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Rabies epidemiology in Ukraine during wartime: a narrative review with insights into viral biology and a regional case study

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Abstract

Rabies remains one of the most dangerous zoonotic diseases worldwide, with nearly 60,000 human deaths annually. It is caused by the rabies virus (RABV), a neurotropic RNA virus of the *Lyssavirus* genus (family *Rhabdoviridae*). Infection typically begins when the saliva of an infected animal enters a bite wound. Ukraine has long been endemic for rabies, with both wild (especially red foxes) and domestic carnivores serving as reservoirs. Before 2022, coordinated oral rabies vaccination (ORV) programs for wildlife and systematic immunization of domestic animals contributed to a gradual decline in disease incidence. However, the full-scale Russian invasion in February 2022 caused a collapse of veterinary infrastructure, disrupted vaccination logistics, and led to the displacement of millions of people and animals, which reversed much of the progress achieved. As a result, the increase in the stray animal population and the suspension of ORV campaigns led to the uncontrolled spread of the virus among both wild and domestic animals. Between 2022 and 2024, Ukraine reported a more than twofold increase in rabies cases among animals. In the Ivano-Frankivsk region (western Ukraine, a key EU buffer zone), cases doubled in 2024 relative to 2020–2021 despite distance from combat zones; by mid-2025, they matched 2021 pre-war levels. This narrative review synthesizes pre- and wartime epidemiology, integrates insights from viral biology relevant to control challenges, distinguishes wild vs. domestic transmission dynamics using species-specific data, compares the Ivano-Frankivsk case with neighboring western regions, and examines stray-animal dynamics. Restoring biannual ORV, rebuilding laboratories, strengthening cross-border surveillance, and advancing One Health integration are critical to mitigate post-war resurgence.

Keywords: rabies virus, Ukraine, Ivano-Frankivsk region, war, pathogenesis, oral rabies vaccination, zoonoses, surveillance, public health.

Abbreviations: ORV, oral rabies vaccination; RABV, rabies virus; SSUFSCP, State Service of Ukraine for Food Safety and Consumer Protection; WOAH, World Organization for Animal Health; WHO,

1. INTRODUCTION

Rabies is a viral disease that causes fatal damage to the brain and spinal cord in humans and other mammals and remains one of the most dangerous zoonotic diseases worldwide, causing nearly 60,000 human deaths annually, in 150 countries, mostly in low- and middle-income countries (WHO 2024). The causative agent of a disease is the rabies virus (RABV), which belongs to the *Rhabdoviridae* family as a member of the *Lyssavirus* genus. Lyssaviruses are neurotropic single-stranded RNA viruses characterized by spherical morphology, a tightly packed nucleocapsid, and five structural proteins. As in other non-segmented, negative-polarity RNA viruses, genome replication and protein synthesis occur in the cytoplasm of infected cells, under the guidance of RNA-dependent viral polymerase (Robertson et al. 2012). Rabies virus is spread to people from the saliva of infected animals, usually transmitted through a bite from a rabid dog. The incubation period for rabies is usually 2-3 months, but can vary from one week to one year, depending on factors such as the site of virus entry and viral load. The initial symptoms of rabies may be similar to those of influenza, including weakness or discomfort, fever, or headache. The severe form of the disease usually manifests within two weeks after the initial symptoms appear, when the rabies virus causes anxiety, confusion, agitation, and hallucinations. Once a person begins to show signs and symptoms of rabies, the disease is almost always fatal (WHO 2023).

Ukraine is considered endemic for rabies, with both wildlife (primarily red foxes and raccoon dogs) and domestic animals serving as reservoirs (Kornienko et al. 2019; Vynograd et al. 2025). Before 2022, the country maintained national programs for oral rabies of wild animals and vaccination of domestic pets (Makovska et al. 2020, 2021; Polupan et al. 2024). While control measures, primarily centered on oral rabies vaccination for wildlife, had achieved some success, the full-scale Russian invasion in February 2022 has profoundly disrupted veterinary surveillance and disease prevention programs (Kozhokaru et al. 2024). This has led to a deterioration of the epizootic situation across the country. This review provides an overview of rabies pathogenesis, the current situation in Ukraine due to the Russian full-scale invasion, and a specific case in the Ivano-Frankivsk region, a strategically important western region in the fight against rabies spread. As the oblast borders European countries, there is a high risk of cross-border disease transmission, which jeopardizes the rabies-free status of many nations (Gossner et al. 2020; Cobby and Eisler 2024).

This narrative review synthesizes peer-reviewed literature, official veterinary and public-health reports (SSUFSCP, WOAH, WHO), and regional data from 2019–2025. Inclusion focused on rabies epidemiology, ORV (oral rabies vaccination) effectiveness, wartime impacts, and regional data in Ukraine/Eastern Europe; exclusion applied to non-English/Ukrainian sources or pre-2019 non-baseline studies. No formal systematic protocol was followed, consistent with the narrative format. It provides a biological context for why wartime disruptions amplify risk, examines wild vs. domestic cycles separately, includes species composition, quantifies stray-animal dynamics, normalizes human-exposure data per capita, and compares the Ivano-Frankivsk region with neighboring western oblasts (Lviv, Zakarpattia). Ukraine's western buffer status heightens the risk of cross-border rabies transmission to rabies-free EU countries.

