Resurgence of measles in Bosnia and Herzegovina amid declining vaccination coverage

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Abstract

Background: Sarajevo Canton reported large measles outbreaks in 2019 and 2024, highlighting the impact of the persistent gaps in immunisation coverage.

Aim: To analyse 2 measles outbreaks in Sarajevo Canton in Bosnia and Herzegovina, identify populations at risk and assess the impact of vaccination coverage on disease transmission.

Methods: We collected publicly available weekly case counts data for 45 weeks from the Public Health Institute of Sarajevo Canton and examined the vaccination coverage for 5 years to assess the impact of immunisation on outbreak dynamics. We conducted descriptive analyses using RStudio version 2024 and evaluated the differences between outbreaks using Mann-Whitney U test. $P < 0.05$ was considered statistically significant.

Results: A total of 869 cases were reported in 2019 and 4505 in 2024, and children aged 1–4 years were mostly affected (42.1%). Most of the cases were either unvaccinated or had unknown vaccination status; 92.3% of cases in 2019 were unvaccinated, and 87.7% in 2024 were unvaccinated, while 9.9% had unknown vaccination status. The 2024 outbreak had a higher and longer peak (416 vs 91 cases) occurence than 2019, and one death was reported in each year.

Conclusion: The declining vaccination coverage in Sarajevo Canton contributed to increased measles incidence. Strengthening mandatory immunisation, targeted catch-up campaigns and public communication are essential to achieve herd immunity, prevent future outbreaks and progress towards Universal Health Coverage.

Keywords: measles, vaccination, immunisation, MMR vaccine, Sarajevo Canton, Bosnia and Herzegovina

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Introduction

Measles is a highly contagious viral disease that remains a major global public health threat. Despite the availability of an efficacious vaccine since the 1960s, outbreaks persist, particularly in areas with low vaccination coverage (*1*). Transmission occurs through respiratory droplets, and the high basic reproduction number of the virus (R_0) allows infection after brief exposure among unvaccinated individuals (*2*). Before widespread immunisation, measles was nearly universal during childhood, but mass vaccination programmes dramatically reduced incidence worldwide. However, vaccine hesitancy, barriers to health care access, and socioeconomic factors have contributed to renewed outbreaks in many regions (*3*). WHO prioritises measles elimination, emphasising the need to achieve and maintain vaccination coverage of at least 95% to ensure herd immunity (*1*).

In Sarajevo Canton, measles vaccination follows national regulations and the official immunisation calendar of the Public Health Institute of the Federation of Bosnia and Herzegovina (*4,5*). The measles–mumps–rubella (MMR) vaccine is mandatory for children aged 12 months to 14 years, with the first dose at 12 months and the second at 6 years. Children who miss scheduled doses may receive catch-up or early vaccination in high-risk situations (*4*).

In early 2024, 3 confirmed cases of measles were reported in Sarajevo Canton, marking the onset of a new outbreak following a previous outbreak in 2019 that persisted until August of that year.

This study analyses and compares the epidemiological characteristics of these 2 outbreaks in Canton Sarajevo and examines the relationship between vaccination coverage and disease spread.

Methods

Study design and data sources

This study analysed epidemiologic data from 2 measles outbreaks that occurred in Sarajevo Canton in 2019 and 2024. Aggregate surveillance data were obtained from routine reports of the Public Health Institute of Sarajevo Canton, while individual-level information on age, sex, and vaccination status was collected through standard epidemiologic questionnaires and review of medical records. Weekly case counts over a 45-week period were used to construct epidemiologic curves, and 5-year

vaccination coverage trends were examined to assess the impact of immunisation on outbreak dynamics.

Case definition

Cases were classified according to the European Centre for Disease Prevention and Control (ECDC) definitions as possible, probable, or confirmed (*6*). A possible case met clinical criteria (fever, rash, and either cough, coryza, or conjunctivitis). A probable case met clinical criteria with an epidemiologic link, while a confirmed case was not recently vaccinated and met both clinical and laboratory criteria.

Index cases in both outbreaks were confirmed using polymerase chain reaction (PCR). During the 2024 outbreak, 50 cases were confirmed using PCR and 11 cases using serology testing (IgM positive). The remaining cases were classified as probable based on clinical presentation and exposure links.

