

# Epidemiology in Southern Europe: West Nile Virus Current Landscape and Future Risks

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Scientific update through 2024–2025  
Including operational insights from outbreak response, Lazio,  
Italy 2025 outbreak

## Mosquito-borne viruses surge in a warming Europe

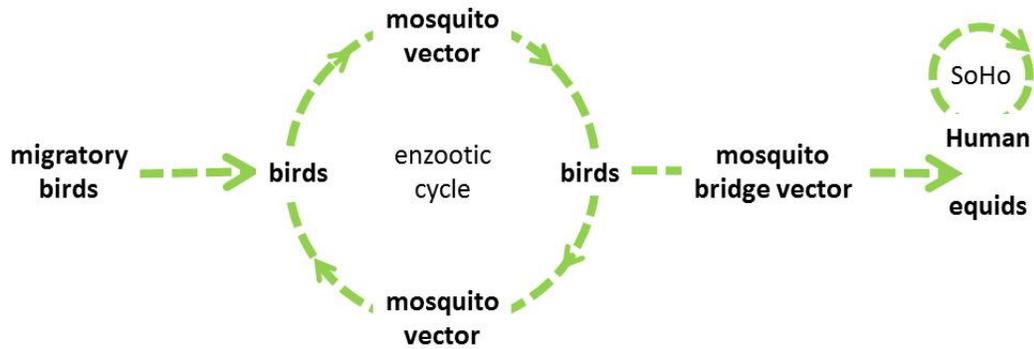
Chikungunya cases break records in France; West Nile virus appears near Rome

3 SEP 2025 • 1:05 PM ET • BY MEREDITH WADMAN

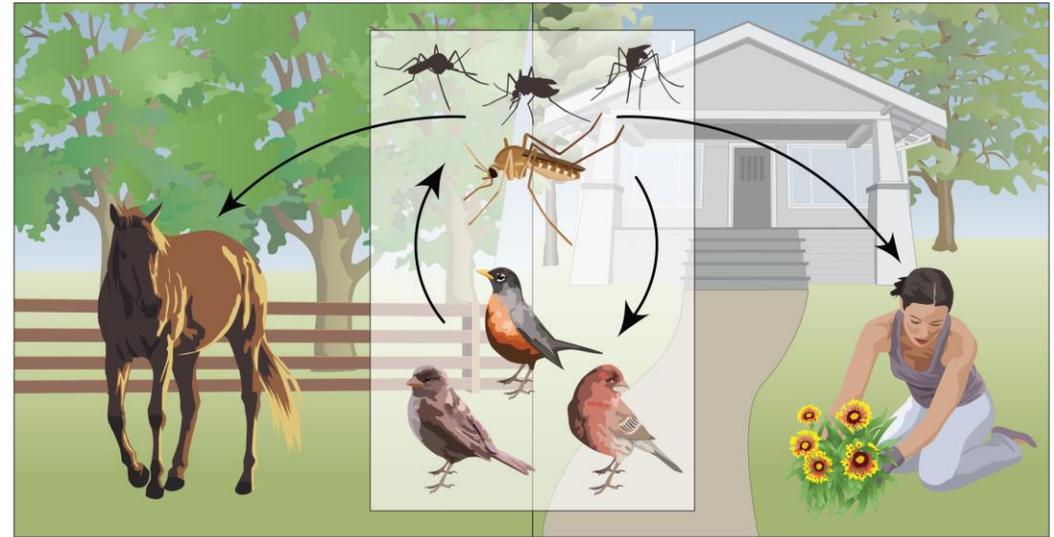


Workers sprayed pesticide in a public park in Naples, Italy, last month, aiming to kill mosquitoes spreading West Nile virus in the region. SALVATORE LAPORTA/KONTROLAB/LIGHTROCKET VIA GETTY IMAGES

<https://www.science.org/content/article/mosquito-borne-viruses-surge-warming-europe>



West Nile Virus Transmission Cycle



# Transmission Cycle Virus West Nile

# Spatio-temporal pattern in Europe: seasonal recurrence, endemicity, and geographic expansion - 2024



Legend (as of 20 November 2024)