2. STRUCTURE, MOLECULAR BIOLOGY OF PATHOGENESIS OF RABIES VIRUS: A INSIGHTS RELEVANT TO EPIDEMIOLOGICAL CONTROL

Rabies virus is an enveloped virus, and its infectious particles are cylindrical in shape, resembling a sphere or stick. The inner capsid has a helical symmetry, and the genome consists of a single-stranded linear RNA (ssRNA) with negative polarity, containing 11,615-11,966 nucleotides (Chen et al. 2025). Genetic information is packaged in the form of a ribonucleoprotein complex in which ssRNA is bound to nucleoprotein (N). The viral RNA genome includes five highly conserved genes that are located in the order of 3′-N-P-M-G-L-5′ and encode nucleoprotein (N), phosphoprotein (P), matrix protein (M), glycoprotein (G), and large structural protein (RNA replicase) (L) (Finke and Conzelmann 2005). Protein L interacts with protein P to form an RNA-dependent RNA polymerase complex. The G protein is an integral membrane protein that interacts with host cell receptors, triggering endocytosis of the virion and facilitating viral entry (Albertini et al. 2011). Replication and transcription of rabies viruses occur in the cytoplasm within a specialized compartment called the Negri body (Nevers et al. 2020). Negri bodies are eosinophilic inclusions formed by the accumulation of viral capsid proteins in cells and are thought to cause the main damage to nervous cells. As these structures are typical of RABV infection of the brain, they have diagnostic value for rabies virus infection (Chen et al. 2025).

Most cases of human infection with the rabies virus result from bites or scratches by animals that expose muscle tissue to animal saliva containing rabies virus particles (Rudenko et al. 2025). One of the known receptors for the rabies virus is the nicotinic acetylcholine receptor (nAChR) (Davis et al. 2015; Chen et al. 2025). nAchR is restricted to muscle cells, suggesting primary infection of muscle cells, followed by viral transmission to neurons. In this model of neuroinvasion, RABV particles enter the CNS by budding from muscle cells into the synaptic cleft of neuromuscular junctions, specialized synapses between efferent nerve endings and muscle fibers. It is thought that after RABV enters the primary motor neurons, retrograde axonal transport, replication, and assembly occur in the neuron body, followed by transport to another synapse and budding from it to start a new cycle of infection and further spread from neuron to neuron. The process of transsynaptic spread continues until RABV spreads throughout the CNS (Davis et al. 2015; Rudenko et al. 2025).

The likelihood of developing rabies after being bitten by a rabid animal depends on the location of the bite (the closer to the brain, the shorter the incubation period), the type of animal that bit you, and the strain of the virus (Strauss and Strauss 2012; Chen et al. 2025). Without treatment, bites to the face and head result in rabies in 40-80% of cases, while bites to the legs result in rabies in 0-10% of cases (Strauss and Strauss 2012). The incubation period before symptomatic rabies develops can range from less than a week to several years. Once the virus reaches the brain, it spreads to various organs. To be transmitted, it must spread to the salivary glands. Infection of brain neurons can lead to behavioral changes that make the animal aggressive and cause it to bite other animals, thereby transmitting the virus present in salivary fluid. In humans, the disease can be paralytic (in 20% cases) or lead to nonspecific neurological symptoms (in about 80% cases), including anxiety, agitation, and delirium. Biting behavior is not a consequence of rabies in humans, and the virus is not transmitted from person to person. Coma and death occur 2-7 days after the onset of rabies symptoms. Only three cases of human recovery from symptomatic rabies have been reported (Strauss and Strauss 2012).

RABV exhibits unusually low genetic variability for an RNA virus (substitution rate ~$1–5 \times 10^{-4}$ substitutions/site/year, with many estimates around 1.5×10^{-4}) due to strong purifying selection on the G protein. This constrained evolution results in limited antigenic drift and underpins the broad cross-protective efficacy of current inactivated vaccines and oral rabies vaccines (ORV baits) against circulating strains. In Europe and Ukraine, classical RABV (genotype 1, species Rabies lyssavirus) dominates terrestrial transmission, with a single major fox-associated cosmopolitan lineage (no significant subtypes or escape variants reported in the region). Related but distinct lyssaviruses (e.g., European bat lyssaviruses EBLV-1 and EBLV-2, genotypes 5 and 6) occur in bats but rarely spill over to terrestrial hosts or humans in Ukraine/Europe (Durrant et al. 2024; Ashwini et al. 2024; Robardet et al., 2026).

Molecular epidemiological tools (whole-genome sequencing) are essential to detect rare introductions of divergent lyssaviruses or potential vaccine-escape mutants—capabilities severely curtailed by wartime laboratory disruptions. Negri bodies retain diagnostic value in histopathology where PCR/antigen detection is unavailable (especially in resource-limited or disrupted settings). These biological features explain why breakdowns in ORV and pet vaccination during conflict rapidly amplify enzootic cycles: long incubation masks early spread, while conserved antigenicity means that restored vaccination programs can still be highly effective if coverage is achieved (Durrant et al. 2024; Ashwini et al. 2024).

3. RABIES SITUATION IN UKRAINE BEFORE THE WAR

For decades, rabies has been an endemic zoonotic disease in Ukraine, characterized by alternating dominance of urban and forest transmission cycles. A retrospective analysis of the epidemiology of rabies from 1950 to 2019 showed three major epidemic peaks (1951, 1979, and 2007) and identified five historical phases of epizootic development – from "urban (dog)" to "forest (fox)" and, finally, the "expansion" phase in 2000-2019 (Makovska et al. 2020). During the early "urban" phase, dogs were the main reservoir and source of human infection; later, the ecological role of wild carnivores, particularly red foxes (*Vulpes vulpes*), increased substantially. During the expansion phase, the proportion of domestic carnivores (dogs and cats) reached approximately 44.6% of all cases, while foxes accounted for about 36.5%, illustrating a growing overlap between domestic and wildlife cycles (Kornienko et al. 2019; Makovska et al. 2020).

Large-scale national monitoring from 1999 to 2018, analyzed by Kornienko et al. (2019), confirmed the long-term endemic nature of rabies in almost all regions of Ukraine. During this 20-year period, an average of 1,500-1,800 rabid animals were registered annually, predominantly foxes, dogs, and cats. The researchers identified cyclical fluctuations every 3-5 years and noted that environmental, socio-economic, and logistical factors, such as insufficient vaccination of domestic animals and an increase in stray dogs, were closely associated with the recurrence of outbreaks. The study emphasized the need for a comprehensive vaccination strategy across different animal species, as control measures targeting domestic animals alone were insufficient to stop the circulation of the virus.

