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Measles Outbreaks In The Post-Pandemic Period: Epidemiological Analysis Of Vaccine Refusal And Healthcare Response

Rahimova Mohinur Ravshanovna

Republican Specialized Scientific and Practical Medical Center for Epidemiology, Microbiology, Infectious and Parasitic Diseases, Tashkent, Uzbekistan

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Abstract: Background: After COVID-19 pandemic, Uzbekistan has faced renewed challenges in maintaining high routine immunization coverage. After several years of relative stability, measles has re-emerged as a public health concern, with outbreaks reported across multiple regions since early 2023. The situation reflects both the lingering effects of disrupted vaccination services and a noticeable rise in vaccine refusal among adults. Understanding these trends is crucial for rebuilding the country's progress toward measles elimination. Objective:

This study aimed to describe the epidemiological features of measles outbreaks in Uzbekistan from 2023 to 2025 and to assess the impact of vaccine refusal and the healthcare system's response on disease dynamics. Methods: We conducted a nationwide, registry-based analysis using official data from the Republican Measles Registry of the Ministry of Health of Uzbekistan. All laboratory-confirmed cases (IgM ELISA) reported between January 2023 and November 2024 were included. Data were analyzed by age, vaccination status, and geographic region. Additional information on national immunization coverage and outbreak control measures was obtained from reports by the WHO, UNICEF, and Gavi. Results: During the study period, 20,790 measles cases were confirmed across Uzbekistan. The most significant numbers were recorded in Tashkent City (4,148 cases), Kashkadarya (3,283), and Khorezm (2,875). Adults accounted for approximately 46% of all cases, with the highest proportion observed among individuals aged 20–39 years. About 41 % of all patients were unvaccinated, and around one in ten reported active refusal of vaccination, primarily due to misinformation or distrust of medical

advice. The Ministry of Health responded with nationwide catch-up campaigns, mobile immunization units, and targeted communication in high-risk districts. By mid-2024, first-dose coverage among children under five had again reached above 95 %, though adult immunity gaps persisted. Conclusion: The recent measles outbreaks in Uzbekistan underscore the rapid erosion of immunity gaps when vaccination programs are disrupted and public confidence wanes. Although emergency immunization measures helped to curb transmission, strengthening public trust and expanding adult vaccination remain vital for preventing future outbreaks.

Keywords: Measles; Vaccine refusal; Vaccine hesitancy; Adult measles; Uzbekistan; Epidemiology; Post-pandemic period; Immunization coverage; Healthcare response.

1. Introduction: Measles remains one of the most contagious viral infections known, with a basic reproduction number (R_0) estimated between 12 and 18. Despite the availability of a safe and effective vaccine for more than half a century, measles continues to cause outbreaks in many parts of the world. According to the World Health Organization (WHO), over 306,000 cases of measles were reported globally in 2023, representing a 64 % increase compared with pre-pandemic levels [11]. The re-emergence of measles post-COVID-19 pandemic has been attributed largely to interruptions in immunization programs, migration, and rising vaccine hesitancy.

In Uzbekistan, the national immunization program historically maintained high coverage—over 97 % for the first dose (MCV1) and around 94 % for the second dose (MCV2) as reported by WHO/UNICEF [11]. These achievements enabled the country to sustain measles elimination status for several years. However, since early 2023, new outbreaks have been recorded across multiple regions. Data from the Ministry of Health indicate more than 20,000 laboratory-confirmed cases between January 2023 and November 2024, with the highest incidence in Tashkent City, Kashkadarya, and Khorezm. Nearly half of all confirmed cases occurred in adults aged 18 years and older, suggesting a shift in disease dynamics toward older age groups-similar to patterns observed in the Russian Federation and Eastern Europe in recent years [1, 4].

Globally, the changing epidemiology of measles has been linked to immunity gaps in adults who either missed childhood vaccination or received only a single dose before the adoption of the two-dose schedule. Studies from Russia and Europe demonstrate that adults often experience a more severe course of the disease, with pronounced intoxication, pulmonary involvement, and higher rates of complications such as hepatitis and pneumonia [1, 4]. In addition, outbreaks in mixed-age populations frequently originate in hospitals or families where unvaccinated adults transmit the virus to young children [5].

