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Leptospirosis outbreak in an urban setting: epidemiological and clinical characteristics of the 2025 epidemic in Sarajevo Canton, Bosnia and Herzegovina

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Abstract

Background. Leptospirosis is an emerging public-health concern in urban settings, but data from temperate European cities remain limited. This study describes the 2025 leptospirosis outbreak in Sarajevo Canton, Bosnia and Herzegovina.

Methods. A descriptive observational study was conducted using mandatory surveillance data and a supplementary epidemiological questionnaire based on the WHO Leptospirosis Surveillance Tool. Cases were classified according to the ECDC case definition. Epidemiological, clinical, laboratory, and exposure characteristics were analysed.

Results. A total of 119 cases were recorded; 63.9% were male and the mean age was 45.8±13.2 years. The overall incidence was 2.84 per 10,000 population, highest in Novi Grad municipality. Common symptoms included weakness, fever, chills, myalgia, and headache. Elevated liver enzymes were the only independent predictor of hospitalisation.

Conclusion. The outbreak indicates a shift toward urban leptospirosis, likely linked to environmental contamination and rodent activity rather than traditional rural or flood-related exposure.

Key words

- leptospirosis
- outbreak
- urban environment
- Sarajevo
- epidemiology

INTRODUCTION

Leptospirosis is a globally distributed zoonotic disease caused by pathogenic spirochaetes of the genus *Leptospira*, which colonise the renal tubules of animal hosts and are excreted in urine. Numerous species act as intermediates, including rodents, livestock, and companion animals, while humans are incidental hosts, typically infected through direct or indirect contact with contaminated water or soil [1]. The genus *Leptospira* comprises more than 60 species grouped into 24 serogroups and over 300 serovars, reflecting substantial genetic diversity [2]. The pathogen can survive for prolonged periods in warm, humid environments, explaining its predominance in tropical and subtropical regions. However, leptospirosis is increasingly recognised as a re-emerging infection in temperate and urban settings, where exposure may occur through environmental contamination and rodent infestation [3-5].

Globally, more than one million human cases are estimated to occur annually, resulting in approximately 59,000 deaths [3, 6]. The clinical presentation ranges from mild influenza-like illness to severe forms such as Weil's disease, characterised by jaundice and renal failure, and leptospirosis pulmonary haemorrhagic syndrome, which carries a fatality rate exceeding 50% [7]. In its most severe form, leptospirosis may rapidly progress to multiorgan dysfunction, including circulatory collapse, acute respiratory distress syndrome (ARDS), and hepatic failure. Patients with critical disease often require intensive care, including vasopressor support, mechanical ventilation, and renal replacement therapy,

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and mortality remains high despite optimal management [8]. Owing to its non-specific early symptoms-commonly fever, myalgia, headache, and chills leptospirosis is frequently misdiagnosed, delaying appropriate antibiotic treatment [7].

In Europe, leptospirosis incidence declined during the latter half of the twentieth century; however, recent studies indicate a recrudescence, particularly in urban environments [4, 5]. This trend highlights the growing importance of urban reservoirs and suboptimal environmental sanitation in sustaining transmission [9]. Nevertheless, comprehensive epidemiological data for Europe remain limited, and the true burden of urban and peri-urban transmission is likely underestimated [10]. Environmental conditions play a central role in leptospirosis transmission by influencing the survival and persistence of pathogenic *Leptospira spp*. The bacteria remains viable for extended periods in fresh water and moist soil under moderate temperatures and neutral-to-alkaline pH conditions [11]. Several studies report higher recovery rates from soil than from surface water, suggesting soil as an important long-term reservoir [9-11]. During heavy rainfall, re-suspension of contaminated soil particles may increase human exposure [12]. Distinct ecological transmission pathways have been described, with environmental distribution varying by setting [11]. Hydro-meteorological factors are consistently associated with leptospirosis risk. Periods of intense rainfall or flooding are commonly followed by increased human incidence, particularly when drainage, sanitation, and waste-management systems are disrupted [12-15]. Urban infrastructure further shapes leptospirosis dynamics. Blocked drains, accumulated waste, open sewage channels, and unplanned urban development create favourable conditions for bacterial survival and rodent proliferation [12]. Environmental sampling has identified pathogenic *Leptospira* in soil and water even in areas without reported clinical cases, with environmental reservoirs often harbouring greater strain diversity than human infections [1, 16]. Rodents and dogs serve as key maintenance hosts, with intensified environmental contamination often following heavy rainfall or flooding [17]. Evidence from Bosnia and Herzegovina shows that leptospirosis circulates among dogs, with higher seropositivity in older animals and during spring and autumn, supporting the role of domestic and stray animals as potential reservoirs and contributors to seasonal transmission patterns [18].