Surveillance and outbreak response

Surveillance activities included active case finding, contact tracing, and field investigations. Suspected cases were identified in primary and secondary health care settings through clinical diagnosis or laboratory confirmation. Parents were interviewed to collect information on symptoms, exposures, school or childcare attendance, and vaccination history. Household visits, institutional surveys, and further investigations (such as school records and travel history) were conducted to identify transmission chains and geographic clustering.

Outbreak control measures involved intensified case finding, isolation of cases, emergency vaccination clinics operating in 2 shifts across the canton, and targeted public communication campaigns. Priority was given to children under 6 years and school-aged children who were unvaccinated or partially vaccinated.

Statistical analysis

Descriptive analyses were conducted using RStudio (version 2024.12.0+467). Categorical variables, including age group, sex, and vaccination status, were summarised as frequencies and percentages, while continuous variables, such as patient age, were assessed for normality and reported as medians with interquartile ranges (IQR). Differences between outbreaks were evaluated using the Mann–Whitney U test, with a $P < 0.05$ considered statistically significant. Epidemic curves were generated by plotting weekly case counts over a 45-week period, and geographic distribution was illustrated by mapping case counts across municipalities. A 21-day moving average was applied to smooth short-term fluctuations, accounting for the measles incubation period and highlighting the overall epidemic trend.

Ethics considerations

Ethics approval was not required because the study used pseudonymised routine surveillance data collected for public health purposes.

Results

Overview of measles outbreaks

During the past decade, Sarajevo Canton experienced 3 measles outbreaks. The first occurred in 2014–2015, with 1251 cases. After sporadic cases in subsequent years, an outbreak in 2019 resulted in 869 cases between January and July. No cases were reported from 2020 to 2023, likely due to COVID-19 containment measures. A third outbreak started in February 2024, with 4505 reported cases by the end of the year. Transmission continued through 2024 (Figure 1).

Vaccination coverage

Declining vaccination coverage preceded each outbreak. Following the 2014 outbreak, a catch-up vaccination campaign increased coverage to 91.0% for the first MMR dose and 97.0% for 2 doses. Coverage subsequently decreased sharply, reaching 63.4% for 2 doses in 2015, amid growing vaccine hesitancy. During the 2019 outbreak, catch-up activities failed to achieve adequate uptake, with only 44.7% of the target population receiving 2 doses.

In 2020, pandemic-related restrictions temporarily halted routine immunisation services for approximately 2 months, further reducing coverage. By the end of the year, only 32.4% of the target population had received one MMR dose and 24.1% had received 2 doses (Figure 1). Despite renewed vaccination efforts in subsequent years, uptake remained limited.

In early 2024, intensified campaigns were implemented, including walk-in vaccination services and direct outreach to parents. Enforcement measures, including penalties for vaccine refusal, were also applied, resulting in improved coverage (63.2% for the first dose, and 46.9% for 2 doses) by the end of the year.

Characteristics of cases

In both outbreaks, children aged 1–5 years were most affected (Table 1). Sex distribution did not differ significantly between years ($P = 0.232$). Median age increased from 5 years (IQR 2–18) in 2019 to 7 years (IQR 3–12) in 2024 ($P < 0.001$).

Most patients were either unvaccinated or had unknown vaccination status. In 2019, 92.3% were unvaccinated or undocumented, 2.9% had received one MMR dose, and 4.8% were fully vaccinated. In 2024, 87.7% of cases were unvaccinated and 9.9% had unknown vaccination status, mainly among adults with missing immunisation records, together accounting for 97.7% of cases. Only 1.6% had received one dose, and 0.7% were fully vaccinated.

Epidemic curves

Both outbreaks showed rapid increase in cases between epidemiologic weeks 6 and 11 (Figure 2). However, the 2024 outbreak continued to intensify for an additional 6 weeks, peaking at 416 cases in week 16, compared with a

Figure 1 Measles cases and MMR vaccination coverage in Sarajevo Canton, 2014–2024 (1a. Number of reported measles cases over a 10-year period. 1b. MMR vaccination coverage trends over the same period)