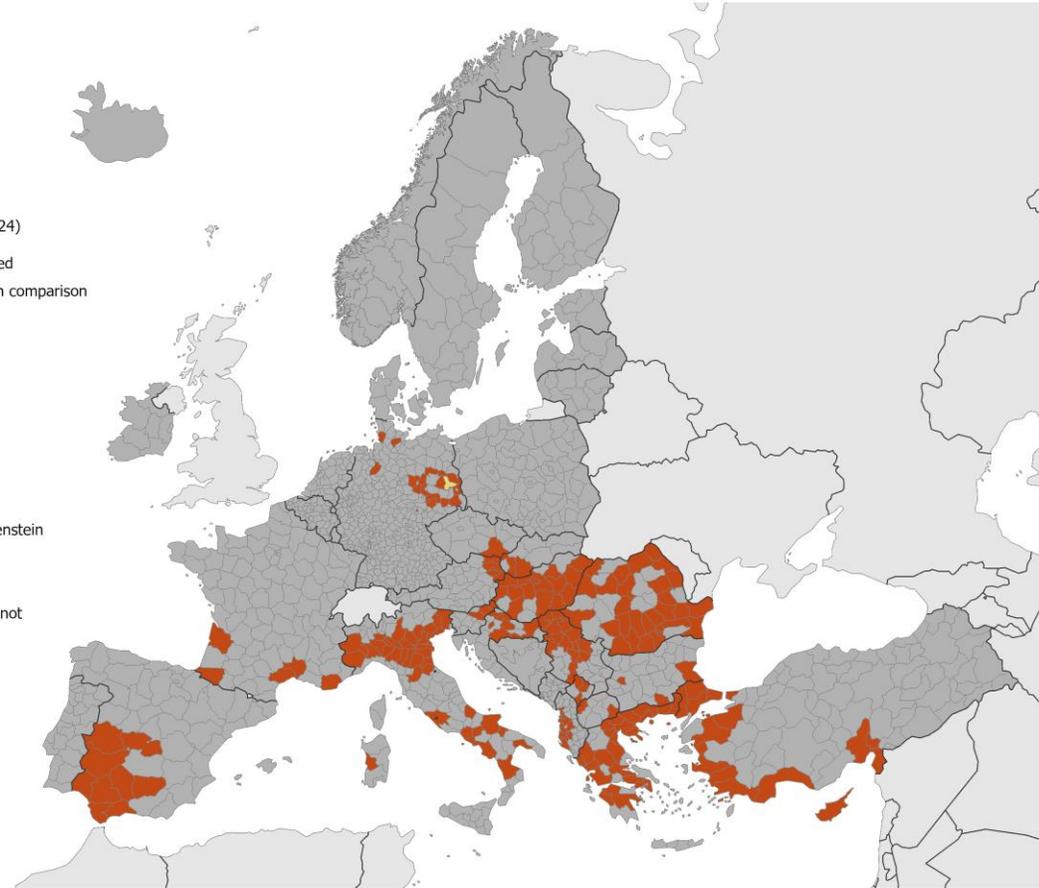
- Human infections reported
- Newly affected regions in comparison with the previous week
- No infections reported
- Not included

Countries not viewable in the main map extent

- Malta
- Liechtenstein

Affected EU Outermost Regions not viewable in the map extent

- Guadeloupe



Administrative boundaries: © EuroGeographics ©UN-FAO ©Turkstat. The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union. Map produced by ECDC on 21 November 2024

ECDC end-of-season map, 2024 transmission season

## Key surveillance facts

2024 recorded 1,436 locally acquired human cases across 19 countries and 212 affected regions - the widest geographic distribution reported in a single year by ECDC. In 2025, Europe still reported 1,112 locally acquired cases across 14 countries and 157 regions.