METHODOLOGY

The 2025 outbreak in Sarajevo Canton provides an opportunity to characterise leptospirosis in a temperate urban European setting and to better define environmental risk factors contributing to this re-emerging zoonosis. Epidemiological surveillance of leptospirosis was conducted through mandatory notifications from primary care physicians and infectious disease specialists at the Clinical Centre of the University of Sarajevo. Cases were classified as probable or confirmed according to the European Centre for Disease Prevention and Control (ECDC) case definition. Harmonised case definitions are essential for effective surveillance and comparability across data collected in EU/EEA Member States. Through Commission Implementing Decision (EU) 2018/945, the ECDC provides standardised clinical, laboratory, and epidemiological criteria to ensure consistent reporting and timely outbreak detection [19]. The EU case definition reflects the broad clinical spectrum of leptospirosis. A case meets clinical criteria if fever is present or if at least two of the following symptoms occur: chills, headache, myalgia, conjunctival suffusion, rash, mucocutaneous bleeding, jaundice, myocarditis, meningitis, renal impairment, or acute respiratory symptoms. These manifestations range from mild febrile illness to severe disease, including Weil's disease and pulmonary haemorrhage [19]. Laboratory confirmation requires evidence of infection with pathogenic *Leptospira spp*., including isolation of the organism, detection of *Leptospira* DNA by polymerase chain reaction (PCR), identification in tissue by immunofluorescence, or serological confirmation of specific antibodies [19]. A probable case fulfilled clinical criteria and had a relevant epidemiological link-such as exposure to contaminated freshwater, animal contact, or high-risk environments-without laboratory confirmation. A confirmed case required clinical criteria plus laboratory confirmation, regardless of documented exposure. This classification framework supports rapid public health action while ensuring diagnostic accuracy [19]. In Canton of Sarajevo serological testing for leptospirosis was performed using chemiluminescent immunoassay (CLIA) in a referral laboratory. In addition, PCR testing was conducted to exclude other infectious diseases that could potentially lead to cross-reactivity in serological assays. Data on *Leptospira* serogroups were not available, as serogroup identification was not performed.

In the Federation of Bosnia and Herzegovina, communicable disease surveillance is based on mandatory reporting under the Law on Health Care [20], the Law on the Protection of the Population from Infectious Diseases [21], and the Rulebook on the Procedure for Reporting Communicable Diseases [22]. Although routine epidemiological interviews for leptospirosis are not formally required under the Rulebook, the unusually high number of reported cases prompted the development of a targeted survey. This survey was adapted from the WHO Leptospirosis Surveillance Tool and used to collect additional data on environmental exposures, occupational risks, and potential transmission routes. In accordance with national legislation, anti-epidemic measures were implemented for each reported case, including rodent control (deratisation) and disinfection of public transport vehicles. The outbreak was formally reported to the veterinary inspection to support coordinated animal and environmental surveillance. Following a rapid increase in case numbers and on the recommendation of epidemiologists from the Institute of Public Health of Sarajevo Canton, a leptospirosis epidemic was officially declared on 15 May 2025 and lifted on 29 September 2025. Municipal services were instructed to intensify sanitation measures, and systematic deratisation was conducted across the entire canton.

Communication

Effective communication was a central component of the outbreak response. After the initial notification of cases presenting as fever of unknown origin, the Public Health Institute of Sarajevo Canton issued an official alert to all healthcare institutions, calling for heightened vigilance, diagnostic consideration of leptospirosis, and timely reporting. In line with ECDC guidance on outbreak risk communication [23] and WHO recommendations for clear, timely, and transparent public communication [24], particular emphasis was placed on accuracy, consistency, and evidence-based messaging, especially in the post-COVID-19 context where public trust is fragile. Once epidemic conditions were formally met, a press conference was organised to inform the public about the disease, current case numbers, geographical distribution, clinical severity based on hospital data, transmission routes, and recommended preventive measures. Communication strategies prioritised clear, factual, and reassuring messages to reduce misinformation and unnecessary social concern. Daily situation updates were disseminated using infographics published on the Institute's website and distributed through established media mailing lists. Preventive guidelines were issued for educational institutions, nursing homes, and pet owners, alongside recommendations related to outdoor activities and contact with potentially contaminated environments.

