodology, the analysis revealed alarming coverage deficits: 75.43% of the cohort was completely unvaccinated, while merely 17.14% and 7.43% had received MCV1 and MCV2, respectively. Furthermore, multivariable regression identified significant independent risk factors for non-vaccination, including caregiver fear of side effects (AOR=8.53), paternal refusal due to rumors (AOR=8.49), geographical distance to hospitals (AOR=6.33), maternal illiteracy (AOR=4.79), and low vaccine valuation (AOR=6.26). Clinical indicators such as child lethargy, diarrhea history, and natural feeding practices also significantly correlated with unvaccinated status.

Conclusion: Taken together, these findings demonstrate that routine MCV coverage among infected children falls dangerously short of regional disease control thresholds. Therefore, mitigating future resurgences demands immediate, targeted health education and localized immunization campaigns explicitly structured to dismantle maternal literacy gaps, community misinformation, vaccine apprehension, and systemic logistical barriers.

1 Introduction

1.1 Study background

Measles is a highly contagious viral disease and remains a leading cause of vaccine-preventable child mortality globally, despite the availability of a safe and effective vaccine [1]. Before widespread vaccination, measles caused an estimated 2.6 million deaths each year [2]. While global efforts have significantly reduced measles incidence and mortality, outbreaks continue to occur, particularly in regions with low immunization coverage [3].

Despite the number of measles cases reduced in the East Mediterranean Region (EMR) in the latest years, it’s still a problem in the region. The number of reported suspected measles were 34,835 in 2015 and 28,225 in 2016 while the laboratory confirmed measles were 8853 in 2015 and 5201 cases in 2016.

In 2016, measles incidence per 1000,000 populations was higher in Sudan (42.94), followed by Oman (34.66) and United Arab Emirates (23.92) [4].

The complications of measles can be severe and include pneumonia, diarrhea, blindness, encephalitis, and long-term immune suppression [5, 6]. Yemen follows the standard WHO-recommended immunization schedule for children. The vaccination protocol begins at birth with administration of the BCG vaccine (against tuberculosis) and the first dose of oral polio vaccine (OPV). At six weeks of age, infants receive their first doses of four key vaccines: OPV, pentavalent vaccine (protecting against diphtheria, pertussis, tetanus, hepatitis B, and Haemophilus influenzae type b), pneumococcal conjugate vaccine (PCV), and rotavirus vaccine.

The 10-week visit includes second doses of OPV, pentavalent, PCV, and rotavirus vaccines. By 14 weeks, children complete their primary series with third doses of OPV and pentavalent vaccine, while also receiving their first dose of inactivated polio vaccine (IPV) to complement the OPV regimen. At nine months, the schedule includes measles-rubella (MR) vaccination along with an additional OPV dose. The final routine immunization at 18 months provides booster doses of both OPV and MR vaccine to ensure lasting protection.

Yemen has been grappling with a protracted conflict and humanitarian crisis, leading to the collapse of its health system and a severe decline in routine immunization coverage [7].

According to international reports, Yemen is ranked first among the countries with the largest measles outbreaks in 2023 [8]. There were 22,828 confirmed measles cases recorded in Yemen from 2018–2019, with a proportion of young children less than five years old (65%) and unvaccinated children (76%) [9]. Moreover, the incidence rate of measles burden per 1,000,000 individuals has increased from 42.4 (1,162 cases) in 2019 to 142.3 (5,341 cases) in 2021 and subsequently rapidly increased to 710.0 (23,924 cases) in 2022 [10]. In addition, more than 50,795 suspected measles cases and 568 deaths were reported in 2023 [11]. In Yemen, measles, polio, and diphtheria-tetanus-pertussis (DTP) immunization rates stand at just 41%, 46%, and 55%, respectively—far below the thresholds needed to ensure herd immunity and protect children's health. A combination of limited healthcare access, vaccine hesitancy, and conflict has allowed once-controlled diseases to resurge [12].

While national estimates from the WHO suggest measles immunization coverage in Yemen ranged from 37% in 2015 to 45% in 2023, these figures are national averages and coverage in Sana'a City is believed to be even lower [13].

To date, no study has comprehensively assessed measles vaccination coverage and its associated factors among children aged 6–60 months presenting with measles in Yemen. These findings highlight a significant public health challenge, as Yemen struggles with measles control. The World Health Organization (WHO) recommends maintaining 90–95% coverage with two doses of measles-containing vaccine (MCV) to establish herd immunity and prevent outbreaks. [14].

Despite the ongoing threat, there are limited recent data from Sana'a city, the capital, specifically examining the measles vaccine coverage status of children who contract measles and the factors contributing to their lack of protection in such a high-risk, facility-based population. Understanding these factors is crucial for developing targeted interventions to improve vaccine uptake and control measles in this challenging, urban, conflict-affected setting. Therefore, this study aimed to assess measles-containing vaccine coverage /utilization status and identify associated factors among children aged 6–60 months presenting with measles at a major public hospitals in Sana’a city, Yemen.

1.2 Objectives of the study

The overarching aim of this study was to assess measles-containing vaccine (MCV) coverage/utilization status and identify the independent socio-demographic, clinical, and behavioral factors associated with non-vaccination among children aged 6–60 months presenting with active measles infections in major public hospitals within the conflict-affected environment of Sana'a City, Yemen.