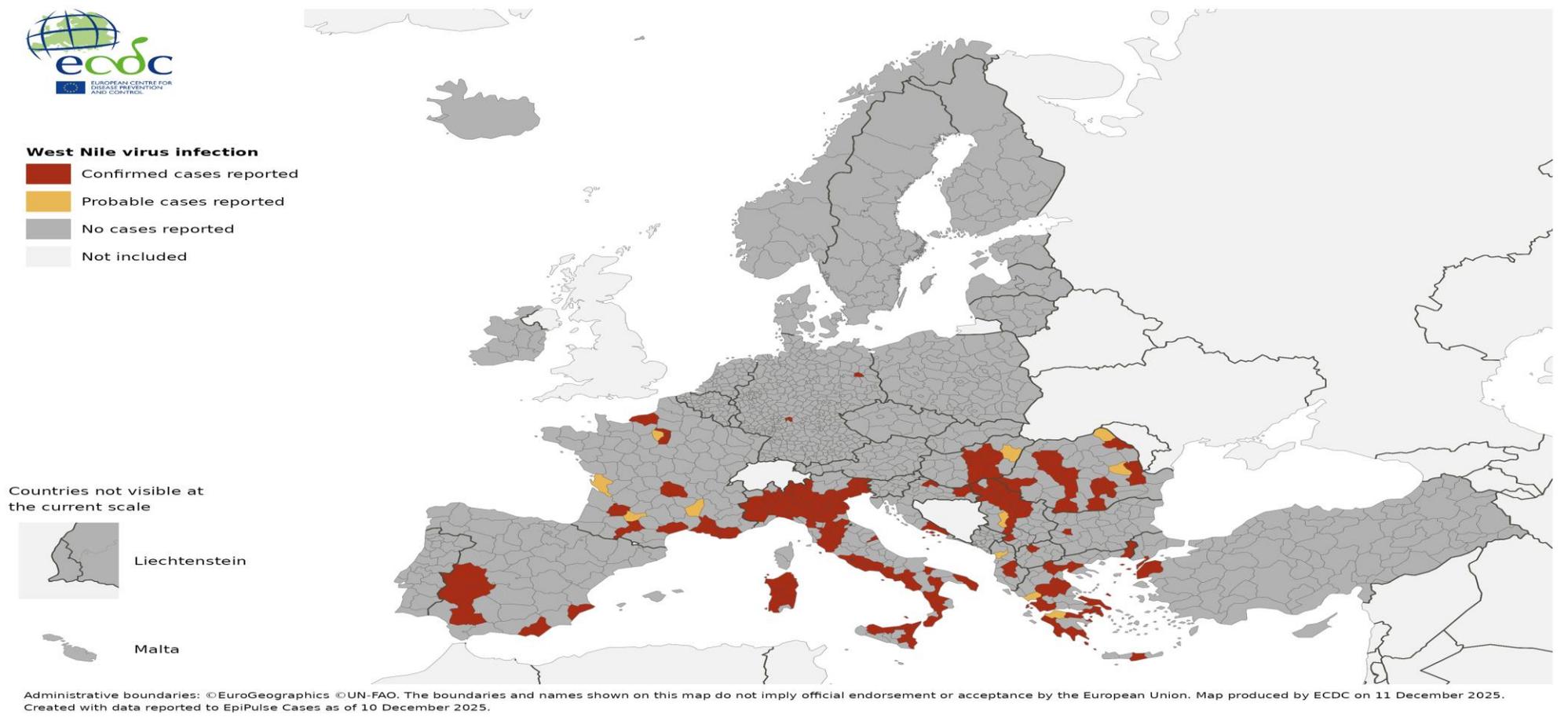
## Seasonality

2024 onset ranged from 1 March to 25 October. In 2025, onset ranged from 19 May to 27 October. The transmission season remains concentrated in warm months but with substantial inter-annual variation.

## GENETIC PATTERN

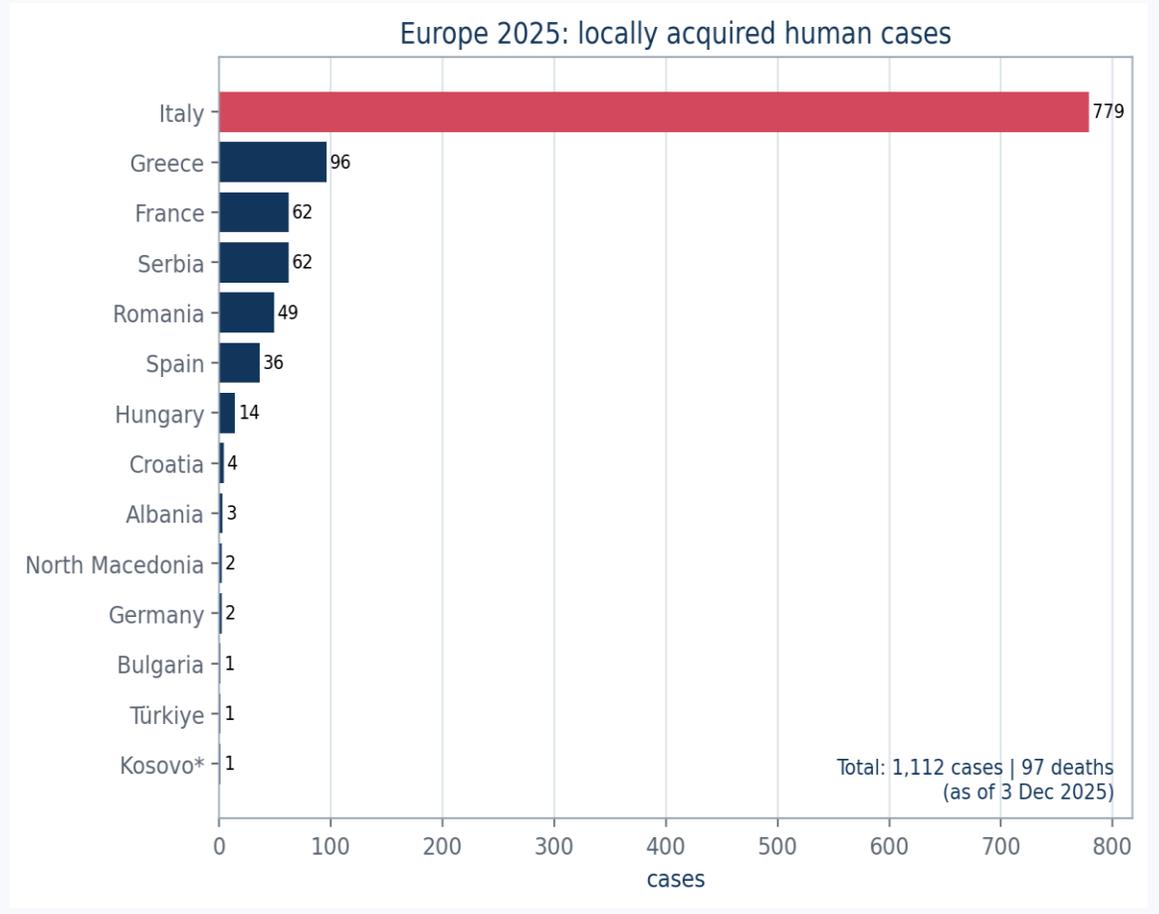
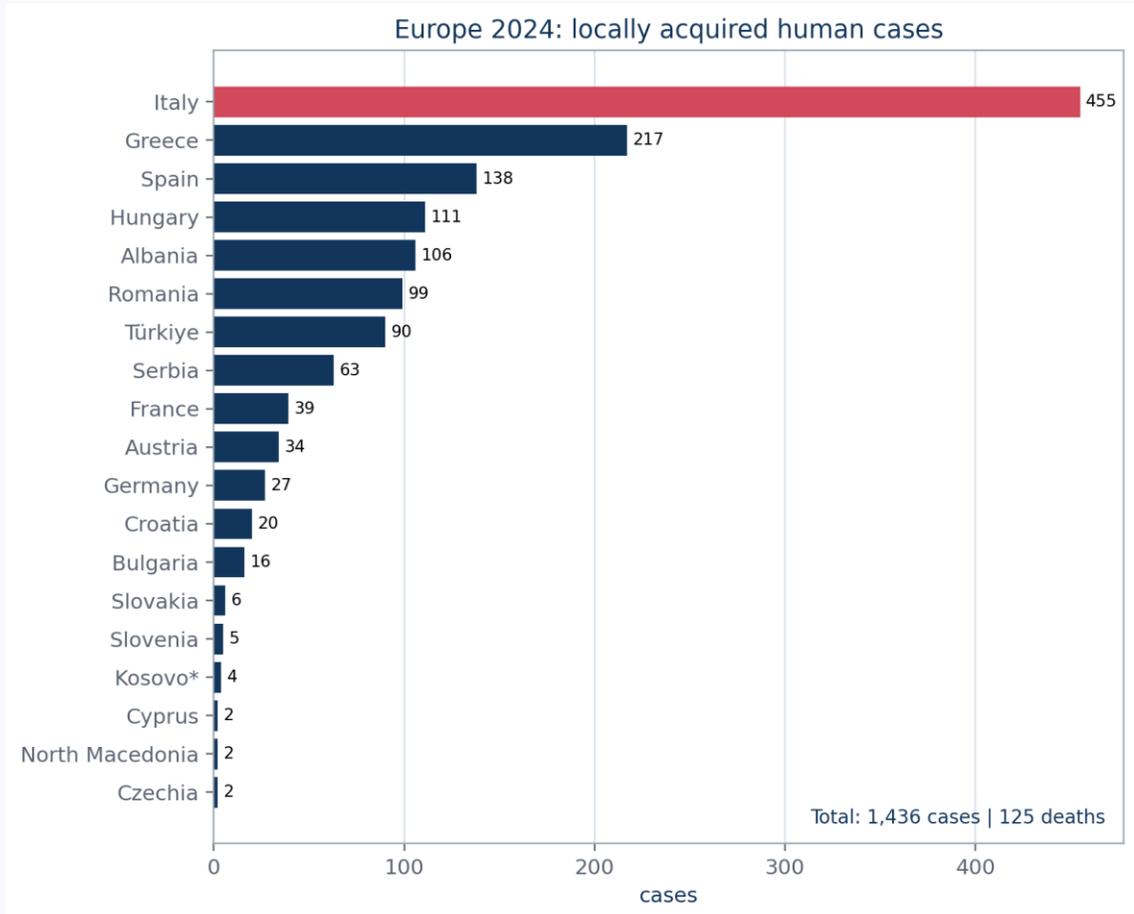
- Lineage 2 is widely established across central, eastern, and much of southern Europe.
- Lineage 1 still co-circulates, especially in the western Mediterranean basin.
- The recent westward detection of lineage 2 supports ongoing phylogeographic expansion.