Statistical analysis

All statistical analyses were performed using RStudio (version 2024.12.0+467, Posit Software, Boston, MA, USA). Descriptive statistics were used to summarise demographic, clinical, laboratory, and exposure characteristics. Continuous variables (e.g., age) were expressed as mean ± standard deviation (SD) and compared between groups using the Student's t-test for independent samples. Categorical variables were presented as absolute numbers and percentages (N, %), and differences between groups (male *vs* female) were assessed using the chi-square (χ^2) test or Fisher's exact test when expected cell counts were below five. The level of statistical significance was set at $p<0.05$. Incidence rates were calculated per 10,000 inhabitants for each municipality within Sarajevo Canton using 2025 population estimates from the Agency for Statistics of Bosnia and Herzegovina. Spatial distribution of cases was visualised using a choropleth map, with municipalities colour-coded according to incidence levels.

RESULTS

A total of 119 individuals were included, of whom 76 (63.9%) were male and 43 (36.1%) female. The mean age was 45.8±13.2 years, with males significantly younger than females (43.4±12.5 *vs* 50.1±13.5 years, p=0.007). Most cases occurred in the 30-65-year age group (76.5%), followed by 20-29 years (13.4%), ≥66 years (8.4%), and 5-19 years (1.7%). Age distribution did not differ significantly by sex (p=0.090) *(Table 1)*. Confirmed cases accounted for 37.8% and probable cases for 62.2%, with no significant sex difference (p=0.281).

Clinical manifestation

The most frequently reported symptoms were general weakness (87.4%), fever (79.0%), chills (63.0%), muscle pain (61.3%), and headache (61.3%). Confusion occurred in 11.8% of cases, more often in males than females (15.8% *vs* 4.7%, p=0.07). Other symptoms included vomiting (3.4%), diarrhoea (0.8%), neck stiffness (7.6%), jaundice (1.7%), cough (10.9%), and shortness of breath (7.6%), with no significant sex differences. Laboratory abnormalities were frequently observed, particularly elevated liver enzymes, with 48.7% of patients showing mild to moderate AST/ALT elevation and 11.8% exhibiting severe elevations (≥5× upper normal limit). Elevated GGT was observed in 21.8% of patients, while bilirubin elevation was rare (1.7%). No significant biochemical differences were found between sexes ($p>0.05$). The vertical timeline illustrates the typical clinical course during the first 10 days of illness (*Figure 1*). Early symptoms included fever, chills, general weakness, headache, and occasional cough, often leading to misdiagnosis as a viral illness. A transient improvement around days 3-4 was followed by recurrent high fever, myalgia, and cough on days 5-6. Days 6-7 were characterised by severe myalgia and marked liver enzyme elevation, while bilirubin levels generally remained normal. Most patients sought medical care during this phase, and antibiotic therapy was initiated. Symptoms peaked around days 7-8, with clinical improvement typically observed within 48 hours of treatment initiation.

Risk factors

Overall, 40 participants (33.6%) reported at least one identifiable risk factor, with similar prevalence among males (34.2%) and females (32.6%) (p=0.855). The most frequent exposures were working the soil (9.2%), cleaning basements (4.2%), and recent skin wounds (4.2%). No respondents reported direct contact with flood waters. Outdoor recreational activities were reported by 5.0%. Animal contact was reported by 14.3% of participants, most commonly cats (46%) and parrots (33%), followed by dogs (13%) and other pets. No association was found between pet ownership and sex (p=0.533).

The full logistic regression model significantly improved fit compared with the null model ($\Delta\chi^2=18.243$, p=0.032), with moderate explanatory power (Nagelkerke $R^2=0.343$; Tjur $R^2=0.167$). Elevated AST-ALT values were the only significant predictor of hospitalization (OR=11.58, p=0.039), indicating substantially increased odds of admission (*Table 2*). Other symptoms, including chills, general weakness, headache, and cough, were not significant predictors. Very large coefficients for recent skin injury and reported risk factors suggested quasi-separation, resulting in unstable estimates. Age ≥50 years and sex were not associated with hospitalization risk.

