Section: Community Medicine

Original Research Article

INVESTIGATION OF A RUBELLA OUTBREAK IN RURAL BIHAR, INDIA: EPIDEMIOLOGY, RISK FACTORS, AND PUBLIC HEALTH RESPONSE (SEPTEMBER 2023–JANUARY 2024)

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Received *: 10/07/2025*
Received in revised form *: 20/07/2025*
Accepted *: 31/07/2025*

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DOI: 10.70034/ijmedph.2025.3.245

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 1326-1332

ABSTRACT

Background: Rubella is a contagious viral illness, generally mild, posing significant risks for congenital rubella syndrome if contracted during early pregnancy. Rubella outbreaks persist in India due to suboptimal vaccination coverage. Bihar demonstrated historically low vaccination coverage area in India. This study investigates a rubella outbreak in Khudabandpur block of district Begusarai, Bihar to identify risk factors and assess public health responses.

Materials and Methods: A descriptive epidemiological investigation of Rubella outbreak conducted using WHO-standardized case definitions. Active surveillance identified 27 suspected cases; 2 lab-confirmed, 21 epidemiologically linked. Data collection included house-to-house surveys, health records review, and root cause analysis of vaccination coverage (HMIS and WHO monitoring data) and health system gaps.

Results: A delayed report of a Rubella outbreak affected 23 individuals (attack rate: 1.36%) primarily children under 10 years. All cases presented with fever and maculopapular rash, without complications or fatalities. Half of the cases were unimmunized, with reasons for non-vaccination including health worker shortages (Medical Officers: 43%, ANMs: 36%) and operational challenges such as fear of adverse events (31%), travel (31%), and lack of awareness (23%).

Conclusion: This investigation revealed a rubella outbreak in rural Bihar, predominantly affecting unvaccinated children <10 years (70%, median age: 7 years). Critical gaps included delayed detection (2 months), high workforce vacancies (MOs: 43%, ANMs: 36%), and vaccination barriers (AEFI fears, child travel, awareness gaps). Strengthening VPD surveillance, targeted immunization drives in high-risk areas, addressing health workforce shortages, and community-based demand generation are essential to achieve >95% MRCV coverage and accelerate measles-rubella elimination in underserved regions.

Keywords: Rubella Outbreak; VPD Surveillance; Congenital Rubella Syndrome (CRS), Measles and Rubella elimination, India.

INTRODUCTION

Rubella is a viral illness caused by Rubivirus and is characterized by a mild, maculopapular rash, transmitted through direct or droplet contact from nasopharyngeal secretions and has an average incubation period of 17 days (range: 12–23 days).[1] When rubella infection occurs during pregnancy, especially during the first trimester, serious consequences can result including miscarriages, fetal deaths, and a range of severe birth defects known as congenital rubella syndrome (CRS). Rubella is

endemic in many parts of the world and it is estimated that more than 100,000 infants worldwide are born annually with CRS.[2] According to National Family Health Survey (NFHS-5) data, India's full immunization coverage for children aged 12-23 months was 76.4%. In Bihar, the full immunization coverage for the same age group was 71.0% remains significantly lower than the national average, potentially increasing the risk of Vaccine Preventable Disease (VPD) outbreaks including Rubella. Begusarai district is considered high-risk for vaccine-preventable diseases (VPDs) due to historically low Measles-Rubella Containing Vaccine (MRCV) coverage. NFHS-5 data reveals that only 66% of children aged 12-23 months in Begusarai have received all basic vaccinations, below the Bihar state average of 71%, thereby increasing the likelihood of VPD outbreaks, including Rubella.[3,4]

India adopted measles elimination and rubella control goals in 2013, introducing the Measles-Rubella Containing Vaccine (MRCV) nationwide[3]. By 2020, 131 of 194 World Health Organization (WHO) member states had incorporated rubella-containing vaccines into their immunization programs[4]. However, heterogeneous vaccine coverage and surveillance limitations continue to obscure India's true rubella burden, particularly in rural areas[5]. The WHO South-East Asia Region's elimination target (Resolution SEA/RC72/R3) faces implementation challenges in these settings.[5,6]

This study investigates a rubella outbreak in Khudabandpur block, Begusarai district, Bihar in a marginalized community identified as high-risk for vaccine-preventable diseases. Following Bihar's 2019 Measles – Rubella (MR) vaccination campaign[6], residual susceptibility pockets persisted, prompting this detailed epidemiological assessment. Our investigation aims to investigate the Rubella outbreak, describe its epidemiology, and implement control measures in the Khudabandpur block of Begusarai district, Bihar, India.[7]

Objectives:

1. To describe the epidemiological characteristics of the Rubella outbreak in Begusarai, Bihar, India.
2. To conduct a root cause analysis of the outbreak, examining gaps in surveillance, human resources, outbreak response and immunity.
3. To propose evidence-based recommendations for strengthening Measles-Rubella surveillance and outbreak control measures.