Specifically, the objectives of this study were to:

1. Describe the baseline measles immunization rates (unvaccinated, partially vaccinated with MCV1, and fully vaccinated with MCV2) among pediatric patients presenting with clinical measles across major urban referral hospitals.
2. Identify the specific, modifiable socio-demographic, maternal, logistical, and behavioral barriers (including maternal literacy, distance to care, vaccine rumors, and fear of adverse side effects) that statistically dictate the lack of vaccine utilization in this high-risk urban population.

2 Methodology

2.1 Study area and population

Sana'a City, the capital of Yemen, serves as the study's setting. It is a major urban metropolis with an estimated population of 3,527,430 as of 2025, expanding at an annual growth rate of 3.51% [15]. The protracted conflict in Yemen has severely compromised local healthcare service delivery, physical infrastructure, and therapeutic access within urban hubs.

This study was conducted across seven major public referral hospitals that manage a substantial proportion of the capital’s pediatric population: Al-Thawra Hospital, Al-Gomhouri Hospital, Al-Kuwait Hospital, Republican Police Hospital, General Police Hospital, Al-Sabeen Hospital, and 48 Hospital. The target population comprised children aged 6 to 60 months who presented with active, clinically diagnosed measles infections in the pediatric inpatient and outpatient departments of these participating facilities during the study period.

2.2 Study design and sample size

This study utilized a facility-based cross-sectional descriptive design to evaluate measles-containing vaccine (MCV) coverage and identify underlying risk factors for non-vaccination. Data collection occurred over a 5-month period between March 1 and July 28, 2024, capturing immunization histories and caregiver behaviors at a single point in time.

The minimum required sample size was determined using Cochran's sample size formula for proportions:

$$Sample\ size\ (n) = \frac{Z^2 * P * (q)}{d^2}$$

$$n = \frac{(1.96)^2 * 0.50 * (1 - 0.50)}{0.05^2} = 384$$

where:

- *Z* = Z score for confidence level (e.g., **1.96 for 95% confidence**)
- *p* = Estimated proportion (p = 0.5 for maximum variability)
- *q* = 1 – *p*
- *d* = Margin of error (e.g., **0.05 for ± 5%**)
- The confidence level used is 95%.

Therefore, the calculated sample size was 384 participants, but the achieved sample size was 350 participants. Due to localized data collection constraints within the conflict environment, a final sample size of 350 eligible children and their respective caregivers was successfully achieved and enrolled.

Participants were selected via systematic random sampling from medical registries across the pediatric outpatient and inpatient clinics. The final sample was proportionally allocated among the seven public hospitals based on their documented average pediatric patient loads for measles-like illnesses. Inclusion criteria required children to be aged 6–60 months, clinically diagnosed with measles by a healthcare professional, and accompanied by a primary caregiver who provided formal consent. Children presenting without clear clinical signs, those lacking official birth/age records, or those whose primary caregivers were unavailable were excluded.

2.3 Data collection instruments and scoring

Data were gathered using a pretested, structured questionnaire administered via face-to-face interviews by twelve trained medical students under close supervisory monitoring. The instrument was adapted from published epidemiological literature and contextualized to reflect Yemen's localized humanitarian conditions. It was translated into Arabic, back-translated to verify structural accuracy, and pretested on a 10% pilot sample outside the main study cohort.

The data collection tool captured variables across five primary domains:

1. **Socio-demographics:** Child indicators (age, sex, birth order) and caregiver/household indicators (age, urban/rural residence, education level, occupation, family size, housing volume, and monthly income).
2. **Clinical presentation & complications:** Active clinical signs including convulsions, lethargy, breathlessness, otitis media, diarrhea, and secondary pneumonia.
3. **Epidemiological exposure:** Known contact with suspected cases or active outbreaks within the immediate residential zone.
4. **Nutritional status:** Breastfeeding history and nutritional indicators verified via Mid-Upper Arm Circumference (MUAC) anthropometric measurements.
5. **Behavioral barriers:** Documented reasons for non-vaccination, including fear of side effects, religious resistance, or community vaccine rumors.

The primary dependent outcome variable was classified as *Vaccinated* (receipt of at least one documented dose of MCV) vs. *Unvaccinated* (zero doses received). For sub-analyses, vaccination status was scored as follows:

- **Measles Unvaccinated**: 0 doses of MCV by the time of the survey.
- **Measles Partially Vaccinated (MCV1 only)**: Receipt of the first dose of MCV only.
- **Measles Fully Vaccinated (MCV1 + MCV2)**: Completion of both routine doses of MCV.

Immunization status was verified directly via physical vaccination cards when available, or validated through rigorous caregiver memory recall. Suspected measles was defined clinically based on the presence of a fever, generalized maculopapular rash, and at least one classic sign (cough, coryza, or conjunctivitis). Due to severe laboratory capacity constraints inside the conflict zone, cases were classified based on bedside clinical confirmation by attending senior pediatricians.

2.4 Statistical analysis

Completed questionnaires were visually audited for accuracy each day prior to digital transcription. Data were entered, cleaned, and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26 software. Missing values were addressed using internal software imputation methods.