Incidence of leptospirosis by municipality, Canton Sarajevo, 2025

A total of 119 leptospirosis cases were recorded in Sarajevo Canton, corresponding to an overall incidence of 2.84 per 10,000 population. Incidence varied markedly

Table 1
Demographic, clinical, and laboratory characteristics of patients with leptospirosis, Canton Sarajevo, 2025

Variable	Total N of patients (n=119)	Male patients (n=76)	Female patients (n=43)	p
Demographic characteristics				
N of subjects, n (%)	119 (100%)	76 (63.9%)	43 (36.1%)	
Age (Mean ± SD)	45.8±13.2	43.4±12.5	50.1±13.5	0.007
Age groups	N (%)	N (%)	N (%)	
5-19 years	2 (1.7%)	0 (0%)	2 (2.6%)	0.090
20-29 years	16 (13.4%)	5 (11.6%)	11 (14.5%)	
30-65 years	91 (76.5%)	31 (72.1%)	60 (78.9%)	
66+ years	10 (8.4%)	7 (16.3%)	3 (3.9%)	
Confirmed or probable case				
Confirmed case	45 (37.8%)	26 (34.2%)	19 (44.2%)	0.281
Probable case	74 (62.2%)	50 (65.8%)	24 (55.8%)	
Clinical characteristics				
Hospitalization	9 (7.6%)	7 (8.9%)	2 (4.6%)	0.368
Symptoms				
Vomiting	4 (3.4%)	1 (1.3%)	3 (7.0%)	0.100
Diarrhoea	1 (0.8%)	0 (0%)	1 (2.3%)	0.182
Fever	94 (79.0%)	58 (76.3%)	36 (83.7%)	0.341
Chills	75 (63.0%)	48 (63.2%)	27 (62.8%)	0.968
General weakness	104 (87.4%)	66 (86.8%)	38 (88.4%)	0.809
Confusion	14 (11.8%)	12 (15.8%)	2 (4.7%)	0.070
Conjunctival hyperaemia	10 (8.4%)	7 (9.2%)	3 (7.0%)	0.673
Headache	73 (61.3%)	50 (65.8%)	23 (53.5%)	0.186
Neck stiffness	9 (7.6%)	4 (5.3%)	5 (11.6%)	0.207
Muscle pain	73 (61.3%)	45 (59.2%)	28 (65.1%)	0.525
Jaundice	2 (1.7%)	1 (1.3%)	1 (2.3%)	0.681
Cough	13 (10.9%)	10 (13.2%)	3 (7.0%)	0.299
Shortness of breath	9 (7.6%)	6 (7.9%)	3 (7.0%)	0.856
Laboratory findings				
Hepatocellular injury markers (AST/ALT), n (%) None/non-reported elevation Mild to moderate elevation ≤5 ULN* Acute liver injury >5 ULN*	 47 (39.5%) 58 (48.7%) 14 (11.8%)	 28 (36.8%) 38 (50.0%) 10 (13.2%)	 19 (44.2%) 20 (46.5%) 4 (9.3%)	0.791
Significantly elevated GGT values	26 (21.8%)	19 (25.0%)	7 (16.3%)	0.269
Elevated bilirubin	2 (1.7%)	1 (1.3%)	1 (2.3%)	0.681
Risk factors				
Any risk factor	40 (33.6%)	26 (34.2%)	14 (32.6%)	0.855
Skin injury or wound in the past month	5 (4.2%)	2 (2.6%)	3 (7%)	0.256
Walking barefoot in the past month across meadows or similar areas	2 (1.7%)	1 (1.3%)	1 (2.3%)	0.681
Working the soil (cultivation/gardening)	11 (9.2%)	9 (11.8%)	2 (4.7%)	0.193
Cleaning the basement	5 (4.2%)	3 (3.9%)	2 (4.7%)	0.854
Contact with flood waters	0	0%	0%	x
Activities: hiking, kayaking, rafting, swimming, or similar	6 (5%)	4 (5.3%)	2 (4.7%)	0.883
Having pets	14.3 (%)	12 (15.8%)	5 (11.6%)	0.533

*ULN: upper limit of normal.