MATERIALS AND METHODS

A descriptive epidemiological investigation of a Rubella outbreak (September 2023-February 2024) was conducted in Khudabandpur block, Begusarai district, following the Measles and Rubella Surveillance Field Guide protocols.[6] Detailed epidemiological analysis, including descriptive data assessment and root cause analysis, was performed in February 2024 in collaboration with Block and District Health Officials and the WHO National Public Health Support Network (NPSN) team of Begusarai district, Bihar.

a. Case Definitions

Suspected Case: Any resident of Khudabandpur village, Begusarai district, Bihar, presenting with (or history of) acute fever and maculopapular rash between 1 September 2023 and 9 February 2024.

Confirmed Rubella Case: A suspected case with laboratory confirmation of Rubella-specific IgM via ELISA, or Identification of Rubella virus antigen by polymerase chain reaction (PCR).

Epidemiologically Linked Case: A suspected case occurring within four weeks of the last laboratory-confirmed Rubella case in the outbreak, without specimen collection or laboratory testing.

Suspected Outbreak: Defined as ≥5 suspected cases reported within a four-week period in a block or neighboring areas, or One suspected measles/rubella-related death. Upon outbreak flagging, a preliminary field investigation was conducted to verify case clustering and clinical diagnoses.[6]

b. Outbreak confirmation and timeline

On 28/11/2023, two suspected cases were reported by Accredited Social Health Activist (ASHA) to the WHO- NPSN in Khudabandpur village, Khudabandpur block, Begusarai district, Bihar. An active case search was conducted the same day, identifying three additional suspected cases in the same village. Suspected MR outbreak was flagged after confirmation of the clustering of five suspected cases. An Epidemic Response Team (ERT) meeting was held on the evening of 28/11/2023, followed by a detailed outbreak investigation on 29/11/2023. Two doses of Vitamin A were administered to all suspected cases. To ensure no cases were missed, weekly surveillance reports from Week 35, 2023 (27 August 2023) to Week 10, 2024 (11 February 2024) was reviewed. Additionally, private clinics in Khudabandpur were interviewed to identify any unreported cases.

c. Case search: active and passive surveillance

We implemented comprehensive case-finding through: (1) house-to-house searches in affected communities; (2) systematic review of outpatient and inpatient records at CHC Khudabandpur; (3) analysis of weekly surveillance reports (VPD-H002 forms) and IDSP data; and (4) interviews with private practitioners in the block to identify potential missed cases.

d. Data collection process

Six teams of trained frontline health workers and community mobilizers conducted comprehensive household surveys using standardized protocols. All team members received structured training on data collection procedures, including the use of two primary tools: (1) the Government of India's MOB-003 surveillance form for recording core epidemiological variables, and (2) a semi-structured questionnaire collecting supplemental information on vaccination history, vitamin A supplementation

status, and health-seeking behaviors. The process incorporated systematic quality checks to ensure complete and accurate data capture from all affected households.

e. Data collection tools

The study employed WHO-standardized case investigation forms and culturally adapted, pretested data collection instruments for household surveys to ensure data completeness. Verbal informed consent was obtained from all participants. The investigation was approved by District Health Authorities of Begusarai as part of public health emergency response.

f. Data analysis

Data analysis was performed at two levels: (1) outbreak-level analysis using the WHO's VSIMS platform to generate epidemiological data, and (2) descriptive statistical analysis in Excel (frequencies, proportions, medians, and attack rate calculations). Discrepancies in vaccination coverage between Health Management Information System (HMIS) and WHO monitoring data were systematically compared.

g. Laboratory investigation and classification of outbreak

In accordance with the WHO MR outbreak investigation protocol, serum samples were collected from six suspected cases within 0–28 days of rash onset for IgM testing. Additionally, throat swab specimens were obtained from two suspected cases within 0–7 days of rash onset for viral isolation. All samples were sent to the Department of Microbiology at AIIMS Patna, Bihar, for laboratory analysis.[6]

Of the six serum samples tested, two were IgM-positive for Rubella, confirming Rubella as the causative agent of the outbreak. The remaining four serological samples, along with two virological specimens, tested negative for both Measles and Rubella. Based on these findings, the outbreak was classified as a Rubella outbreak[6].