Figure 1a

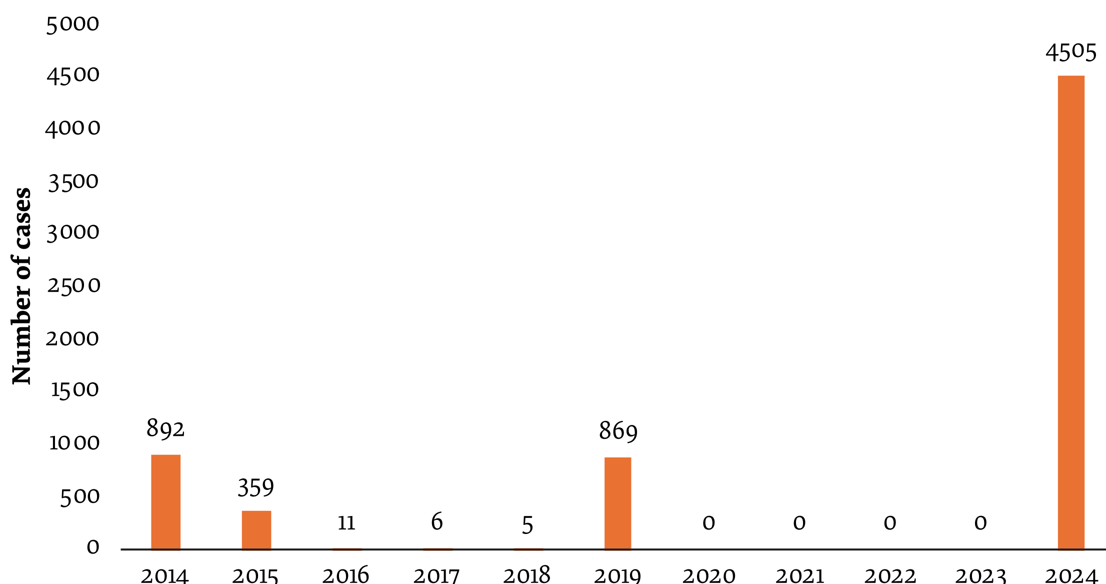
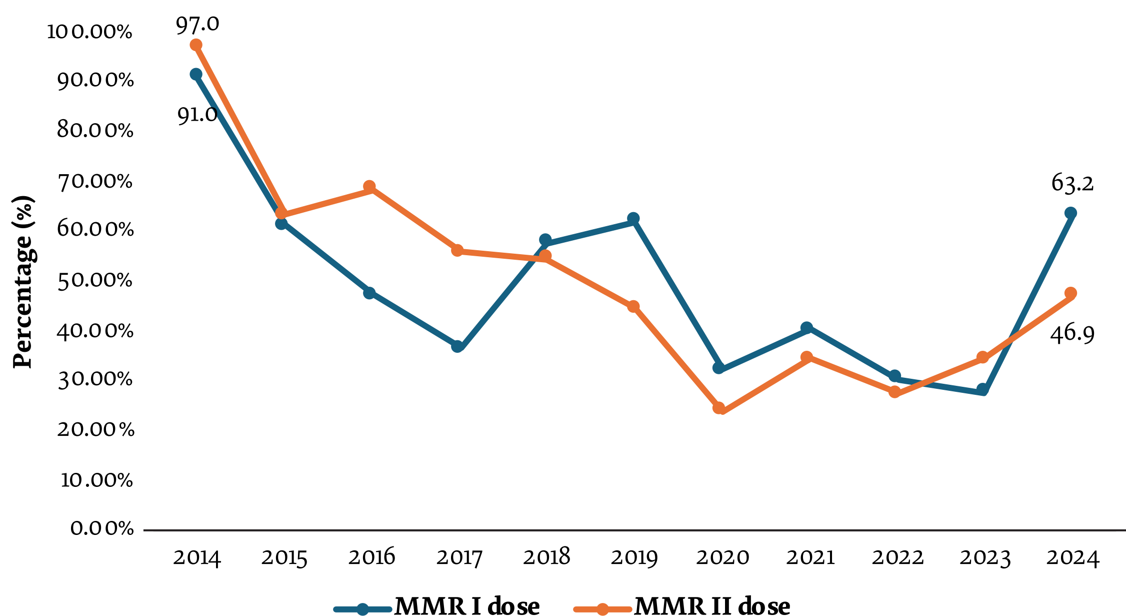


Figure 1b



peak of 91 cases in week 11 of 2019. Each outbreak resulted in one death.

Discussion

Analysis of the 2 recent measles outbreaks in Sarajevo Canton highlights a concerning and consistent pattern of increasing case numbers associated with decreasing vaccination coverage. The proportion of unvaccinated individuals increased from 92.3% in 2019 to 97.7% in 2024, coinciding with an approximately 5-fold increase in reported cases. Given the ≥ 95% coverage required for herd immunity, both outbreaks illustrate how even modest declines in uptake can sustain widespread transmission.