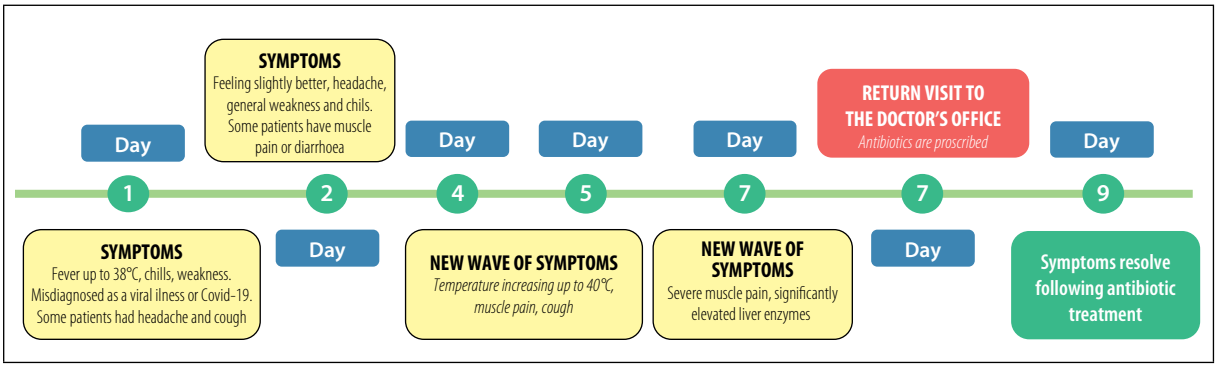

Figure 1
Timeline of symptom progression among patients with leptospirosis in Canton Sarajevo, 2025.

Table 2
Factors contributing to hospitalization

Model*	Deviance	AIC	BIC	df	$\Delta\chi^2$	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
M_0	63.78	65.776	68.55	118	—	—	0	0	0	0
M_1	45.53	65.533	93.32	109	18.243	**0.032**	0.286	0.343	0.167	0.142

Predictor	Estimate	Standard Error	Odds Ratio	z	Wald χ^2	p
Intercept	-3.651	2.324	0.026	-1.571	2.468	0.116
Chills	-1.554	1.025	0.212	-1.516	2.297	0.130
General weakness	0.494	1.406	1.638	0.351	0.123	0.726
Headache	-0.817	1.041	0.442	-0.785	0.617	0.432
Cough	1.285	1.416	3.614	0.908	0.824	0.364
Skin injury in past month	20.195	2654.172	5.899×10^{8}	0.008	5.79×10^{-5}	0.994
Risk factors	-17.885	2654.171	1.708×10^{-8}	-0.007	4.54×10^{-5}	0.995
Age ≥50	-0.164	0.829	0.849	-0.198	0.039	0.843
Sex	0.561	0.849	1.752	0.660	0.436	0.509
Significant increase of liver enzymes	**2.449**	1.184	**11.581**	**2.069**	**4.281**	**0.039**

*M_0 denotes the null logistic regression model including only the intercept, whereas M_1 denotes the full multivariable model including all candidate predictors. $\Delta\chi^2$ indicates the likelihood ratio test comparing M_1 to M_0.

by municipality, with the highest rate in Novi Grad (6.52/10,000), accounting for 67.2% of cases (n=80). Moderate rates were observed in Centar (2.48/10,000) and Stari Grad (1.76/10,000), while Novo Sarajevo (1.11/10,000) and Ilidža (1.26/10,000) had lower rates (*Figure 2*). Peripheral municipalities showed the lowest incidence, and no cases were reported in Trnovo. The spatial pattern demonstrates a clear concentration of cases in the urban core, particularly Novi Grad, suggesting a potential association with population density, sanitation conditions, and rodent exposure.

DISCUSSION

This study provides the first detailed description of a leptospirosis outbreak in an urban setting in Bosnia and Herzegovina, highlighting a change in the epidemiological pattern of this traditionally rural zoonosis. The concentration of cases in densely populated municipalities, highlights the growing role of urban environmental factors-such as sanitation, waste management, and rodent activity-in sustaining transmission. Clinical presentation was largely non-specific in the early phase, frequently resulting in diagnostic delays and misclassification as viral illnesses, a challenge well documented in leptospirosis literature. Notably, classic transmission pathways were largely absent. Most patients denied recent skin wounds, and despite the presumed role of rodents in urban transmission, no cases of haemorrhagic fever or other rodent-borne viral infections were detected in Sarajevo Canton during 2025 up to 15 November, nor were any suspected cases reported. Interestingly, the municipality with the highest incidence was Novi Grad Sarajevo, a highly urbanized area with developed infrastructure and complex environmental and municipal management systems. Water supply is predominantly provided through the central public system, with most residents supplied from the Sarajevsko polje source and an extensive distribution network. Sewerage