Root cause assessment for outbreak:

The laboratory-confirmed Rubella outbreak was analyzed across key epidemiological dimensions to identify systemic gaps contributing to disease transmission. Root cause analysis was conducted for the Surveillance System Gaps, Human Resource Gaps, outbreak response gaps and Immunity Gaps based on the outbreak investigation finding.

a. Surveillance system status:

In 2023, Block Khudabandpur reported 133 suspected measles-rubella cases with 100% adequate specimen collection. The block's measles incidence was 97.5 per million population and rubella incidence was 178.7 per million population. The Non-Measles Non-Rubella (NMNR) discard rate stood at 80.4 per 100,000 population. Nine suspected outbreaks were flagged, with one laboratory-confirmed rubella outbreak and no measles outbreaks. Weekly VPD surveillance reports were 100% complete. Comparative district data show 1063 suspected cases, 99.5% adequate specimen collection, 53.4 measles cases per million, 10.2 rubella cases per million, and a 20 per 100,000 NMNR discard rate. The district recorded 75 flagged outbreaks, including 21 confirmed measles and 2 rubella outbreaks. Kindly refer to the [Table 1].

Table 1: MR Surveillance Cardinal indicator, Block Khudabandpur, district Begusarai, Bihar 2023

	District Begusarai	Block Khudabandpur
Total suspected Measles-Rubella Case Reported	1063	133
% of Cases with Adequate Specimen	99.5	100
No. of suspected Outbreak Flagged in 2023	75	9
No. of Lab Confirmed Measles Outbreak in 2023	21	0
No. Lab Confirmed Rubella Outbreak in 2023	2	1
Incidence of Measles per Million Population	53.4	97.5
Incidence of Rubella per Million Population	10.2	178.7
NMNR Discard Rate per 100000 Population	20	80.4

b. Human resource status:

As per official records, Block Khudabandpur had 7 sanctioned positions for Medical Officers, with 4 currently filled (43% vacancy). For Auxiliary Nurse Midwives (ANMs), 25 of 39 sanctioned positions were occupied (36% vacancy). The block maintained near-complete staffing for Accredited Social Health Activists (ASHAs), with 75 of 79 positions filled (5% vacancy). Kindly refer to the [Table 2].

Table 2: Human resource status of the block Khudabandpur, district Begusarai, Bihar

	Post Sanctions	Posted	Posted %	Vacant Position %
Medical Officers	7	4	57	43
ANM	39	25	64	36
ASHA	79	75	95	5

c. Outbreak response gaps:

Following identification of the index case on 28 November 2023, active case searching identified three additional suspected cases on same day. The suspected outbreak was flagged on 29 November 2023 and specimens were collected for laboratory confirmation. Laboratory confirmation was received on 6 December 2023 and the outbreak was classified as Rubella outbreak. The Outbreak Response Immunization (ORI) campaign was implemented on

13 December 2023 and 156 children aged 9 months to 5 years vaccinated with an additional dose of MRCV.

d. Immunity gaps:

Analysis of vaccination coverage data from the affected block revealed several key findings. the block's microplan for routine immunization was updated in October 2023. HMIS reports for FY 2022-23 indicated a Full Immunization Coverage (FIC) of 76%, with MRCV-1 and MRCV-2 coverage at 78% and 86% respectively. However, WHO monitoring data presented higher coverage rates of 94% for MRCV-1 and 87% for MRCV-2, suggesting potential reporting inconsistencies between systems. The variation in reported coverage rates suggests challenges in vaccination data management and monitoring. Kindly refer to the [Table 3].

Table 3: Routine Immunization Coverage of block Khudabandpur, district Begusarai, Bihar

	District Begusarai	Block Khudabandpur
Full Immunization Coverage (NFHS-5)	66	NA
Full Immunization Coverage (HMIS)	81	76
MRCV-1 Coverage (HMIS)	81	78
MRCV-1 Coverage (WHO Monitoring)	84	94
MRCV-2 Coverage (HMIS)	86	86
MRCV-2 Coverage (WHO Monitoring)	73	87

e. Reason analysis of missed MRCV dose

Analysis of WHO monitoring data of the affected block revealed that 6% of eligible children missed their MRCV-1 dose while 13% missed the MRCV-2 dose. Reasons for these vaccination gaps were child travel and fear of adverse events following immunization (AEFI) each accounted for 31% of missed doses, followed by caregiver awareness gaps (23%) and operational challenges in vaccine delivery (15%). Kindly refer to the [Table 4]

Table 4: Reason Analysis of missed MRCV doses, Block Khudabandpur, district Begusarai, Bihar

	2022		2023	
	N	%	N	%
Child traveling	10	16	4	31
AEFI apprehension	14	22	4	31
Awareness Gap	25	39	3	23
Operational Gap	13	20	2	15
Refusal	0	0	0	0
Others	2	3	0	0