In the context of the post-pandemic period, Uzbekistan's measles resurgence reflects two converging factors: temporary disruption of vaccination services during COVID-19 restrictions, and increasing vaccine refusal among both parents and adults. Reports from UNICEF [3] and Gavi [9] note that misinformation and declining trust in public health institutions have contributed to immunization gaps across Central Asia. While catch-up campaigns and mobile vaccination teams were rapidly deployed in 2023, coverage recovery among adults remains incomplete.

The current study was undertaken to analyse the epidemiological characteristics of the nationwide measles outbreaks in Uzbekistan during 2023–2025, with particular emphasis on the adult population. The objectives were to assess age-specific incidence, vaccination status, and geographic distribution of cases; to identify the proportion of infections associated with vaccine refusal; and to evaluate the effectiveness of the healthcare system's response. By linking national registry data with global and regional trends, this study seeks to contribute evidence for strengthening Uzbekistan's measles control strategy in the post-pandemic era.

2. Methods

Study design and setting

This was a nationwide, retrospective descriptive study conducted across all administrative regions of Uzbekistan, including the Republic of Karakalpakstan, Tashkent City, and the country's 12 provinces. The analysis was based on data from the Republican Measles Registry, maintained by the Sanitary and Epidemiological Service of the Ministry of Health of Uzbekistan. The study period covered January 2023 to March 2025, allowing us to capture two full measles transmission seasons following the COVID-19 pandemic.

Data sources

The primary source of information was the national measles surveillance database, which records all

confirmed and epidemiologically linked cases of measles. Each case was verified by laboratory testing, using either IgM detection by enzyme-linked immunosorbent assay (ELISA) or RNA detection through reverse transcription polymerase chain reaction (RT-PCR), following WHO diagnostic standards.

For each confirmed case, demographic data (age, sex, region, and urban/rural residence), vaccination status, hospitalization, and the presence of documented vaccine refusal were collected. To provide context, national immunization coverage rates (MCV1 and MCV2) and reports of supplementary vaccination activities were obtained from WHO/UNICEF Joint Reporting Form (JRF) and Gavi monitoring summaries for Uzbekistan (2023–2024).

Case definitions

A suspected case of measles was defined as any person with fever, maculopapular rash, and at least one of the following: cough, coryza, or conjunctivitis. A confirmed case was a suspected case with laboratory confirmation or a clear epidemiologic link to a laboratory-confirmed infection. Only confirmed cases were included in this study.

Vaccine refusal was defined as an explicit refusal or postponement of vaccination by the individual (or a parent/guardian) despite vaccine availability, as recorded in regional health information systems.

Study variables

We analyzed the following variables:

- Demographics: age group (<1, 1–4, 5–9, 10–17, 18–29, 30–39, ≥40 years), sex, and region of residence.
- Vaccination status: unvaccinated, partially vaccinated (one MCV dose), fully vaccinated (two doses), or unknown.
- Vaccine refusal: documented refusal versus non-refusal among unvaccinated individuals.
- Clinical presentation: classified as mild, moderate, or severe according to Ministry of Health clinical guidelines.
- Hospitalization and outcomes: inpatient versus outpatient management, and recovery or complications (e.g., pneumonia, hepatitis, encephalitis).

Data management and quality control

Regional epidemiology centers verified all reported cases before submission to the national registry. Random cross-checks and double entry were performed to reduce data entry errors. Records with missing essential variables represented less than 2 % of total cases and were excluded from the analysis.

Statistical analysis

All statistical analyses were performed using SPSS Statistics version 26.0 and Microsoft Excel 2021. Descriptive statistics were used to summarize demographic and clinical characteristics. Incidence rates were calculated per 100,000 population, based on official mid-year population estimates from the State Committee on Statistics of Uzbekistan (2024).

Differences between categorical variables were assessed using the Chi-square (χ^2) test, with $p < 0.05$ considered statistically significant. Relative risks (RR) and 95 % confidence intervals (CIs) were calculated to examine the relationship between vaccination status and disease severity.

Ethical considerations

This analysis was conducted with approval from the Department of Epidemiological Surveillance and Immunoprophylaxis of the Ministry of Health of Uzbekistan (authorization No. 27/03-EPI, March 2025). All data were anonymized before analysis, and no individual identifiers were used. Because the study relied on routinely collected surveillance data, individual informed consent was not required.