Descriptive statistics—including frequencies, percentages, medians, ranges, and means with standard deviations—were computed to summarize socio-demographic indicators, clinical profiles, and coverage metrics. Binary logistic regression modeling was utilized to evaluate the individual relationship between each independent variable and the primary vaccination outcome. Covariates demonstrating a p-value < 0.25 on bivariate screening were selected for inclusion in the final multivariable logistic regression model. A backward elimination stepwise approach was executed to isolate independent risk factors.

Associations in the final model were considered statistically significant at a threshold of p-value < 0.05, and results were reported using Adjusted Odds Ratios (AOR) accompanied by 95% Confidence Intervals (CI).

2.5 Ethical Approval and Accordance

This study was conducted in accordance with the Declaration of Helsinki. The research protocol, including all procedures involving human subjects, was reviewed and approved by the Institutional Review Board (IRB) of the Faculty of Medicine, 21 September University for Medical and Applied Sciences, Sana'a, Yemen (Approval Number: EBSHREC 05/09). All procedures were performed in compliance with relevant institutional and national ethical guidelines for research involving human data prior to the initiation of the study.

3 Results

3.1 Sociodemographic and socioeconomic characteristics of the participants

A total of 350 child–caregiver pairs completed the study across the seven participating urban referral hospitals. The baseline sociodemographic characteristics of the enrolled children and their primary caregivers are detailed in Table 1.

The median age of the children presenting with active measles was 24.0 months (range = 6–60 months). The most prevalent age stratum was 13–24 months, accounting for 41.1% (144/350) of the cohort. Male children predominated, constituting 58.9% (206/350) of the study sample. In terms of residence, more than two-thirds (68.6%, 240/350) of the participants were situated in urban areas. The vast majority of children (92.0%, 322/350) had a birth order ranking between 1 and 5.

Analysis of parental educational attainment revealed severe literacy gaps. Approximately 23.4% of the mothers and 10.6% of the fathers lacked any formal education. Conversely, university-level education was held by 22.6% of fathers but only 7.4% of mothers. Household socioeconomics reflected profound financial deprivation. The median family size was 6.0 members (range = 1–38 members). The mean monthly household income was 67,977 ± 37,201.68 Yemeni Rials (YR), with 48.3% (169/350) of households earning less than 50,000 YR per month.

Table 1
Baseline sociodemographic characteristics of children and caregivers (N = 350)

Characteristics	Frequency (n)	Percentage (%)
Age of the child (months)		
6–12	84	24
13–24	144	41.1
25–36	62	17.7
> 36	60	17.1
Sex of the child		
Male	206	58.9
Female	144	41.1
Residential status		
Urban	240	68.6
Rural	110	31.4
Birth order		
1–5	322	92
> 5	28	8
Maternal educational level		
Illiterate / No formal education	82	23.4
Primary education	128	36.6
Secondary education	114	32.6
Tertiary / University	26	7.4
Paternal educational level		
Illiterate / No formal education	37	10.6
Primary education	115	32.9
Secondary education	119	34
Tertiary / University	79	22.6
Monthly family income *(YR)		
*(YR)-Yemeni Rial; 1 $ USD = 25 YR		

Characteristics	Frequency (n)	Percentage (%)
Age of the child (months)		
< 50,000 YR	169	48.3
≥ 50,000 YR	181	51.7
*(YR)-Yemeni Rial; 1 $ USD = 25 YR		

3.2 Measles Containing Vaccine (MCV) coverage status

The utilization of routine measles vaccines among children presenting with active disease was critically suppressed. Out of the 350 children clinically diagnosed with measles, the vast majority—**75.43% (264/350)**—were completely unvaccinated (zero-dose status) against the virus.

Partial vaccination coverage was exceptionally low; only 17.14% (60/350) of children had received the first dose of the measles-containing vaccine (MCV1). Furthermore, a mere 7.43% (26/350) had completed the full two-dose routine immunization schedule (MCV1 + MCV2) required for adequate cellular immunity (Fig. 1).

3.3 Behavioral and structural reasons for non-vaccination

Caregivers of the unvaccinated cohort (n = 264) cited multiple overlapping behavioral barriers and structural impediments to service delivery. The leading behavioral obstacle was parental vaccine hesitancy driven by fear of immediate adverse side effects (such as post-vaccination fever or localized pain), reported by 42.8% (113/264) of responsive caregivers. Misinformation was highly pervasive: 28.4% (75/264) of fathers explicitly refused to permit vaccination due to compliance with community rumors regarding vaccine safety and contamination.

Logistical and structural accessibility constraints were equally prominent under conflict conditions. Geographic distance and lack of operational transport to municipal health facilities accounted for 31.1% (82/264) of non-vaccination instances. Additionally, 19.3% (51/264) of caregivers expressed a localized perception that the vaccine was unnecessary or lacked functional clinical importance, while persistent stockouts and ongoing physical facility closures due to active conflict directly barred access for 14.8% (39/264) of the families (Fig. 2).

3.4 Bivariate and multivariable factors associated with unvaccinated status

In the bivariate analysis, several factors were initially associated with measles vaccination status. For example, children of mothers with no education were more likely to be unvaccinated than were children of mothers with no formal education (COR = 3.34, 95% CI: 1.09–10.24, p = 0.035).