RESULTS

a. Epidemiological description of the outbreak

A Rubella outbreak was reported in Khudabandpur village, Khudabandpur block of district Begusarai, Bihar with a population of 1,690. A total of 27 suspected MR cases were identified, with no pregnant women affected. Six serological and two virological specimens were collected from six cases. Two serological specimens tested positive for Rubella, while four were negative for both Measles and Rubella and were discarded. Twenty-one cases were classified as epidemiologically linked, making the total outbreak size 23. The median age of the cases was 7 years, 52% were male, and the attack rate was 1.36%. No complications, hospitalizations, or deaths were reported in this outbreak. Kindly refer to the [Table 5].

Table 5: Descriptive analysis of Rubella Outbreak of block Khudabandpur, district Begusarai, Bihar

Population of village	1690
Suspect cases (Pregnant Women)	27 (0)
Lab. Confirmed Rubella cases	2
Epi linked Rubella cases	21
Median age (range) years	7 year (07 months - 38 years)
Male (%)	12/23 (52.17%)
Attack rate	23/1693 (1.36%)
Complication	0
Hospitalized	0
Death (case fatality rate)	0

b. Age Distribution of Cases

The outbreak primarily affected children under 10 years (70% of cases), with the highest proportion occurring in 5–9-year-olds (48%). Younger children (1–4 years) represented 13% of cases, while infants (<1 year) accounted for 9%. Older cases included adolescents (10–15 years, 13%) and adults (>15 years, 17%). Kindly refer to the [Table 6].

Table 6: Distribution of Rubella Cases by Age

Age category	N	(%)
<1 Year	2	9
1–4 Year	3	13
5–9 Year	11	48
10–15 Year	3	13
>15 Year	4	17

c. Temporal Distribution of the case – Epi curve

The outbreak displayed continuous transmission over a 15-week period from the primary case onset on 29 September 2023 to the terminal case on 12 January 2024. The index case was identified on 28 November 2023 with rash onset two days prior. Analysis of the epidemic curve [Figure 1] revealed initial sporadic transmission from September through November, followed by a distinct peak in late November through December 2023 after case detection began. The 7-week gap between the earliest case and outbreak recognition indicates probable undetected community transmission prior to surveillance activation.

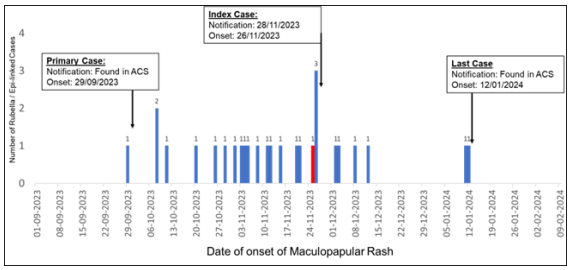

Figure 1: Distribution of the cases by time

d. Geographic Distribution of Cases

The outbreak exhibited distinct spatial clustering within Khudabandpur village, Begusarai district. Case distribution analysis revealed the highest burden in Das Tola (Ward 7), followed by Paswan Tola (Ward 6) and Purvi Tola (Ward 8) demonstrates concentrated transmission in specific residential areas of the affected village.

Kindly refer to the picture number 2 for the spot map.

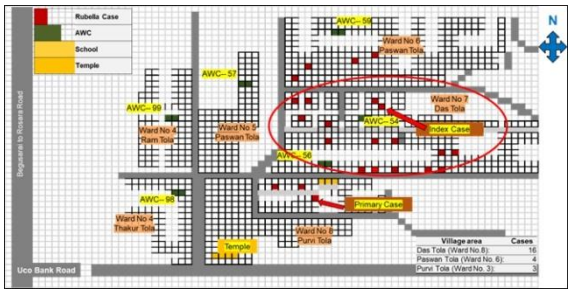

Figure 2: Geographic Distribution of the Rubella cases in village Khudabandpur

e. Clinical presentation of the cases

All laboratory-confirmed rubella and epi-linked cases (n=23) presented with fever and maculopapular rash (100%). Among these cases, 57% (n=13) reported concurrent cough and coryza. Conjunctivitis and joint pain were each observed in 9% of cases (n=2). No cases exhibited enlarged lymph nodes, diarrhea, or pneumonia. Kindly refer to the [Table 7] for clinical features:

Table 7: Clinical presentation of the cases

Clinical presentation	N	(%)
Fever	23	100
Maculopapular Rash	23	100
Cough	13	57
Coryza	13	57
Conjunctivitis	2	9
Enlarged lymph nodes	0	0
Joint Pain	2	9
Diarrhea	0	0
Pneumonia	0	0

f. Vaccination status of the cases

Among rubella cases (n=23), 48% (n=11) had received no doses of MRCV, while 44% (n=10) were vaccinated with two doses. A single case (4%) had received one MRCV dose. No cases reported receiving more than two doses. One case (4%) was ineligible for vaccination based on age criteria. Kindly refer to the [Table 8] for vaccination status.