# Spatio-temporal pattern in Europe: seasonal recurrence, endemicity, and geographic expansion - 2025



# The current landscape in Europe: Southern Europe remains the centre of gravity

Human surveillance highlights from the 2024 and 2025 European transmission seasons



2024: 1,436 locally acquired cases, 125 deaths, 19 reporting countries

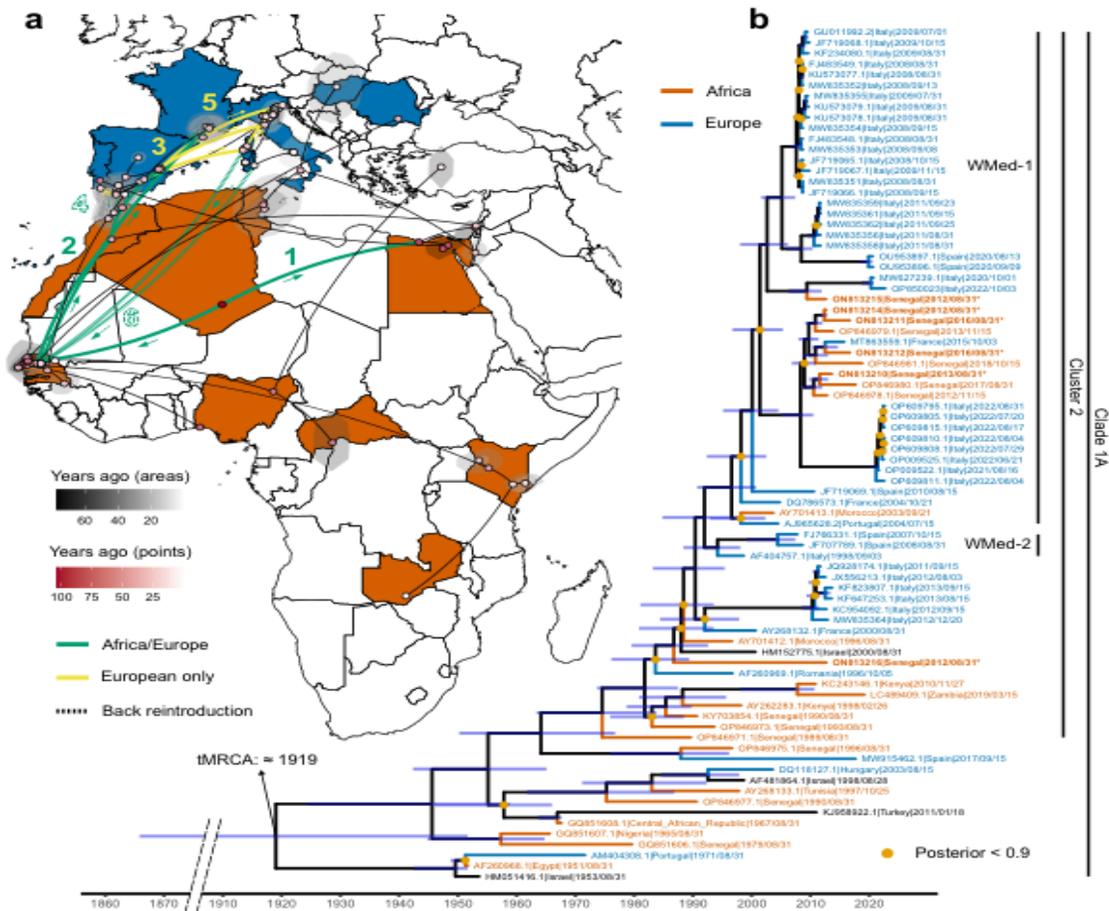
Data from: <https://www.ecdc.europa.eu/en/west-nile-fever/surveillance-and-disease-data/historical>