Table 2
Association between sociodemographic characteristics of children with measles and their caregivers with measles vaccination coverage in Sana'a City, Yemen, 2024 (N = 350)

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
Age group (months)					
≤ 12	15 (34.9)	28 (65.1)	1.22	0.51–2.93	0.656
13–24	31 (21.5)	113 (78.5)	1.89	0.92–3.87	0.081
25–36	14 (19.40	58 (80.6)	2.08	0.92–4.71	0.800
37–48	11 (22.9)	37 (77.1)	1.64	0.68–3.90	0.269
49–60	15 (34.9)	28 (65.1)	1.00		
Gender					
Male	53 (25.7)	153 (74.3)	0.99	0.61–1.59	0.973
Female	33 (22.9)	111 (77.1)	1.00		
Residence					
Urban	63 (26.3)	177 (73.8)	0.8	0.48–1.33	0.383
Rural	23 (20.9)	87 (79.1)	1.00		
Birth order					
1–4	73 (25.3)	216 (74.7)	2.52	0.16–40.84	0.514
5–8	12 (20.3)	47 (79.7)	2.47	0.15–41.80	0.531
> 8	1 (50.0)	1 (50.0)	1.00		
Father education level					
Formal education	68 (24.8)	206 (75.2)	0.78	0.34–1.78	0.558
None formal education	8 (20.5)	31 (79.5)	1.00		

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant, YR-Yemeni rial, 1 USD = 25,000 YR.

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
Age group (months)					
No education	10 (27.0)	27 (73.0)	0.70	0.24–2.02	0.505
Mother education level					
Formal education	70 (28.7)	174 (71.3)	1.02	0.41–2.58	0.961
None formal education	7 (29.2)	17 (70.8)	1.00		
No education	9 (11.0)	73 (89.0)	3.34	1.09–10.24	**0.035**
Numbor of rooms					
1–3	46 (23.8)	147 (76.2)	0.94	0.39–2.23	0.881
4–6	32 (25.2)	95 (74.8)	0.85	0.35–2.08	0.725
> 6	8 (26.7)	22 (73.3)	1.00		
Family size (members)					
1–5	37 (25.3)	109 (74.7)	1.07	0.56–2.04	0.839
6–10	30 (21.3)	111 (78.7)	1.13	0.59–2.17	0.715
> 10	19 (30.2)	44 (69.8)	1.00		
House ventilation					
Good	66 (24.4)	205 (75.6)	1.12	0.65–1.94	0.686
Bad	20 (25.3)	59 (74.7)	1.00		
Family monthly income (YR)					
< 50000	46 (27.2)	123 (72.8)	1.27	0.56–2.85	0.567
50000–70000	13 (18.1)	59 (81.9)	1.74	0.70–4.33	0.237
71000–100000	16 (20.3)	63 (79.7)	1.96	0.79–4.87	0.147

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant, YR-Yemeni rial, 1 USD = 25,000 YR.

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
Age group (months)					
> 100000	11 (36.7)	19 (63.3)	1.00		

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant, YR-Yemeni rial, 1 USD = 25,000 YR.

Children who experienced complications such as lethargy (COR = 2.55, 95% CI: 1.48–4.38, p = 0.001), breathlessness (COR = 2.31, 95% CI: 1.37–3.86, p = 0.001), and diarrhea (COR = 2.37, 95% CI: 1.39–4.03, p = 0.001) were more likely to be unvaccinated than those without these complications. Compared with artificial feeding, natural breastfeeding was associated with a greater likelihood of unvaccination (COR = 1.91, 95% CI: 1.13–3.23, P = 0.016).

Table 3
Factors associated with measles vaccination coverage (bivariate analysis)

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
A. Clinical complications					
Convulsion					
Yes	10 (22..7)	34 (77.3)	0.95	0.47–1.90	0.878
No	76 (24.8)	230 (75.2)	1.00		
Letharge					
Yes	58 (20.8)	221 (79.2)	2.55	1.48–4.38	**0.001**
No	28 (39.4)	43 (60.6)	1.00		
Breathless					
Yes	54 (20.4)	211 (79.6)	2.31	1.37–3.86	**0.001**
No	32 (37.6)	53 (62.4)	1.00		
Otitis					
Yes	15 (22.1)	53 (77.9)	1.25	0.68–2.29	0.468
No	71 (25.2)	211 (74.8)	1.00		
Diarrhea					
Yes	57 (20.8)	217 (79.2)	2.37	1.39–4.03	**0.001**
No	29 (38.2)	47 (61.8)	1.00		
Pneumonia					
Yes	65 (23.0)	218 (77.0)	1.65	0.94–2.89	0.080
No	21 (31.3)	46 (68.7)	1.00		
B. Nutritional status					
Breastfeeding					
Natural	42 (20.1)	167 (79.9)	1.906	1.13–3.23	**0.016**

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
A. Clinical complications					
Artificial	35 (32.4)	73 (67.6)	1.00		
Mix	9 (27.3)	24 (72.7)	1.279	0.54–3.04	0.578

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant

Among the reasons for no vaccination, fear of side effects (COR = 7.41, 95% CI: 3.44–15.96, p < 0.001), perception that the vaccine is not important (COR = 4.46, 95% CI: 1.73–11.53, p = 0.002), and concerns about vaccine safety (COR = 3.88, 95% CI: 1.35–11.15, p = 0.012) were observed. Specifically, individuals who perceived the health facility as far away had significantly greater odds of being unvaccinated than did those who did not report this barrier (aOR = 3.06; 95% CI: 1.17–8.02), and paternal refusal due to rumors (COR = 6.78, 95% CI: 2.85–16.15, p < 0.001) was significantly associated with a child being unvaccinated.