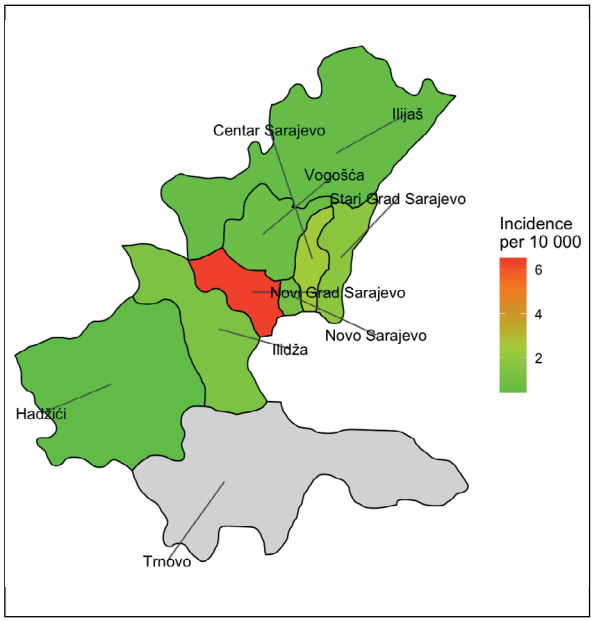

Figure 2
Incidence of leptospirosis by municipality, Canton Sarajevo, 2025.

infrastructure is also widely present, and the municipality hosts the central wastewater treatment plant in Butile, which treats wastewater before discharge into the Bosna River. The area is also exposed to flood risks, particularly following major events in 2014 and 2021 that prompted river regulation and flood protection measures. However, most reported cases were identified in urban residential blocks where full municipal infrastructure is present [25].

Findings from Okinawa Prefecture align closely with our observations [26]. In their 18-year review, 46.3% of 531 clinically suspected cases were laboratory-confirmed, with a strong male predominance and most cases occurring in young adults. Fever, myalgia, and conjunctival hyperaemia predominated, reflecting non-specific febrile illness at presentation. Importantly, traditional agricultural exposures were uncommon, while recreational and occupational river-water exposure emerged as the main risk factors in this urban-peri-urban setting [26]. These findings are consistent with global evidence that leptospirosis is increasing an urban disease. A systematic review by Mutalip *et al*. identified a growing burden in urban areas, driven by inadequate waste management, rodent proliferation, and deteriorating sanitation [5]. Similarly, Obels *et al*. reported a rising national incidence in the Netherlands between 2010 and 2021, linking urban cases to environmental exposure and climatic variability [9]. At a broader scale, Costa *et al*. estimated over one million cases and nearly 59,000 deaths annually worldwide, underscoring the major public health impact of leptospirosis and its frequently under-recognised clinical presentation [7]. Beauté *et al*. further highlighted substantial heterogeneity across EU/EEA countries, noting that urban outbreaks are likely under-detected because of non-specific symptoms and misdiagnosis [27].

Evidence from Western Europe further supports the urban transmission pattern observed in Sarajevo. Dupouey *et al*. described the re-emergence of leptospirosis in Europe, with an increasing proportion of cases linked to urban transmission rather than traditional rural exposures. Expansion of wild rodent populations in cities was identified as a key driver, and although overall EU incidence remains low (0.13 per 100,000), urban outbreaks are likely underestimated, mirroring the diagnostic challenges seen in our setting [4]. Global modelling by Costa *et al*. estimated an annual incidence of 14.77 cases per 100,000 population and 0.84 deaths per 100,000 worldwide [7]. In contrast, Sarajevo Canton experienced an incidence of 2.84 per 10,000 (≈28.4 per 100,000), with one municipality reaching 6.52 per 10,000 (≈65.2 per 100,000), substantially exceeding global averages. This disparity suggests either an unusually intense local outbreak or enhanced surveillance and diagnostic awareness, or both. It also reinforces the likelihood that leptospirosis remains under-estimated elsewhere, partly due to empirical antibiotic treatment prior to confirmation. Environmental and occupational risk factors related to water, infrastructure, landscape, agriculture, and animal exposure play an essential role in leptospirosis transmission. The magnitude of these risk factors varies across geographical regions and is influenced by climate, urbanization, population growth, and socio-economic conditions [28]. These risk factors are particularly relevant for Bosnia and Herzegovina, where seasonal precipitation, flood events, and mixed urban–rural environments create favourable conditions for transmission, especially in areas with inadequate infrastructure and close human-animal interaction [29].