2025: 1,112 locally acquired cases, 97 deaths, 14 reporting countries (to 3 Dec)

Data from: <https://www.ecdc.europa.eu/en/infectious-disease-topics/west-nile-virus-infection/surveillance-and-disease-data/monthly-updates>

# Lineage 1: a North-West African origin with back-and-forth exchange

Nature Communications 2023 - figure adapted



**Fig. 1 | Phylogeographic reconstruction of West Nile virus lineage 1 (WNV L1) strains. a** Geographic diffusion pattern of 80 WNV L1 genomes and their ancestors was reconstructed. African and European countries from which the samples come from are coloured in dark orange and blue, respectively. Black areas correspond to

involving Africa and Europe (in green) and routes that took place entirely in Europe (in yellow). Dotted arcs indicate back reintroductions from Europe to Africa. **b** A molecular clock shows the phylogenetic relationships between the same 80 WNV L1 genomes. Light orange dots indicate nodes with a posterior probability <0.9.

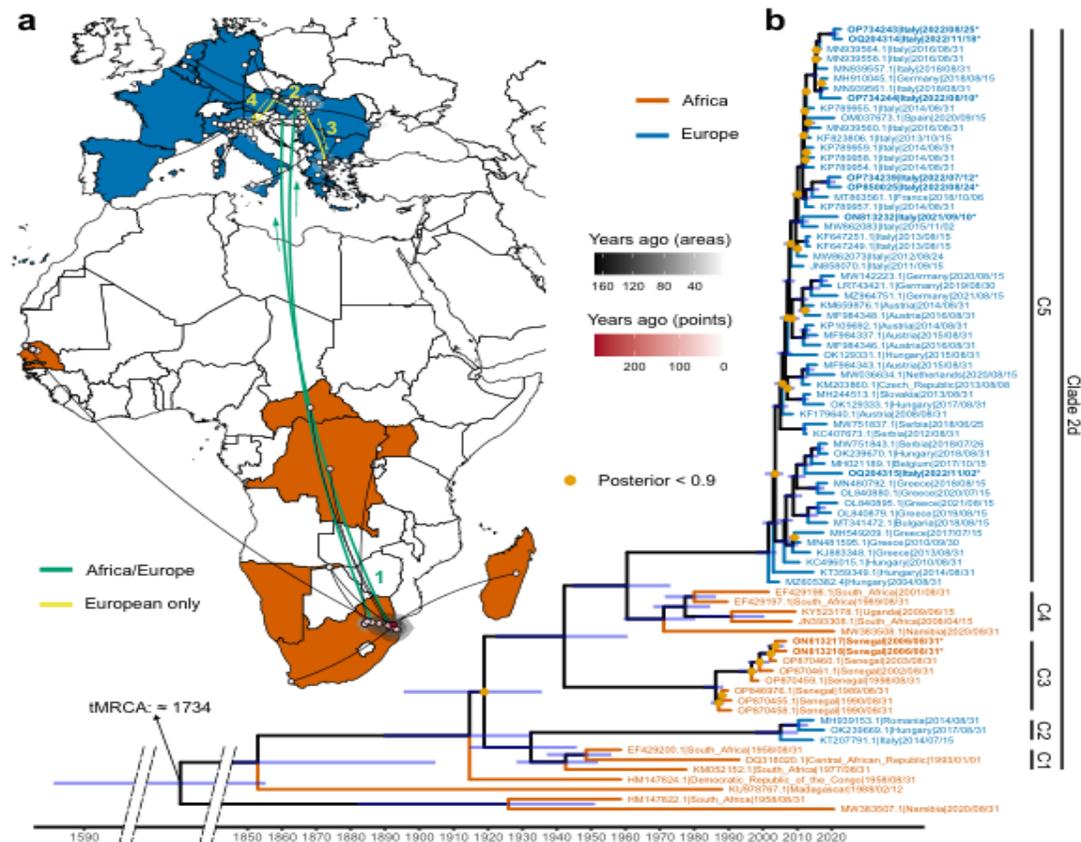
- Northern-Western African origin for WNV lineage 1 (L1).
- The inferred movements support repeated exchanges between West Africa and Southern-Western Europe, rather than a one-way spillover model.
- The spatial pattern is compatible with Afro-Palaeartic migratory flyways linking West Africa, Iberia and the western Mediterranean.