Table 4
Association between reasons for not vaccination and measles vaccination coverage (bivariate analysis).

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
Reasons for not vaccination					
Fear from side effects of vaccine					
Yes	8 (6.6)	114 (93.4)	7.41	3.44–15.96	**< 0.001**
No	78 (34.2)	150 (65.8)	1.00		
Vaccine not important					
Yes	5 (8.1)	57 (91.9)	4.46	1.73–11.53	**0.002**
No	81 (28.1)	207 (71.9)	1.00		
Father refuse due to religion belief					
Yes	3 (15.0)	17 (85.0)	1.90	0.54–6.66	0.313
No	83 (25.2)	247 (74.8)	1.00		
Concern of safety of vaccine					
Yes	4 (4.7)	42 (91.3)	3.88	1.35–11.15	**0.012**
No	82 (27.0)	222 (73.0)	1.00		
Health facility is far away					
Yes	5 (10.6)	42 (89.4)	3.06	1.17–8.02	**0.022**
No	81 (26.7)	222 (73.3)	1.00		
Unavailabilityof vaccine servicesin nearby health facility					
Yes	3 (12.5)	21 (87.5)	2.39	0.70–8.22	0.167

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant

Variables	Measles vaccination coverage (N = 350)		[a]COR	[b]95% C.I.	*P value
	Vaccinated (n = 86) n (%)	Unvaccinated (n = 264) n (%)			
Reasons for not vaccination					
No	83 (25.6)	243 (74.5)	1.00		
Father refusal due to rumors about the vaccine					
Yes	6 (6.3)	89 (93.7)	6.78	2.85–16.15	**< 0.001**
No	80 (31.4)	175 (68.6)	1.00		

[a]COR - Crude odds ratio, [b]95% C.I.- Confidence interval *P value < 0.05 statistically significant

Multivariable analysis of factors associated with being unvaccinated against measles

To isolate independent risk factors associated with an unvaccinated status among children presenting with measles, variables were screened via bivariate analysis. Covariates matching the pre-specified p-value threshold < 0.25 were transferred into a backward-stepwise multivariable logistic regression model. The final model fit is summarized in Table 5.

The multivariable logistic regression analysis revealed several factors significantly associated with being unvaccinated against measles among children aged 6–60 months in Sana'a city, Yemen. These findings highlight key sociodemographic, health-related, and perceptual barriers influencing vaccination status.

Children of mothers with no education had 4.79 times greater odds of being unvaccinated than did those whose mothers had nonformal education (AOR = 4.79, 95% CI: 1.23–18.68, p = 0.024). Children who experienced lethargy had 2.47 times greater odds of being unvaccinated (AOR = 2.47, 95% CI: 1.19–5.15, p = 0.015). Similarly, those with a history of diarrhea were 2.15 times more likely to remain unvaccinated (AOR = 2.15, 95% CI: 1.07–4.34, p = 0.032).

Fear of vaccine side effects emerged as a strong deterrent, with children whose parents held such concerns having 8.53 times higher odds of being unvaccinated (AOR = 8.53, 95% CI: 3.66–19.87, p < 0.001). Similarly, the belief that vaccination is not important was associated with 6.26 times greater odds of no vaccination (AOR = 6.26, 95% CI: 2.17–18.07; p = 0.001). Fathers' refusal due to vaccine-related rumors further exacerbated this trend, increasing the odds of no vaccination by 8.49 times (AOR = 8.49, 95% CI: 3.21–22.43, p < 0.001).

Logistical challenges also played a significant role, as children living in areas where hospitals were perceived as far away had 6.33 times higher odds of being unvaccinated (AOR = 6.33, 95% CI: 2.09–

19.22, p = 0.001).

Compared with artificial feeding, natural breastfeeding was associated with 2.25 times greater odds of unvaccination (AOR = 2.25, 95% CI: 1.15–4.37, p = 0.017).

Table 5
Multivariable logistic regression analysis of factors associated with being unvaccinated against measles among children aged 6–60 months, Sana'a City, Yemen, 2024 (N = 350)

Variables/Factors	[a]β	[b]AOR	[c]95% C.I.	*P value
Mother's education level				
Formal education	0.127	1.14	0.36–3.58	0.828
None formal education		1.00		
No education	1.567	4.79	1.23–18.68	**0.024**
Letharge				
Yes	0.906	2.47	1.19–5.15	**0.015**
No		1.00		
Diarrhea				
Yes	0.766	2.15	1.07–4.34	**0.032**
No		1.00		
Fear from side effects of vaccine				
Yes	2.144	8.53	3.66–19.87	**< 0.001**
No		1.00		
Not_important(1)				
Yes	1.834	6.26	2.17–18.07	**0.001**
No		1.00		
Concern of safety of vaccine				
Yes	0.942	2.56	0.76–8.65	0.129
No		1.00		
Health facility is far away				
Yes	1.845	6.33	2.09–19.22	**0.001**
No		1.00		
Father refusal due to rumors about the vaccine				
Yes	2.138	8.49	3.21–22.43	**< 0.001**