Mazur et al. (2017) provided a retrospective overview of the rabies epizootic situation in Ukraine between 2011 and 2016, when national ORV campaigns and domestic-animal immunization were consistently implemented. During that period, Ukraine recorded steady declines in animal rabies cases, from 1,604 outbreaks in 2011 to 917 in 2016, reflecting the effectiveness of national control strategies. Western oblasts, including Ivano-Frankivsk and Lviv, showed some of the lowest incidence rates nationwide.

The spatial and temporal dynamics of rabies in Ukraine were further investigated by Polupan et al. (2024), who evaluated the effectiveness of oral rabies vaccination (ORV) programs for wild carnivores. Their geospatial analysis (2012-2021) showed that the density and continuity of bait distribution directly correlated with a decrease in rabies incidence, especially in western and central regions. Where ORV campaigns were conducted regularly, the number of rabies cases decreased significantly; conversely, in regions with incomplete coverage or logistical disruptions, disease intensity remained high. The authors concluded that biannual ORV remains the most effective large-scale measure for controlling rabies in wild animals and indirectly reducing infection in domestic animals and humans.

In parallel, Makovska et al. (2021) analyzed systemic gaps and challenges in the implementation of rabies prevention strategies in Ukraine over the past decades. They identified limited and inconsistent funding, insufficient coordination between the veterinary and health sectors, and the lack of a unified national database as the main obstacles. The authors called for a more robust One Health system that integrates animal and human health surveillance, improves vaccine logistics, and strengthens information campaigns to increase vaccination compliance among pet owners.

In summary, the pre-war situation with rabies in Ukraine was characterized by a stable yet persistent endemic pattern, with simultaneous circulation of the virus among wild and domestic carnivores. The main factors contributing to this were incomplete vaccination, fluctuations in the effectiveness of rabies vaccination campaigns, an increase in the population of stray animals, and structural gaps in coordination between the veterinary and human health sectors. Ukraine's rabies control strategy at that time was largely centered on managing infection in its principal wildlife reservoir, the red fox. National ORV programs, supported by the European Union, played a critical role in reducing rabies incidence in wildlife and limiting spillover to domestic animals and humans (Polupan et al. 2024). Regular biannual ORV campaigns led to a steady decline in wildlife rabies cases between 2012 and 2021, as confirmed by national veterinary reports and WOAH data (OIE/WOAH 2022-2023; WHO/EURO 2023). Parallel vaccination of domestic animals was conducted by the State Service of Ukraine on Food Safety and Consumer Protection, achieving generally high coverage rates in both urban and rural areas. Despite these advances, persistent funding and logistical gaps prevented full eradication of the disease, which continued to display cyclical patterns of resurgence every few years (Makovska et al. 2021; Polupan et al. 2024). Thus, before the war, Ukraine's rabies control system was functional but fragile because it depended on ongoing international support, coordinated vaccination programs, and continuous surveillance measures to keep the disease endemic but under control.

4. RABIES DURING THE WAR (2022–2024) IN UKRAINE

Before 2022, rabies displayed alternating urban (dog-driven) and sylvatic (fox-driven) cycles, with the latter expanding progressively. In wildlife cycle, foxes accounted for ~36–40% of cases in national data (Kornienko et al. 2019; Makovska et al. 2020). Biannual ORV campaigns (2012–2021) in western and central regions produced marked declines (Polupan et al. 2024). Regarding domestic cycle, dogs and cats comprised ~44–45% of cases by the late expansion phase. Stray populations (estimated 100,000–200,000 dogs pre-war) (FOUR PAWS, 20024) acted as bridges. Western oblasts (including Ivano-Frankivsk, Lviv, and Zakarpattia) consistently had the lowest national incidence rates owing to better ORV coverage and lower stray densities (Mazur et al. 2017). Overall, 1,500–1,800 animal cases were registered annually (1999–2018 average), with cyclical 3–5-year peaks modulated by vaccination continuity.

The full-scale war in Ukraine that began in 2022 triggered a series of events that led to a decline in the vaccination of wild and domestic animals against rabies and an increase in the number of registered cases of rabies, posing a serious health threat. The consequences can be divided into several main categories:

1) *Disruptions in veterinary services and vaccinations*. The war led to the destruction of veterinary infrastructure, the displacement of veterinary personnel, and the redirection of public resources to defense measures. This limited diagnostic capacity and led to the mass suspension of rabies vaccination campaigns, especially in 2022-2023 (Ukhovskyi et al. 2024; Polupan et al. 2024), allowing the rabies virus to circulate and spread uncontrollably among the fox population.

2) *Mass displacement of people and animals*. The humanitarian crisis caused mass displacement of people, many of whom had pets, from areas of ongoing hostilities to safer regions. These pets often had unknown or expired vaccination histories, posing a significant risk to new communities.

3) *Increase in the stray animal population*. The abandonment of pets in conflict zones and disruptions to municipal animal control services led to a sharp increase in the number of stray dogs and cats. These animals serve as an important bridge for virus transmission from wild animals to humans (Ukhovskyi et al. 2024; Vysotskyi et al. 2025). Pre-war estimates indicated 100,000–200,000 stray dogs nationwide (FOUR PAWS, 2024). Wartime abandonment, shelter destruction, and halted municipal control programs led to a sharp rise; some assessments now exceed 1 million homeless dogs, with additional unquantified stray cats (Vysotskyi et al. 2025; WHO Europe 2025). Strays function as critical bridge hosts, amplifying spillover from foxes to humans and facilitating long-distance translocation via refugee movements.