## Interpretation for Southern Europe

L1 should be viewed as part of a connected transcontinental eco-epidemiological system. Southern Europe is both a recipient and amplifier of circulation within that system.

# Lineage 2: Southern African origin and durable European establishment

Nature Communications 2023 - figure adapted



**Fig. 2 | Phylogenetic inference of West Nile virus lineage 2 (WNV L2) strains.**  
**a** Geographic diffusion pattern of 80 WNV L2 genomes and their ancestors was reconstructed. African and European countries from which the samples come from are coloured in dark orange and blue, respectively. Black areas correspond to the 80%HPDs of the inferred location. The time of each area or sample is indicated by different shades (black for areas and red for dots), with the oldest samples corresponding to the most intense shade. The main events of the diffusion of the virus are indicated on the map, with numbers from 1 to 4: 1) two introductions from

Africa or involving Africa and Europe (in green) and routes that took place entirely in Europe (in yellow). Dotted arcs indicate back reintroductions from Europe to Africa. **b** A molecular clock shows the phylogenetic relationships between the same 80 WNV L2 genomes. Light orange dots indicate nodes with a posterior probability <0.9, while 95% HPDs of the median ages are indicated with blue bars. African and European sequences are coloured by continent. The time of the most recent common ancestor (tMRCA) for all WNV L2 sequences included in the analysis was estimated to be around 1733. On the right, 6 groups of interest, which are con-

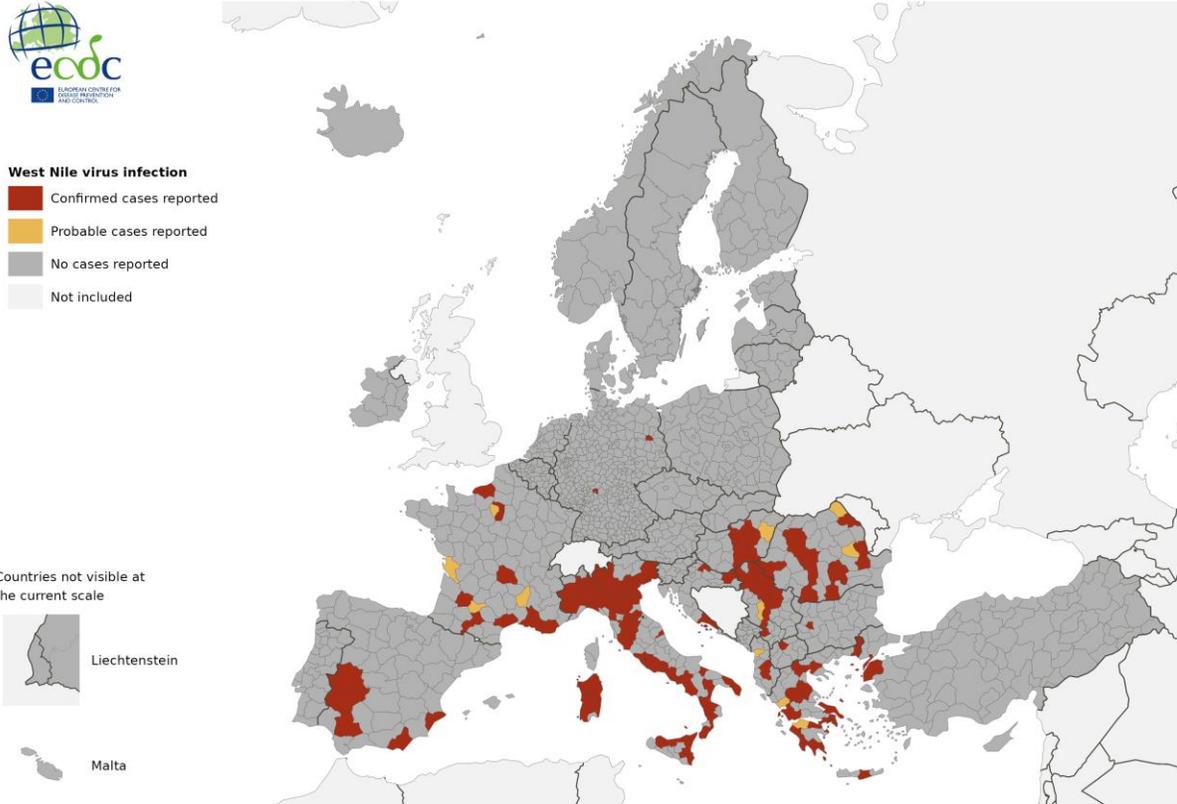
- For WNV lineage 2 (L2), Southern African origin.
- The dominant pattern is one main introduction from South Africa into Europe, followed by extensive European diversification.
- No back-introductions from Europe to Africa were observed for L2 in this analysis.
- This helps explain why L2 now behaves as an established European lineage rather than an episodic incursion.

**Implication**  
 For preparedness planning, Europe must address both external introductions and internal persistence. Once introduced, L2 can sustain broad regional spread across European ecological niches.