Childhood vaccination coverage in Bosnia and Herzegovina has been decreasing steadily since 2014 (7). Although MMR first dose coverage showed a modest

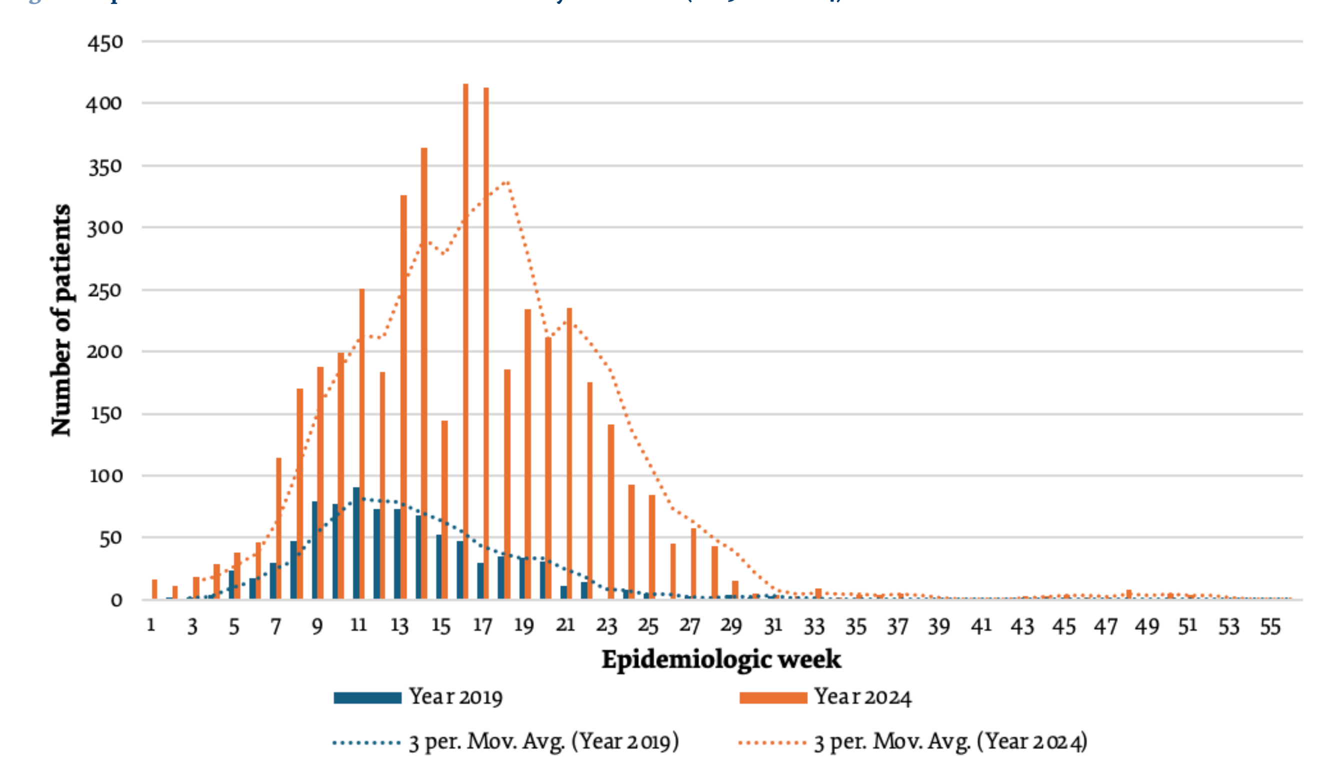
Table 1 **Demographic characteristics and vaccination outcomes of measles cases in Sarajevo Canton, 2014–2024**

	2019		2024	
Sex	**N**	**%**	**N**	**%**
Male	431	49.6	2334	51.8
Female	438	50.4	2171	48.2
Age (median and IQR)	5 (2–18)		7 (3–12)	
Age groups (years)	**N**	**%**	**N**	**%**
< 1	19	2.2	187	4.2
1–4	366	42.1	1549	34.4
5–9	189	21.8	1307	29.0
10–14	61	7.0	631	14.0
15–19	24	2.7	133	3.0
20–29	60	6.8	234	5.2
30–65	150	17.3	462	10.3
≥66	0	0.0	2	0.04
Deaths	1	0.12	1	0.02

improvement in 2019 (79.0%), it remained substantially below the threshold required for measles elimination (*8,9*). Weak enforcement of mandatory immunisation policies, inconsistent reporting of parental refusal, and increased vaccine hesitancy contributed to this outcome. These challenges were further exacerbated during the COVID-19 pandemic, when routine immunisation services were disrupted, resulting in a 26.7% reduction in coverage in 2020 (*7*).