Across the country, the number of rabies cases among animals has risen sharply: in 2023, Ukraine recorded an approximately 2.3-fold increase compared to 2022, primarily due to the cessation of oral vaccination of wild carnivores (OPV) and reduced opportunities for vaccinating domestic animals under martial law (Fig. 1A). Suspension of ORV in 2022 (and only partial resumption in buffer zones in 2023) allowed rapid resurgence in foxes – the dominant reservoir (39.5% of all cases 2019–2023 nationally) (Ukhovskyi et al. 2024). Cases in dogs and cats (23.1% and 27.8% nationally, 2019–2023) surged due to disrupted routine vaccination and the massive displacement of pets with unknown vaccination status.

In the first seven months of 2025, there were 30% more cases of rabies among animals (domestic and wild ones) than in the whole of 2022. This shows the seriousness of the rabies problem in Ukraine (Fig. 1A).

From 2023 to mid-2025 (January-July), a total of 3,403 laboratory-confirmed rabies cases were recorded in animals in Ukraine (Table 1). Domestic carnivores clearly dominated the species breakdown, accounting for approximately 68% of all infections. Cats were the single largest group, with 1,257 cases (36.9%), followed closely by dogs with 1,050 cases (30.9%) (Kuriata-Pavlenko, 2025). In contrast, wildlife reservoirs played a smaller but still significant role, contributing about 24% of cases overall: foxes, the primary sylvatic host, were implicated in 710 cases (20.9%), while other wild animals (such as raccoon dogs, martens, wolves, and similar species) accounted for only 121 cases (3.6%). The remaining 265 cases (7.8%) involved other domestic animals, most likely livestock, including cattle, horses, and goats. This pronounced shift toward domestic species, particularly cats and dogs, highlights the increased bridging role of stray and unvaccinated companion animals in maintaining and amplifying rabies transmission during and after wartime disruptions, compared to the historically more wildlife-dominated pattern observed in Ukraine before 2022 (Kuriata-Pavlenko, 2025; Ukhovskyi et al., 2025).

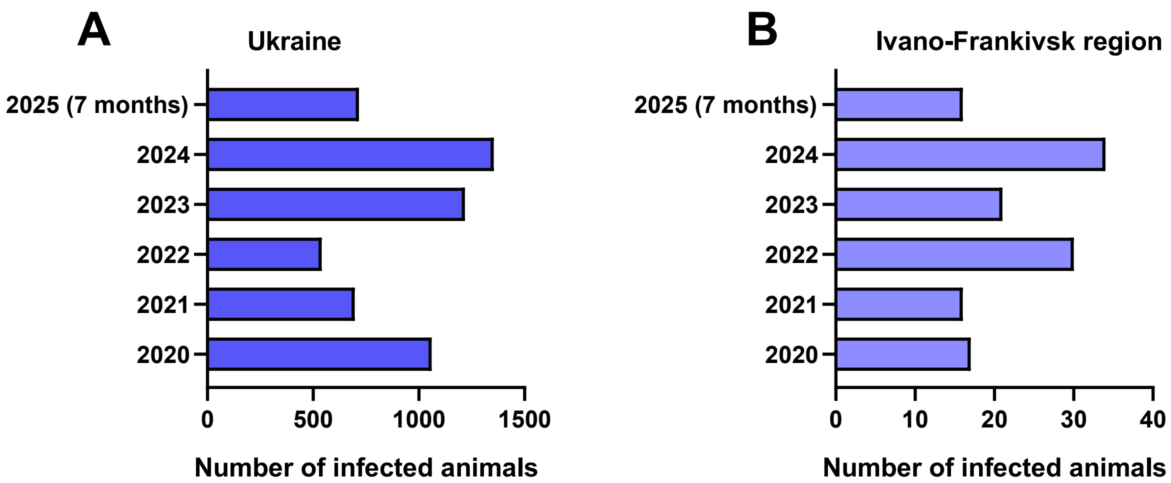

Figure 1. Registered number of animals infected with rabies during 2020-2025 in Ukraine (A) and in the Ivano-Frankivsk region (data from the report of the State Service of Ukraine for Food Safety and Consumer Protection).

Table 1. Number of registered animal rabies cases in Ukraine during 2023-2025.

Year	Total Animals	Infected Cats	Dogs	Foxes	Wild Animals	Other Domestic Animals
2025 (Jan-Jul)	747	267	275	152	20	33

2024	1438	520	421	313	74	110
2023	1218	470	354	245	27	122
TOTAL	3403	1257	1050	710	121	265

Data from (Kuriata-Pavlenko, 2025).

According to the date of the Public Health Center of Ukraine, in 2023, there were 1,845 reports of bites or licks by animals infected with rabies, which is 4.5 cases per 100,000 people (Fig. 2). According to preliminary data, in 2024, the number of such reports increased to 2,427 (5.86 per 100,000 people) (Fig. 2) (PHCU 2025).

Although cases of rabies among humans remained rare (usually one or two fatalities per year nationwide), they were associated with unvaccinated domestic animals and delayed post-exposure prophylaxis. In 2020 and 2021, no human rabies cases were reported. From the beginning of 2022 to January 2026, six confirmed cases of death from rabies were registered, the last of which—a 51-year-old woman bitten by a stray dog in the yard of her house—was registered in the Kharkiv region on January 15, 2026 (Holt, 2026).