[a]β – Cofficiant, [b]AOR-Adjusted odds ratio; [c](95% CI)-Confidence interval, *P value < 0.05-Statstically significant

Variables/Factors	[a]β	[b]AOR	[c]95% C.I.	*P value
Mother's education level				
No		1.00		
Breastfeeding				
Natural	0.809	2.25	1.15–4.37	**0.017**
Artificial		1.00		
Mix	0.229	1.26	0.44–3.61	0.670

[a]β – Cofficiant, [b]AOR-Adjusted odds ratio; [c](95% CI)-Confidence interval, *P value < 0.05-Statstically significant

4 Discussion

This study aimed to assess measles vaccination status and associated factors among children aged 6–60 months who presented with measles at the hospital in Sana'a city, Yemen. The findings revealed critically low vaccination uptake within this specific population: only 17.14% had received MCV1, a mere 7.43% had received MCV2, and an alarming 75.42% were completely unvaccinated. These figures are substantially below the WHO recommended coverage of ≥ 95% for the two doses of MCV needed for measles elimination [14] and paint a grim picture of the vulnerability of children in this conflict-affected urban setting. The fact that these low vaccination rates are observed among children already suffering from measles highlights the direct consequence of missed vaccination opportunities

4.1 Measles immunization gaps in conflict-affected urban settings

The observed vaccination status in our study population is lower than national estimates for Yemen and figures from some other low- and middle-income countries (LMICs) when general child populations are surveyed [16–18]. However, our study focuses on a facility-based sample of measles cases, which inherently represents a group where vaccination has failed, either due to lack of access, hesitancy, or other system/individual failures. The ongoing conflict in Yemen has severely disrupted routine immunization services, contributing to these low rates [7, 19].

A key finding of this study is the strong association between caregiver-related factors and no vaccination. Consistent with a vast body of literature, lower maternal education has emerged as a critical determinant of under vaccination. Our finding that children of mothers with no formal education were 4.79 times more likely to be unvaccinated aligns with studies from various low- and middle-income countries (LMICs), such as Eritrea [20], Nigeria [21], and Jordan [22].

This consistently observed association underscores the pivotal role of maternal education in empowering mothers with knowledge about vaccine benefits, improving health literacy, and enhancing their ability to navigate the healthcare system for immunization services.

4.2 Clinical implications and symptom correlation

Interestingly, children who experienced lethargy or had a history of diarrhea during the vaccination period were significantly more likely to be unvaccinated (AOR = 2.47 and 2.15, respectively). This aligns with global evidence suggesting that caregivers often postpone vaccination when a child is perceived as unwell—a practice documented by the World Health Organization [14]. Although such delays may stem from precautionary intentions, they can result in missed vaccination opportunities, leaving children vulnerable to preventable diseases owing to incomplete immunization. These findings underscore the need for clearer guidance to both caregivers and healthcare providers to distinguish between valid contraindications and minor, nonrestrictive ailments. In support of this observation, additional studies have identified parental concerns about child illness as a common reason for incomplete vaccination [23, 24].

4.3 Independent behavioral and socio-demographic determinants of non-vaccination

Multivariable logistic regression modeling isolated several critical, modifiable behavioral and socio-demographic barriers that independently dictate the lack of vaccine utilization in this population.

Fear of vaccine side effects (AOR 8.03) and paternal refusal due to rumors (AOR 7.89) were the most powerful predictors of a child being unvaccinated.

The predominant factor contributing to vaccine refusal among Yemeni parents is the profound fear of adverse side effects, as evidenced by the notably high adjusted odds ratio (AOR = 8.03). This apprehension primarily stems from the perceived severity of potential harm, wherein parents erroneously associate vaccinations with grave consequences such as infertility, developmental delays, or even mortality. Such misconceptions are further exacerbated by the widespread dissemination of misinformation, wherein exaggerated accounts of vaccine-related adverse events circulate rapidly through social media platforms and community networks. Compounding this issue is the pervasive distrust in the healthcare system, particularly due to inadequate post-vaccination surveillance, which amplifies parental concerns regarding the safety and efficacy of immunization programs. This aligns with global research identifying vaccine hesitancy, often fueled by misinformation and safety concerns, as a major barrier to vaccine uptake [25–27]. The perception that the vaccine is not important (AOR 4.31) further underscores the critical need for effective health education and community engagement to address these misconceptions and build trust in vaccination programs [28].

The results of the present study indicate that misinformation can profoundly affect immunization rates and parental refusal based on rumors.

Our results are comparable to those of other studies, which revealed that significant predictors of measles vaccine hesitancy were parental exposure to anti-vaccination information or materials and parents' perceptions of the effectiveness of measles vaccines [27]. Another study reported that dissatisfaction with the quality of information surrounding vaccination is linked with parental hesitancy to have their children vaccinated [29].

Logistical barriers, such as increased distance to hospitals (AOR 3.35), also significantly contributed to no vaccination, which is consistent with findings from other resource-limited settings where physical access impedes service utilization [30–32], highlights the need for strategies that bring services closer to communities, such as reactivating outreach immunization services, especially in urban areas with vulnerable populations.