Table 8: Vaccination status (MRCV doses) of Rubella Cases

No. of MRCV Dose received	N	%
0 Dose	11	48
1 Dose	1	4
2 Dose	10	44
>2 Dose	0	0
Not Applicable*	1	4

*Case not eligible for MRCV doses as per age criteria

DISCUSSION

This study highlights a Rubella outbreak in rural Bihar, India, emphasizing critical gaps in vaccination coverage, surveillance, and health system preparedness. The attack rate of 1.36% primarily affected children under 10 years (70% of cases), with nearly half (48%) being unvaccinated. These findings align with previous Rubella outbreaks in India, such as in Gujarat, where low immunization coverage (MRCV-1: 78%, MRCV-2: 86%) facilitated transmission among under-vaccinated communities.[7] Similar trends were observed in Karnataka and Uttar Pradesh, where suboptimal vaccine uptake (<90%) led to recurrent outbreaks.[8,9] The high dropout rates (6% for MRCV-1, 13% for MRCV-2) due to operational barriers (e.g., fear of adverse effects, mobility of families) mirror challenges documented in low-resource settings globally.[10,11]

The delayed outbreak detection (two months from primary case to reporting) highlights weaknesses in surveillance, consistent with studies from Maharashtra and Odisha, where inadequate frontline workforce delayed timely response.[12,13] The high vacancy rates of medical officers (43%) and ANMs (36%) in Khudabandpur block further exacerbated these gaps, reflecting systemic issues in rural healthcare delivery. Comparatively, countries like Sri Lanka and Bangladesh achieved Rubella elimination through supplementary immunization activities (SIAs) and school-based vaccination drives,[14,15] suggesting that India must prioritize similar strategies in high-risk regions.[16]

CONCLUSION

This rubella outbreak investigation in Khudabandpur block, Begusarai district, revealed critical gaps undermining measles-rubella elimination in rural Bihar. The 1.36% attack rate predominantly affected unvaccinated children (48%) and those under 10 years (70%), exposing significant immunity gaps. Systemic failures included delayed detection (2 months), severe workforce shortages (43% medical officer, 36% ANM, 5% ASHA vacancies), and vaccination barriers (31% AEFI fears, 31% child mobility, 23% awareness gaps, 15% operational challenges).

Case clustering in underserved areas like Das Tola ward highlighted the disproportionate impact on high-risk populations. Discrepancies between HMIS (78%) and WHO (94%) MRCV-1 coverage estimates revealed data quality issues. These findings reflect national patterns of rubella persistence in low-coverage communities, demonstrating how interconnected health system weaknesses (workforce shortages, immunization gaps, and surveillance limitations) sustain outbreak risks.

The study illustrates the compound effect of these barriers in rural settings, where operational challenges (missed sessions, stockouts) intersect with demand-side hesitancy. Such systemic failures create persistent vulnerability in underserved areas, with children bearing the highest burden. These results provide empirical evidence of the multifaceted challenges facing measles-rubella elimination in India's rural health systems, where improving coverage requires addressing both service delivery and community engagement simultaneously.

RECOMMENDATIONS

Based on the outbreak investigation findings and conclusions, the following recommendations are made to block and district health officials to strengthen the FR surveillance and routine immunization coverage to prevent the Rubella outbreak.

Strengthen Vaccination Coverage:

- Focus on low MRCV coverage areas by ensuring high quality head count survey, updating the due list of beneficiaries of routine immunization and effective community mobilization to minimize the dropout.
- Address the reasons for dropout, particularly fears of adverse events following immunization (AEFI) and awareness gap.

Strengthen FR Surveillance Systems:

- Sensitize frontline and community health workers, as well as local clinical practitioners, through VPD surveillance workshops and active case searches for timely notification of cases.

Increase Healthcare Workforce:

- Fill vacancies for Medical Officers, ANMs, and ASHA workers to strengthen healthcare infrastructure and ensure effective field surveillance and immunization coverage.

Community Engagement and Awareness:

- Launch awareness campaigns to educate the community about Rubella, its symptoms, and the importance of timely vaccination.

Limitations: As some families did not have immunization card, the evidence of immunization was recorded by recall which might have led to incorrect estimation of coverage.

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