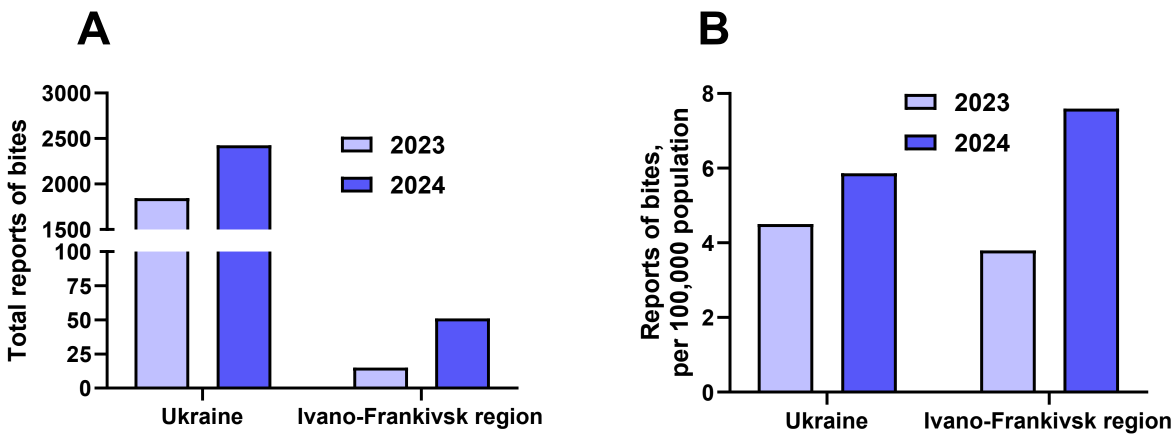

Figure 2. Recorded reports of people bitten by dogs in 2023-2024: A) absolute number; B) normalized number per 100,000 population (according to the date of the Public Health Center of Ukraine, Ministry of Health (PHCU, 2025).

5. REGIONAL CASE STUDY: IVANO-FRANKIVSK OBLAST IN COMPARISON WITH NEIGHBORING WESTERN REGIONS

Spatial analysis of rabies outbreaks in Ukraine from 2019 to 2024 showed a consistently high incidence in the central and northern regions, particularly in Vinnytsia, Kirovohrad, Cherkasy, Kyiv, Khmelnytskyi, and Kharkiv, while the western regions showed consistently lower incidence rates (Ukhovskyi et al., 2025). The Ivano-Frankivsk region (population ≈1.35 million in 2022 estimates) serves as a valuable illustrative case of indirect wartime effects on rabies epidemiology in a non-frontline EU-buffer oblast. Unlike eastern and central regions directly impacted by combat destruction, Ivano-Frankivsk experienced no widespread infrastructure damage but still showed a marked deterioration in the epizootic situation. In the Ivano-Frankivsk region, rabies cases were sporadic and primarily confined to rural areas, involving dogs and cats. Its location in the foothills of the Ukrainian Carpathians provides a distinctive ecological setting: extensive mixed forests and mountainous terrain adjacent to the Carpathian range support relatively high densities of red foxes (the primary wildlife reservoir) and create natural migration corridors for wild carnivores. These landscape features facilitate both sustained sylvatic circulation and potential long-distance movement of infected animals, increasing the risk of spillover to domestic species and cross-border transmission toward neighboring EU countries (Poland, Slovakia, Romania). This ecological uniqueness contrasts with flatter, more agricultural landscapes in other western oblasts (e.g., parts of Lviv or Volyn) and underscores why rabies persistence in Ivano-Frankivsk has implications beyond local control.

The region has participated in cross-border surveillance and prevention programs with neighboring EU member states (Poland, Slovakia, Romania, and Hungary) to reduce the risk of transboundary transmission (Gossner et al. 2020; Vynograd et al. 2024). European risk assessments conducted prior to the full-scale war emphasized Ukraine's importance as a buffer zone for rabies prevention in the EU, underscoring the need for continuous monitoring and coordinated vaccination campaigns (Gossner et al. 2020; Cobby and Eisler 2024).

According to a national report compiled for the World Organization for Animal Health (WOAH/WAHIS), the Ivano-Frankivsk region was one of the buffer regions where the OPV campaign failed to take place in 2022, and it was only partially resumed in 2023 (OIE/WOAH 2022-2023). Specifically, in the Ivano-Frankivsk region, a workshop held in August 2023 under the auspices of the World Health Organization (WHO) identified sustained limitations in zoonotic disease tracking and veterinary service coordination, which were caused by wartime conditions (WHO/EURO 2023). The workshop identified rabies as one of the ten prioritized zoonoses for regional One Health action.

According to data from the State Service of Ukraine for Food Safety and Consumer Protection (SSUFSCP, 2025), compared to 2020 and 2021, twice as many cases of rabies among animals were registered in the Ivano-Frankivsk region in 2024. In the first half of 2025, the same number of cases of rabies in animals was registered as in the whole of 2021 (Fig. 1B). In 2023, there were 51 reported cases of bites or licks by animals infected with rabies (Fig. 2). According to preliminary data, in 2024, the number of such cases increased by 51. Epidemiological trends in the neighboring Lviv region, described by Rudenko et al. (2025), provide a similar regional perspective. Their analysis showed an increase in rabies cases among animals (especially foxes and domestic cats) after 2022, with the virus circulating continuously in forest reservoirs and periodically spreading to domestic animals. Zakarpattia and Volyn (also buffer zones) experienced similar ORV gaps and case rises driven by eastward-to-westward animal displacement (Polupan et al. 2024; Gossner et al. 2020). Western regions collectively retained lower absolute incidence than central/northern or frontline oblasts (e.g., Kharkiv, where bite reports rose several-fold; WHO 2025), yet relative doubling and per-capita exposure trends mirror national patterns. Nationally, foxes predominate (39.5%), cats (27.8%), and dogs (23.1%) (Ukhovskyi et al. 2024); the same hierarchy is inferred for western wildlife-rich landscapes, though region-specific breakdowns are unavailable. The authors of the above-mentioned studies noted that the war exacerbated several risk factors: reduced rabies vaccination coverage and vaccination of domestic animals, uncontrolled movement of animals from combat zones, and delays in laboratory diagnostics due to logistical disruptions. These findings strongly suggest that mechanisms of rabies persistence and re-emergence during the war are similar in all western regions, including the Ivano-Frankivsk region. National species proportions (Ukhovskyi et al. 2024, 2025) show foxes as the dominant wildlife reservoir (20.9–39.5% across periods) and cats/dogs as primary bridge hosts (≈68% combined in recent years). The same hierarchy is inferred for Ivano-Frankivsk and neighboring western oblasts, given their forested landscapes and higher fox suitability compared to more urbanized or steppe regions.