This study revealed that exclusively breastfed infants had significantly higher odds of being unvaccinated compared to those who were artficial-fed infants (AOR = 2.25).

The findings suggest that breastfed children who contracted measles were more than twice as likely to have missed the measles vaccine because their mothers mistakenly believed that breastfeeding alone provided sufficient protection against the disease. As a result, they did not vaccinate their children. This misconception likely stems from a lack of awareness about vaccine efficacy and inadequate healthcare access in conflict-affected regions.

In contrast, other reports indicate that for infants too young to be vaccinated, breastfeeding offers critical immune support. This is due to protective antibodies in breast milk, which can help combat measles and other infections. While breastfeeding is not a substitute for vaccination, it may provide an additional layer of defense, especially during the first months of life [33].

However, a previous study suggested that while breastfeeding may not prevent symptomatic measles, it could be associated with atypical disease manifestations—which can be just as severe as classic measles but less likely to be recognized [34].

4.4 Strengths and limitations of the study

A primary strength of this study is its multi-center execution across seven major public referral hospitals in a highly restricted conflict environment, capturing a diverse and highly representative sample of urban pediatric cases. Additionally, the utilization of rigorous multivariable logistic regression allowed for the effective isolation of independent behavioral and socio-demographic predictors while controlling for extensive socioeconomic confounding factors.

However, several limitations must be acknowledged. Due to the cross-sectional design, a definitive causal relationship between the identified risk factors and vaccination status cannot be firmly established. Furthermore, because data collection relied partly on caregiver memory recall when physical immunization cards were missing, the potential for recall bias exists. Furthermore, because this study was restricted to major public hospital settings within Sana'a City, the findings may not fully

capture the operational dynamics and coverage constraints experienced in remote rural districts or within private healthcare networks. Finaly, All multivariable logistic regression analyses treated physicians as independent observations and did not explicitly account for clustering at the hospital level (e.g., through multilevel modeling or cluster-robust standard errors). This may lead to underestimation of standard errors and over-confident inferences, and therefore represents a limitation of the study.

4.5 Conclusion and programmatic implications

In conclusion, measles immunization coverage among pediatric patients presenting with active disease in Sana'a City is dangerously low, with three-quarters of the infected population completely unvaccinated. To mitigate the threat of future catastrophic resurgences, the Yemen Ministry of Public Health and Population, alongside international humanitarian partners, must pivot from passive facility-based immunization models toward aggressive, localized outreach strategies.

Addressing modifiable behavioral barriers requires the deployment of community-based health education campaigns designed to actively counter vaccine rumors, reduce fear of adverse effects, and emphasize the safety and clinical necessity of the MCV series. Concurrently, structural access barriers must be alleviated through the establishment of mobile immunization clinics targeting geographically isolated neighborhoods, the integration of vaccine delivery into community-based breastfeeding and nutritional support programs, and the systematic tracking of zero-dose children at every point of clinical contact.

Declarations

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Author contributions

AHA-S and NAN conceived and designed the study. FAM, EAA-S, and GGA developed the data collection instruments and supervised the fieldwork. AMA-S, AGA-D, FAN, HMA, AAA-W, AAA-B, EMA-B, FSA-M, KGS, HNA-N, MGS, RKJ, and YSA-A coordinated the systematic sampling, conducted caregiver interviews, and handled primary data entry. AHA-S and FAM performed the statistical analyses and multivariable logistic regression modeling. AHA-S, NAN, and EAA-S drafted the manuscript. All authors critically reviewed, revised, and approved the final version of the manuscript.

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Availability of data and materials

The quantitative datasets generated, cleaned, and analyzed during the current study are not publicly available due to institutional ethical restrictions and the sensitive nature of clinical data collected within an active conflict zone. However, anonymized data extracts are available from the corresponding author upon reasonable academic request.

Consent to participate

Informed verbal consent was obtained from the primary caregiver of each participating child prior to the administration of the survey. Throughout the study, the anonymity and confidentiality of all personal data were strictly maintained.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing financial or personal interests that could have influenced or appeared to influence the work reported in this paper.