Although leptospirosis is considered uncommon in the continental United States, surveillance data indicate persistent underdiagnosis and periodic outbreaks too. National data linked most cases to freshwater exposure and rodent contact, with frequent hospitalisation and case-fatality rates up to 6% [30]. Waterborne outbreaks among athletes, including triathlon- and adventure-race-associated events, further emphasise the role of environmental exposure following rainfall [31]. More recent CDC surveillance confirmed ongoing sporadic transmission, with Puerto Rico experiencing recurrent clusters of severe disease [32]. Hawai'i continues to report the highest endemic incidence in the US, driven by heavy rainfall, abundant rodent reservoirs, and occupational exposure, with long-term surveillance confirming persistent environmental circulation of pathogenic *Leptospira* [33].

Collectively, these findings support our conclusion that leptospirosis in Sarajevo Canton during 2025 followed an urban transmission pattern, characterised by non-specific clinical presentation, absence of classic exposure pathways, and risk factors consistent with rodent-associated environmental contamination rather than agricultural or flood-related exposure.

CONCLUSION

The 2025 leptospirosis outbreak in Sarajevo Canton demonstrates that this traditionally rural zoonosis can

represent a significant urban public health challenge. The concentration of cases in densely populated areas highlights the importance of urban environmental determinants, including sanitation, waste management, and rodent control, in sustaining transmission. Although clinical outcomes were generally favourable, diagnostic delays were observed, largely due to non-specific early symptoms and initial misclassification as viral infections, underscoring the need for improved clinical awareness and timely laboratory confirmation.

This outbreak emphasises the importance of integrated surveillance and intersectoral collaboration between public health, veterinary, and municipal services. Strengthening routine environmental monitoring, systematic rodent control, and targeted risk communication should be prioritised in urban preparedness strategies. The findings indicate that leptospirosis is not confined to rural or post-flood settings but can emerge in urban environments through complex interactions between humans, animals, and the urban ecosystem.

Strengths and limitations

Strengths

This study represents the largest systematically documented leptospirosis outbreak in an urban setting in Bosnia and Herzegovina and the surrounding region, providing novel insight into the epidemiology of a traditionally rural zoonosis within a densely populated European environment. Integration of clinical, laboratory, environmental, and epidemiological data enabled comprehensive characterisation of the outbreak and its determinants. Use of the standardised ECDC case definition ensured comparability with European surveillance systems, while the epidemiological questionnaire adapted from the WHO Leptospirosis Surveillance Tool allowed detailed assessment of exposure pathways beyond routine reporting. Complete inclusion of all diagnosed cases and high-resolution spatial analysis strengthened the understanding of urban transmission dynamics in temperate settings.

Limitations

Reliance on routine diagnostic pathways resulted in a high proportion of probable cases, reflecting limited access to confirmatory laboratory testing, which was mainly available early in the outbreak or through serological analysis. The non-specific clinical presentation, overlapping with common viral illnesses, may have contributed to delayed diagnosis and underreporting. Exposure data were based on self-reported questionnaires, introducing potential recall bias for minor environmental contacts. Although all cases were included, the small number of hospitalisations limited statistical power in regression analyses, leading to unstable estimates. As an observational outbreak investigation, causal relationships between environmental conditions and transmission cannot be definitively established.

Ethical approval

In November 2025, the joint Ethics Committee of several healthcare institutions in the Canton of Sarajevo granted approval for the conduct of this study (05.5.46-9055-1/25). It should be noted that the epidemiological questionnaire used in this research is part of the Institute's routine daily work. The study was carried out in accordance with the principles of good clinical and epidemiological practice and in full compliance with data protection standards.

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Authors' contributions

AJ performed the statistical analyses and wrote the Results and Discussion sections. ZH contributed to the Introduction and Methodology. APB was responsible for data collection and the legal framework of the study. AS contributed to the Results and portions of the Discussion. AB drafted part of the Introduction. AT contributed to sections of the Discussion and performed final paper revision. APH wrote the environmental factors section and contributed to the Methodology. LA provided final review, critical revisions, and overall manuscript finalisation.

Conflict of interest statement

None

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