6. INTERNATIONAL IMPLICATIONS AND PUBLIC HEALTH RISKS

The deteriorating rabies situation in Ukraine poses a risk not only to its citizens but also to neighboring countries. European health bodies such as the ECDC and EFSA have issued warnings about the risk of rabies reintroduction into rabies-free EU nations by pets accompanying refugees

(Cobby and Eisler 2024). The movement of unvaccinated animals across borders undermines the collective public health security of the continent (Gossner et al. 2020; Cobby and Eisler 2024).

The war in Ukraine since February 2022 has significantly increased the risk of rabies spillover into neighboring EU countries (primarily Poland, Slovakia, Romania, and Hungary), which had previously achieved or maintained rabies-free status through sustained ORV programs and surveillance (Robardet et al., 2026). The conflict disrupted Ukraine's veterinary infrastructure, halted wildlife ORV campaigns, increased stray and free-roaming animal populations (including abandoned pets), and led to a sharp rise in animal rabies cases, creating conditions for cross-border transmission via wildlife movement and, to a lesser extent, pet displacement with refugees (Gossner et al. 2020; Cobby and Eisler 2024). According to the Eurogroup for Animals report (December 2025), phylogenetic and spatial analyses link recent re-emergences in bordering EU states directly to strains circulating in Ukraine. Slovakia achieved rabies-free status in 2021 but lost it after cases in 2022–2023 (including a dog detected at a Ukraine border crossing in December 2022, plus badger and red fox cases). Virus homology showed close matches to Ukrainian strains. Hungary regained rabies-free status prior to the war but recorded 4 cases in 2022 and 15 in 2023, predominantly near eastern borders with Ukraine. Romania saw a sharp escalation from 5 cases in 2021 (the first in a fox ~20 km from the Ukraine border) to 26 in 2022 and 49 in 2023, mostly in bordering areas; many involved wildlife spillovers. Poland experienced favorable conditions until ~2020 but reported 36 cases in 2022 and 7 in 2023, concentrated in the border triangle with Hungary and Romania. These cases were often clustered <50 km from Ukraine or Moldova borders, with two main virus variants (Central Europe and North Eastern Europe) detected across Ukraine, Moldova, Poland, and Romania during 2022-2024. The reports emphasize that the movement of infected animals from Ukraine compromised the epizootiological situation in the EU, despite ongoing immune belts via ORV in border zones (Eurogroup for Animals, 2025; Robardet et al., 2026).

The primary risk remains for the people within Ukraine. Every confirmed animal case represents a potential chain of transmission that could lead to a fatal human infection if not managed with timely and effective post-exposure prophylaxis, which consists of a series of vaccine doses and, in severe cases, rabies immunoglobulin (WHO 2023). Despite the challenges, international organizations have supported Ukraine’s rabies control. The World Health Organization (WHO), World Organization for Animal Health (WOAH), and Food and Agriculture Organization (FAO) have provided vaccines and technical assistance. The European Union reinforced cross-border surveillance, especially with Poland, Slovakia, and Romania, to prevent the importation of rabies from Ukraine (Vynograd et al. 2024). However, these efforts remain insufficient given the scale of the disruption caused by war.

In October 2025, albeit slightly after the immediate war-onset years, the State Service of Ukraine for Food Safety and Consumer Protection held a National Coordination Forum on Rabies Elimination in Odesa, bringing together national and international experts, as well as representatives from the veterinary medicine, agriculture, environment, and health sectors. The forum emphasized Ukraine’s ambition to eliminate human rabies by 2030 and underscored the need for multi-sectoral efforts (veterinary, wildlife, human health) and international cooperation. This reflects a recognition of the wartime setbacks and a renewed push to restore and strengthen the national rabies control program (SSUFSCP 2025). One Health recognizes that human, animal, and environmental health are closely interconnected, and rabies is a prime example of this. Eliminating rabies requires thorough vaccination campaigns, which can be greatly facilitated by the identification and registration of dogs and cats. Knowing which animals are vaccinated, where they are located, and who is responsible for them helps competent authorities optimize vaccination efforts to eliminate the disease and prevent its re-emergence (Eurogroup for Animals, 2025).

CONCLUSIONS AND PERSPECTIVES

Wartime disruption demonstrably reversed a decade of progress through halted ORV, laboratory collapse, and explosive growth of the stray population. Evidence-based priorities: (1) resume biannual ORV in all wildlife corridors (target ≥70% fox coverage); (2) secure sustainable human/animal vaccine supply chains; (3) rebuild molecular surveillance (genotyping) capacity; (4) implement mandatory pet identification/registration and humane stray management (CNVR programs); (5) strengthen cross-border EU–Ukraine One Health platforms. With sustained national and international support, Ukraine can regain control and protect both its population and continental rabies-free status by 2030.

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Conflict of interest. The author has no competing interests.

Research involving human participants and/or animals. None

References

Albertini AA, Ruigrok RW, Blondel D (2011). Rabies virus transcription and replication. Advances in virus research 79:1–22. https://doi.org/10.1016/B978-0-12-387040-7.00001-9

Ashwini MA, et al. (2024). Recent updates on laboratory diagnosis of rabies. Indian Journal of Medical Microbiology. https://doi.org/10.1016/j.ijmmb.2024.100xxx (or full DOI once published; PMC10954107).