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Figures

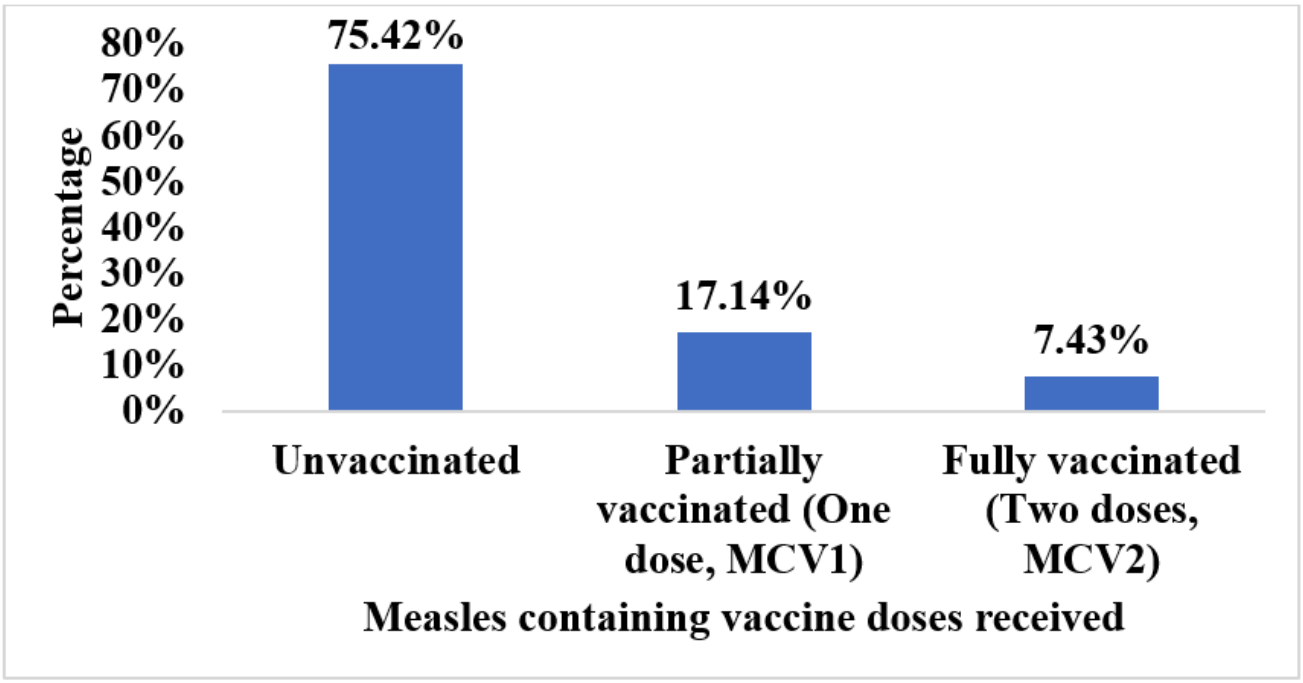


Figure 1

The measles containing vaccine (MCV) coverage among children presenting with measles, Sana'a City, Yemen, 2024 (N=350)

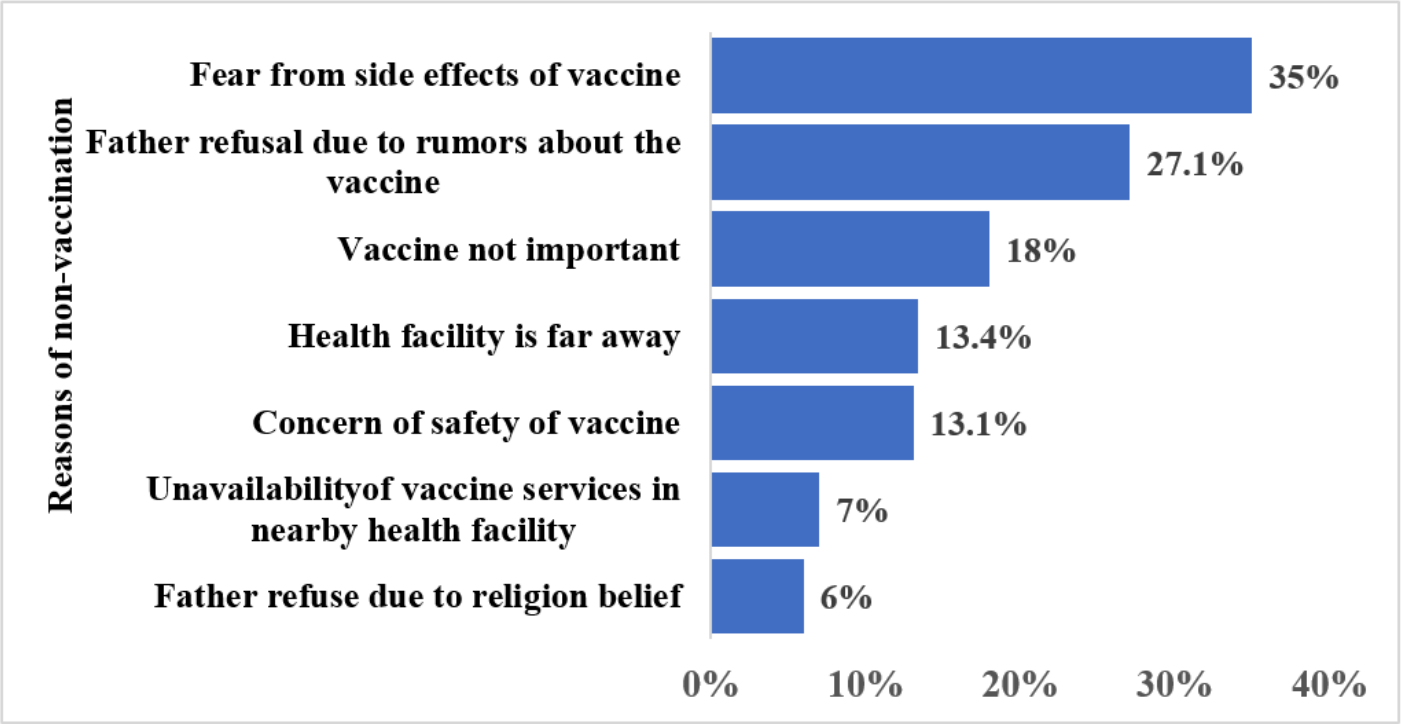


Figure 2

Distribution of reported reasons for non-vaccination against measles