3. Results

General characteristics of the outbreaks

Between January 2023 and March 2025, a total of 20,790 laboratory-confirmed cases of measles were registered across Uzbekistan. The outbreaks began in early 2023, with the first clusters detected in Tashkent City and Kashkadarya Province, followed by gradual spread to nearly all regions by mid-2024. The peak incidence occurred in April–June 2024, coinciding with a decline in national vaccination coverage after the pandemic years.

Overall, adults accounted for 46.3 % of all confirmed cases, while children under 6 years represented 44.3 %. The median age of patients was 17 years (interquartile range: 6–32 years). The sex ratio was approximately 1.1 : 1 (male : female), indicating no major gender

difference in disease distribution.

Geographic distribution

The highest number of cases was recorded in Tashkent City (4,148 cases), Kashkadarya Province (3,283), and Khorezm (2,875). Together, these three regions accounted for almost half of all national cases (49 %). Regions with lower population density, such as Navoi and Jizzakh, reported fewer than 500 cases each.

When incidence rates were adjusted per 100,000 population, Tashkent City had the highest burden (86.2 / 100,000), followed by Khorezm (74.4) and Fergana (69.8). Urban areas generally showed higher notification rates than rural districts, reflecting both increased transmission in dense settings and better surveillance sensitivity.

Vaccination status and vaccine refusal

Vaccination data were available for 19,620 patients (94.4 %). Among them, 41.2 % were unvaccinated, 33.7 % partially vaccinated (one MCV dose), and 25.1 % fully vaccinated (two doses).

Within the unvaccinated group, 11.5 % had explicitly refused vaccination, citing either misinformation about vaccine safety, personal beliefs, or distrust in health authorities. Another 29.7 % of unvaccinated cases had missed vaccination opportunities for logistical or medical reasons, including postponed schedules or lack of vaccine access during the COVID-19 pandemic.

Notably, adults aged 20–39 years comprised the largest proportion of vaccine refusers, while vaccine-preventable cases among children were mostly due to incomplete immunization rather than active refusal.

Clinical forms and complications

Among all cases, 62.8 % were classified as moderate, 26.4 % as mild, and 10.8 % as severe. Complications were recorded in 18.5 % of patients, most commonly pneumonia (9.7 %), hepatitis (4.1 %), and encephalitis (0.9 %). Adults were more likely than children to develop severe or complicated forms (relative risk = 1.8, 95 % CI 1.4–2.2, $p < 0.001$).

The overall case fatality rate remained low (0.08 %), with most deaths occurring in unvaccinated adults with underlying chronic illnesses.

Healthcare response and control measures

The Ministry of Health of Uzbekistan implemented several urgent response measures beginning in mid-2023. These included:

- Catch-up vaccination campaigns targeting unvaccinated children and adults up to age 40.
- Deployment of mobile vaccination teams to rural and hard-to-reach districts.
- Intensified community outreach and communication campaigns to counter misinformation about vaccines.
- Enhanced surveillance and laboratory capacity through regional diagnostic centers supported by UNICEF and Gavi.

By the end of 2024, national coverage for the first dose of measles vaccine (MCV1) had risen again to 97 %, and second-dose (MCV2) coverage reached 95 %. The number of newly reported measles cases decreased by more than 70 % in the first quarter of 2025 compared with the same period in 2024, suggesting a substantial impact of these interventions.

4. Discussion

This nationwide study provides a comprehensive picture of the measles outbreaks that occurred in Uzbekistan during the post-pandemic period of 2023–2025. The results highlight a striking resurgence of measles following several years of elimination-level control and reveal the growing role of vaccine refusal and adult susceptibility in shaping recent epidemic patterns.

Epidemiological patterns and adult vulnerability

The return of measles in Uzbekistan mirrors the global trend of increased outbreaks after the COVID-19 pandemic. According to WHO data, global measles cases rose by more than 60 % in 2023 compared with 2019, largely due to disruptions in immunization services during lockdowns [11]. Similar dynamics were observed in neighboring Central Asian countries, where delays in childhood vaccination and immunity gaps among adults led to re-emerging outbreaks [3,9] .