Cobby TR, Eisler MC (2024). Risk of rabies reintroduction into the European Union as a result of the Russo-Ukrainian war: A quantitative disease risk analysis. Zoonoses and Public Health 71(5): 515-525. https://doi.org/10.1111/zph.13135

Davis BM, Rall GF, Schnell MJ (2015). Everything you always wanted to know about rabies virus (but were afraid to ask). Annual review of virology 2(1): 451-471. https://doi.org/10.1146/annurev-virology-100114-055157

Durrant R, et al. (2024). Examining the molecular clock hypothesis for the contemporary evolution of the rabies virus. PLoS Pathogens 20(11): e1012740. https://doi.org/10.1371/journal.ppat.1012740Chen S J, Rai C I, Wang SC, Chen YC (2025). Infection and prevention of rabies viruses. Microorganisms 13(2): 380. https://doi.org/10.3390/microorganisms13020380

Eurogroup for Animals (2025, December 12). RABIES ELIMINATION THROUGH ONE HEALTH: mandatory dog & cat identification & registration https://www.eurogroupforanimals.org/library/rabies-elimination-through-one-health

Finke S, Conzelmann KK (2005) Replication strategies of rabies virus. Virus Res 111:120-131. https://doi.org/10.1016/j.virusres.2005.04.004

FOUR PAWS (2024, Oktober 22). FOUR PAWS in Ukraine: Pressing Need for Veterinary Care Continues. https://www.four-paws.org/our-stories/press-releases/october-2024/four-paws-in-ukraine-pressing-need-for-veterinary-care-continues

Holt, E (2026). Rabies an increasing threat in Ukraine. The Lancet Infectious Diseases. 26(3): e147. https://doi.org/110.1016/S1473-3099(26)00055-1

Gossner CM, Mailles A, Aznar I, Dimina E, Echevarría JE, Feruglio SL, Lange H, Maraglino FP, Parodi P, Perevoscikovs J, Van der Stede Y, Bakonyi T (2020). Prevention of human rabies: a challenge for the European Union and the European Economic Area. Euro Surveill. 25(38):2000158. https://doi.org/10.2807/1560-7917.ES.2020.25.38.2000158

Kornienko LE, Moroz OA, Mezhensky AO, Skorokhod SV, Datsenko R A et al. (2019). Epizootological and epidemiological aspects for rabies in Ukraine for the period from 1999 to 2018. Veterinary science, technologies of animal husbandry and nature management 3:90-109. https://doi.org/10.31890/vttp.2019.03.14 http://ojs.hdzva.edu.ua/

Kozhokaru AA, Zadorozhna VI, Yanishevskyi OV (2024). Topical issues of rabies in Ukraine and tactics of medical specialists in providing anti-rabies assistance to servicemen of the Armed Forces of Ukraine. Ukrainian Journal of Military Medicine 5(2): 48-60. https://doi.org/10.46847/ujmm.2024.2(5)-048

Kuriata-Pavlenko O., 2025. WOAH-Europe. Rabies elimination in Ukraine: One Health approach, communication, and lessons learned. 1st GF-TADs Regional Conference of Standing Groups of Experts on priority transboundary animal diseases in the European region, September 24, 2025 https://rr-europe.woah.org/app/uploads/2025/10/Olena-Kuriata_WHO_SGE-RAB.pdf

Makovska IF, Krupinina TM, Nedosekov VV, Tsarenko TM, Novohatniy YA, Fahrion AS (2021). Current issues and gaps in the implementation of rabies prevention in Ukraine in recent decades. Regulatory Mechanisms in Biosystems 12(2):251-259. https://doi.org/10.15421/022134

Makovska IF, Nedosekov VV, Kornienko LYe, Novokhatny Yu O, Nebogatkin IV, Yustyniuk VYe (2020). Retrospective study of rabies epidemiology in Ukraine (1950-2019). Theoretical and Applied Veterinary Medicine 8(1):36-49. https://doi.org/10.32819/2020.81007

Mazur M, Mazur N, Polupan I (2017). Characteristics of epizootic situation of rabies for the animal species in Ukraine from 2011–2016. Scientific Messenger LNUVMBT named after S.Z. Gzhytskyj, 19(73):159-162.

Nevers Q, Albertini AA, Lagaudrière-Gesbert C, Gaudin Y (2020). Negri bodies and other virus membrane-less replication compartments. Biochim Biophys Acta Mol Cell Res 1867:118831. https://doi.org/10.1016/j.bbamcr.2020.118831

OIE/WOAH (2022-2023). Rabies outbreaks in Ukraine. *WAHIS* database. https://rr-europe.woah.org/app/uploads/2019/11/11_gf-tads-rsc5_s4_rabies-ukraine.pdf

PHCU, Public Health Center of Ukraine. How war increases the risk of rabies infection — what can be done (2025, March 13). https://phc.org.ua/news/yak-viyna-pidvischue-riziki-zarazhennya-skazom-scho-mozhna-zrobiti

Polupan I, Bezymennyi M, Rudoi O, Nychyk S, Mezhenskyi A, Tuyakhov M, Lozhkina O, Radzyk-Hovskyi, M, Gutyj B, Ihnatovska M (2024). Spatial and temporal analysis of rabies and effectiveness of the oral rabies vaccination program in Ukraine. Biosystems Diversity 32(2):193-202. https://doi.org/10.15421/012420

Robardet E, Smreczak M, Orłowska A, Malik P, Nándori A, Dirbáková Z, Odaloš R, Rudoi O, Polupan I, Groza O, Arseniev S, Barbuceanu F, Vuta V, Picard-Meyer E (2026). Rabies Reemergence, Central Europe, 2022-2024. Emerg Infect Dis. 32(2):229-232. https://doi.org/10.3201/eid3202.251597.