# Why Southern Europe sustains WNV transmission

The ecological niche is shaped by climate, vectors, birds, and human-modified landscapes

## 1. Warm springs, hot summers, mild winters



Administrative boundaries: ©EuroGeographics ©UN-FAO. The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union. Map produced by ECDC on 11 December 2025. Created with data reported to EpiPulse Cases as of 10 December 2025.

## 1. Warm springs, hot summers, mild winters

Temperature compresses the extrinsic incubation period, increases vector abundance, and can favour earlier seasonal activation.

## 2. Wetlands, irrigation and drainage systems

River valleys, reclaimed coastal plains, rice fields and ditch networks create persistent larval habitats for *Culex* spp.

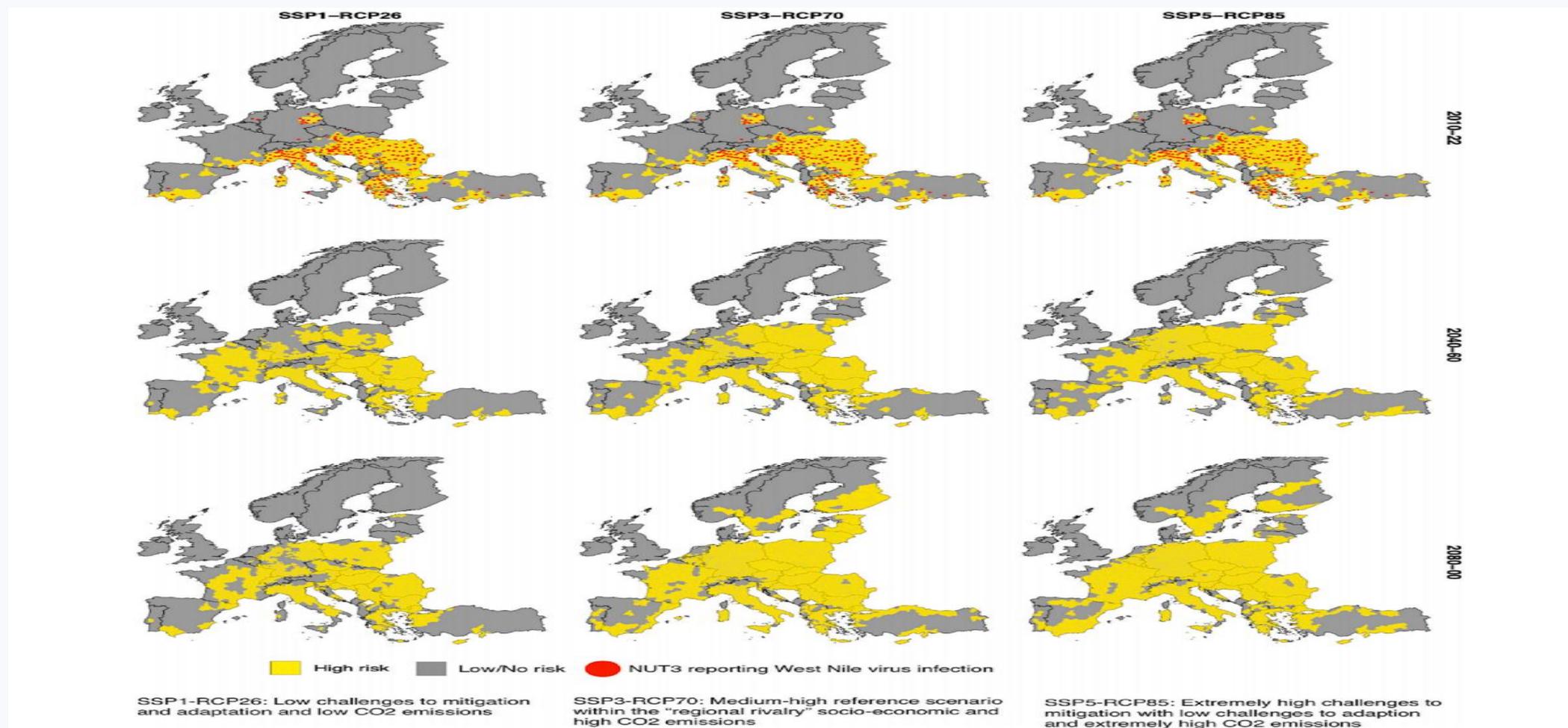
## 3. Migratory and resident birds

Southern Europe sits at the interface of Afro-Palaearctic flyways, enabling viral introduction, amplification and regional reseedling.