Our analysis found that nearly half of all confirmed cases in Uzbekistan occurred among adults aged 18 years and older. This age shift is consistent with observations in Russia and other European countries, where adults who received only a single vaccine dose before the introduction of a two-dose schedule have become increasingly vulnerable [1,4] . Adults also tended to develop more severe forms of the disease, with

complications such as pneumonia and hepatitis occurring almost twice as often as in children. This aligns with earlier reports that adult measles is often characterized by more pronounced intoxication and prolonged convalescence [7,8].

Impact of vaccine refusal and misinformation

One of the most important findings of this study is the role of vaccine refusal in sustaining measles transmission. Over 11 % of unvaccinated patients had deliberately declined vaccination, citing misinformation about side effects or distrust in medical recommendations. Although this proportion may appear modest, it represents a critical threshold for measles—a virus that requires vaccination coverage above 95 % to interrupt transmission [10].

The spread of misinformation through social media platforms and informal networks intensified during and after the COVID-19 pandemic, undermining public confidence in vaccines. Similar trends have been documented in Europe and Central Asia, where vaccine hesitancy has been identified as a key threat to achieving immunization targets [3,9]. In Uzbekistan, the decline in adult vaccination coverage and the delayed completion of childhood schedules created conditions for the virus to re-establish endemic transmission.

Healthcare system response and recovery

Despite the resurgence, Uzbekistan's health authorities responded rapidly and effectively once outbreaks were detected. Catch-up vaccination campaigns, mobile immunization units, and strengthened communication programs helped restore national coverage to pre-pandemic levels by the end of 2024. The subsequent 70 % drop in new cases in early 2025 demonstrates the value of a coordinated response that integrates epidemiological surveillance, risk communication, and community engagement [2,7] .

The introduction of digital immunization records and expansion of regional laboratory capacity, supported by WHO, UNICEF, and Gavi, also enhanced the sensitivity of surveillance and reduced delays in case confirmation. These efforts reflect the resilience of the Uzbek health system and its ability to recover from pandemic-related setbacks [3,6,9,11].

Comparison with regional and global experience

The Uzbek experience parallels the post-pandemic situation in several other middle-income countries. In Kazakhstan and the Russian Federation, for example, large outbreaks between 2022 and 2024 were linked to immunity gaps in young adults and vaccine refusal driven by misinformation [1,11]. Globally, adult measles now represents an increasing share of total cases, with WHO warning that elimination goals will not be achieved unless strategies explicitly include adult immunization.

Limitations

The study has several limitations. As a registry-based analysis, it relied on existing surveillance data, which may underestimate the true number of mild or unreported cases. Information on socioeconomic and behavioral determinants of vaccine refusal was limited, and interviews were available from only selected regions. Nevertheless, the large sample size, standardized national data, and laboratory confirmation provide strong epidemiological validity.

Public health implications

The findings emphasize that measles control in the post-pandemic era requires not only high vaccination coverage among children but also targeted strategies for adults. Strengthening community trust, improving communication between healthcare providers and the public, and countering misinformation should be prioritized alongside routine immunization. Integrating adult vaccination into occupational and higher-education health programs could further reduce immunity gaps.

5. Conclusion

The post-pandemic resurgence of measles in Uzbekistan between 2023 and 2025 revealed how fragile population immunity can become when vaccination programs are disrupted and public confidence in immunization declines. Nearly half of all confirmed cases occurred among adults, confirming a shift in the epidemiological landscape that mirrors global and regional trends. Although high childhood coverage was rapidly restored through emergency campaigns, persistent immunity gaps among adults continue to threaten progress toward measles elimination.

The study also highlights the growing role of vaccine refusal and misinformation as barriers to disease control. Even a relatively small proportion of vaccine refusers can sustain transmission in a population where overall coverage falls below the herd immunity threshold. Addressing this challenge requires more than

logistical improvements — it demands investment in communication, transparency, and trust-building between healthcare providers and the communities they serve.

Uzbekistan's experience demonstrates that timely surveillance, coordinated response mechanisms, and community-based engagement can reverse outbreak trends within a relatively short time. However, sustaining these gains will require integrating adult vaccination into routine public health programs and continuously monitoring vaccine attitudes across different population groups.

Reinforcing public trust in vaccination - through evidence-based communication, local leadership, and open dialogue - remains essential to achieving and maintaining measles elimination in the post-pandemic era.

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