Robertson K, Marano N, Johnson KJ (2012). 68 - Rabies, In: Editor(s): E. C. Jong, D. L. Stevens, Netter's Infectious Diseases, W.B. Saunders, 2012, pp 411-418, ISBN 9781437701265, https://doi.org/10.1016/B978-1-4377-0126-5.00068-9

Rudenko OP, Malysheva KV, Kurtiak BM, Pundiak TO, Romanovych MS (2025). rabies in Ukraine: pathogenesis, diagnostics, and epidemiological trends in the Lviv region. One Health Journal *3*(II):5–24. https://doi.org/10.31073/onehealthjournal2025-II-01

SSUFSCP, State Service of Ukraine for Food Safety and Consumer Protection. National Coordination Forum on Rabies Elimination Held (2025, October 1) https://dpss.gov.ua/news/vidbuvsia-natsionalnyi-koordynatsiinyi-forum-z-eliminatsii-skazu

Strauss JH, StraussEG (2012). Chapter 4 - Minus-strand RNA viruses. In: Viruses and human disease, 2nd ed, 2008, pp. 137-191. https://doi.org/10.1016/B978-0-12-373741-0.50007-6

Ukhovskyi VV, Pishchanskyi OV, Korniienko LY, Rudoi OV, Drozhzhe ZM, Dedok LA, Radzykhovskyi M L, Pyskun AV, Tsarenko TM (2024). Spatio-temporal analysis of rabies in animals in Ukraine over 2019–2023. Regulatory Mechanisms in Biosystems 15(4): 740-748. https://doi.org/10.15421/0224107

Ukhovskyi, V. V., Korniienko, L. Y., Rudoi, O. V., Matviienko, O. V., Pishchanskyi, O. V., Drozhzhe, Z. M., Kulykova, V. V., Radzykhovskyi, M. L., Gutyj, B. V., & Kyivska, G. V. (2025). Retrospective epizootic and geographical characteristics of rabies in Ukraine. Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Veterinary Sciences, 27(118): 32-43. https://doi.org/10.32718/nvlvet11805

Vynograd N, Grychtoł S, Kołodziej W, Chaklosh I, Vasylyshyn Z, Kozak L, Stybel T (2024). Epizootic-epidemiological features of rabies in the Eastern European region at the current stage. Proceeding of the Shevchenko Scientific Society. Medical Sciences. 73:1 (Jun. 2024). https://doi.org/10.25040/ntsh2024.01.18

Vysotskyi A, Kozenko O, Gutyj B, Krempa N, Dvyliuk I, Magrelo N, Klym H, Martyshuk T, Vus U (2025). Homeless animals – challenges of our time. Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Veterinary Sciences *27*(118):157-160. https://doi.org/10.32718/nvlvet11821

WHO (2023). Rabies – Bulletin – Europe. Rabies Information System of the WHO. World Health Organisation. https://www.who-rabie s-bulletin.org/

WHO (2024, June 24). Rabies: key facts. https://www.who.int/news-room/fact-sheets/detail/rabies

WHO/EURO (2023). Workshop report on the joint risk assessment operational tool for zoonotic diseases in Ukraine:29–31 August 2023, Ivano-Frankivsk region, Ukraine. Copenhagen: WHO Regional Office for Europe; 2023 *WHO/EURO:2023-8214-47982-71039*

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Байляк М. (2026) Епідеміологія сказу в Україні під час війни: оглядова стаття з урахуванням даних про біологію вірусу та регіональне дослідження конкретного випадку. *Журнал Прикарпатського національного університету імені Василя Стефаника. Біологія* 13: 6-17.

Анотація. Сказ залишається однією з найнебезпечніших зоонозних хвороб у світі, щорічно забираючи життя майже 60 000 людей. Його викликає вірус сказу (RABV) – нейротропний РНК-вірус роду *Lyssavirus* (родина *Rhabdoviridae*). Зараження зазвичай починається, коли слина інфікованої тварини потрапляє в рану від укусу. Україна вже давно є ендемічною країною щодо сказу, де резервуарами вірусу є як дикі (особливо червоні лисиці), так і домашні хижаки. До 2022 року скоординовані програми пероральної вакцинації проти сказу для диких тварин та систематична імунізація домашніх тварин сприяли поступовому зниженню захворюваності. Однак повномасштабне вторгнення Росії в лютому 2022 року спричинило руйнування ветеринарної інфраструктури, порушило логістику вакцинації та призвело до переміщення мільйонів людей і тварин, що знівелювало значну частину досягнутого прогресу. В результаті збільшення популяції безпритульних тварин та призупинення кампаній вакцинації спричинило неконтрольоване поширення вірусу серед диких і домашніх тварин. У період з 2022 по 2024 рік Україна повідомила про більш ніж двократне збільшення випадків сказу серед тварин. В Івано-Франківській області (західна Україна, ключова буферна зона ЄС) кількість випадків у 2024 році подвоїлася порівняно з 2020–2021 роками, незважаючи на віддаленість від зон бойових дій; до середини 2025 року вони досягли рівня 2021 року, тобто до початку війни. Цей огляд узагальнює епідеміологію до та під час війни, інтегрує відомості з вірусної біології, що мають значення для боротьби з вірусом, розрізняє динаміку передачі вірусу дикими та домашніми тваринами на основі даних про конкретні види, порівнює ситуацію в Івано-Франківській області з сусідніми західними регіонами та аналізує динаміку безпритульних тварин. Відновлення дворічної програми ORV, відновлення лабораторій, посилення транскордонного нагляду та просування інтеграції One Health мають вирішальне значення для пом'якшення наслідків післявоєнного спалаху.

Ключові слова: вірус сказу, Україна, Івано-Франківська область, війна, патогенез, пероральна вакцинація проти сказу, зоонози, нагляд, охорона здоров'я.