The clinical and public health impact of these outbreaks was substantial. During late 2023 and early 2024, clusters of hospitalised measles cases were reported among preschoolers, most of whom were unvaccinated (*10*). Similarly, a 2024 study conducted at the University Clinical Centre of Sarajevo identified 279 laboratory-confirmed cases with complications such as pneumonia and otitis media, as well as severe neurologic outcomes, including meningoencephalitis and transverse myelitis. Two fatal cases were reported, both among unvaccinated children with underlying comorbidities (*11*). These findings are consistent with observations from the 2019 outbreak in Bosnia and Herzegovina, during which most cases occurred among unvaccinated children

Figure 2 **Epidemic curves of measles outbreaks in Sarajevo Canton (2019 and 2024)**



under 6 years of age, with measles virus genotype B3 predominating (*12*).

Regional comparisons with neighbouring countries reveal persistent regional disparities. While Croatia, Slovenia, and Serbia succeeded in maintaining high vaccination coverage after 2015, Bosnia and Herzegovina and North Macedonia experienced sharp declines, leaving substantial immunity gaps among their populations (*13*). WHO surveillance data confirm that Bosnia and Herzegovina and Serbia continue to rank among the countries with the lowest MMR coverage in Eastern Europe (*14*). Similar trends have been observed in Bulgaria, Montenegro, and Romania (*15*).

These patterns reflect broader global concerns about measles resurgence. In 2023, measles cases increased by 20%, with 10.3 million infections reported worldwide. More than 22 million children missed their first MMR dose, while second-dose coverage decreased to 74.0% (*15*). Within the WHO European Region alone, over 56 000 cases were reported during the first quarter of 2024 (16). Data from the European Centre for Disease Prevention and Control indicate a significant increase in measles cases across the European Union/European Economic Area in 2024, particularly in Romania, Italy, Germany, Belgium and Austria. Romania was among the most affected, reporting 27 568 cases and 18 deaths (*17*). These findings indicate persistent immunity gaps among children, adolescents and adults throughout Europe.

Public health implications

In the aftermath of the recent outbreaks, strengthening routine immunisation coverage, particularly ensuring timely completion of the 2-dose MMR schedule before school entry, remains the foremost priority. Sustainable preparedness requires robust surveillance systems, rapid outbreak response capacity, and closer integration with the education sector to promote vaccination awareness and school-based interventions. Strict protocols for case isolation and criteria for re-entry into educational settings should continue to be enforced.

Meaningful community engagement, targeted risk communication, and continuous monitoring and evaluation are essential to address vaccine hesitancy, assess intervention effectiveness and prevent future outbreaks. These findings support the need for urgent and coordinated action, including expanded vaccination campaigns, stronger enforcement of mandatory immunisation policies, and sustained investment in surveillance and outbreak preparedness.

Without decisive efforts to improve vaccination coverage, future measles outbreaks will likely result in increased morbidity, additional strain on healthcare systems, and heightened risk for vulnerable populations.

The 2 recent measles epidemics in Sarajevo Canton provide a clear illustration of the consequences of decreasing vaccine coverage. The remarkable increase in case numbers, together with the increasing proportion of unvaccinated individuals, indicate the cumulative risk posed by insufficient immunisation. Strengthening immunisation programmes and enforcing mandatory vaccination policies are essential to achieve herd immunity and prevent future outbreaks.

Study limitations

This study relied on routine surveillance data, which may underestimate case numbers due to underreporting, particularly in rural areas, or incomplete laboratory confirmation. Vaccination status was missing for some adults and data on hospitalisations were unavailable. Due to resource constraints, PCR or serological testing was not universally applied.

Conclusion

The 2019 and 2024 measles outbreaks in Sarajevo Canton highlight the critical impact of insufficient vaccination coverage. Sustained investment in immunisation programmes, surveillance, and public engagement is required to achieve herd immunity and prevent future outbreaks.

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Conflict of interests: None declared.

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