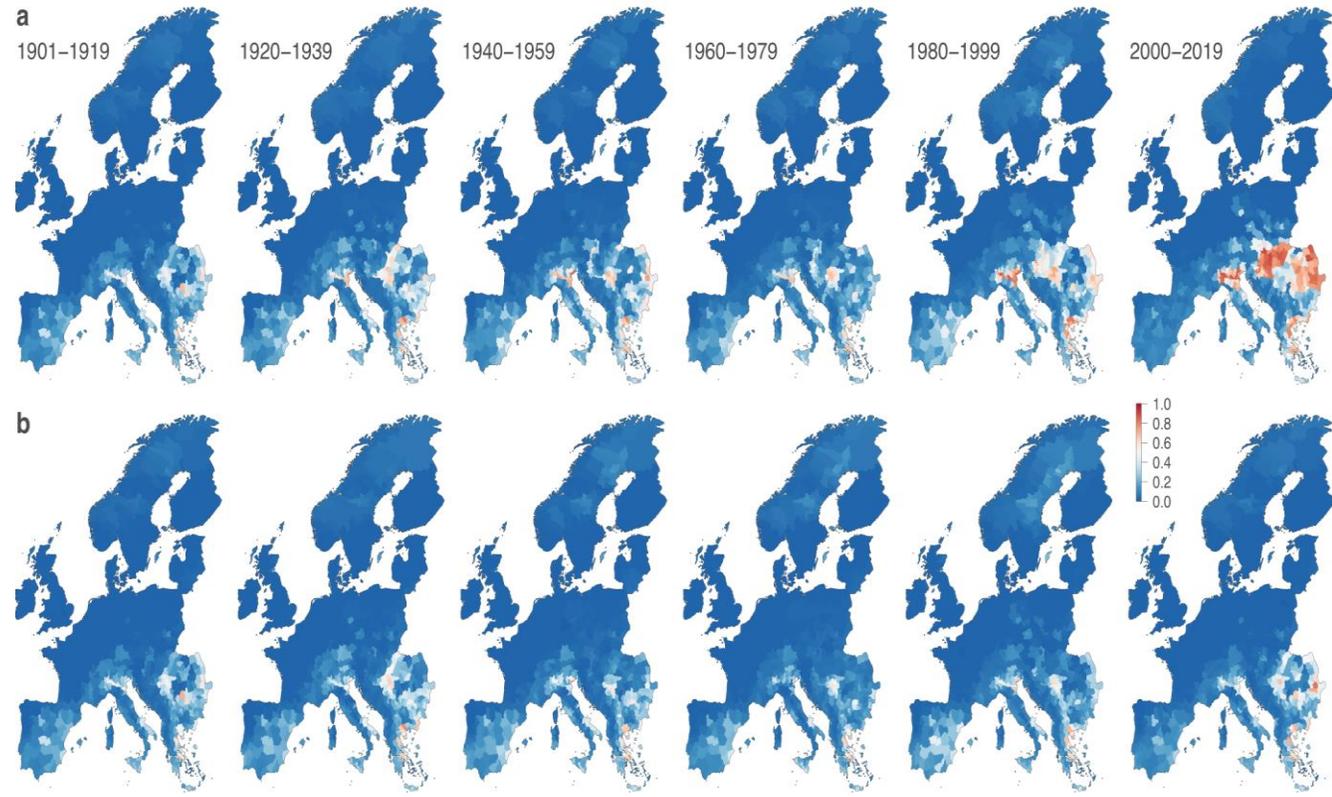
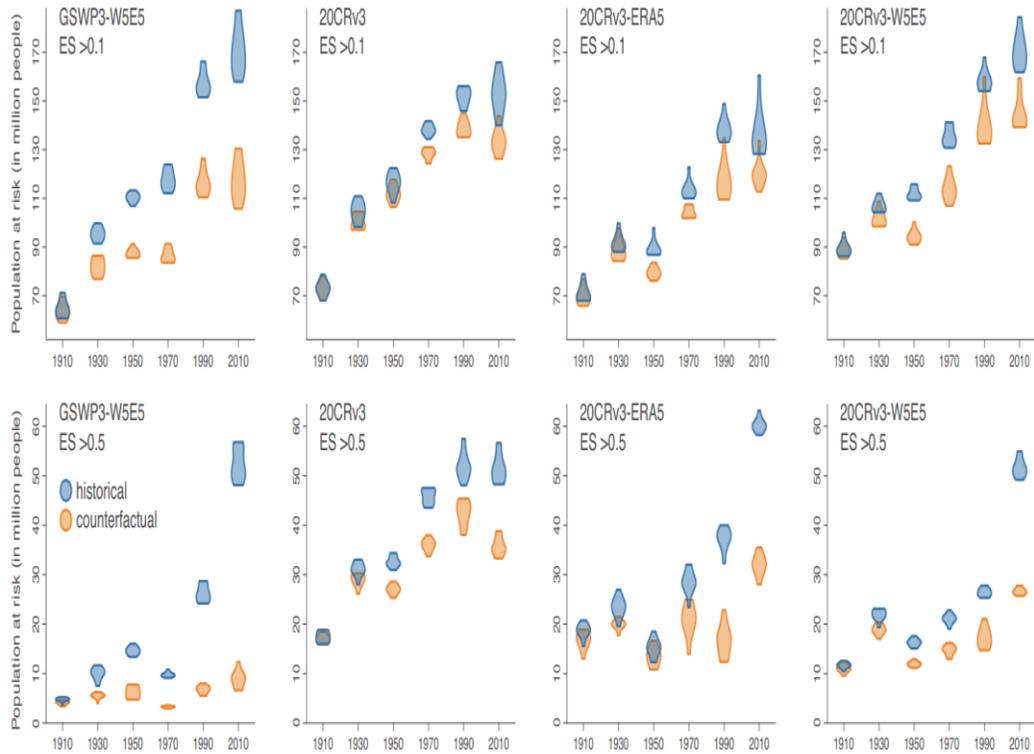
## 4. Urban–rural ecotones and ageing populations

Human exposure increases where peri-urban settlements overlap with vector habitats, while older populations increase the burden of WNND.

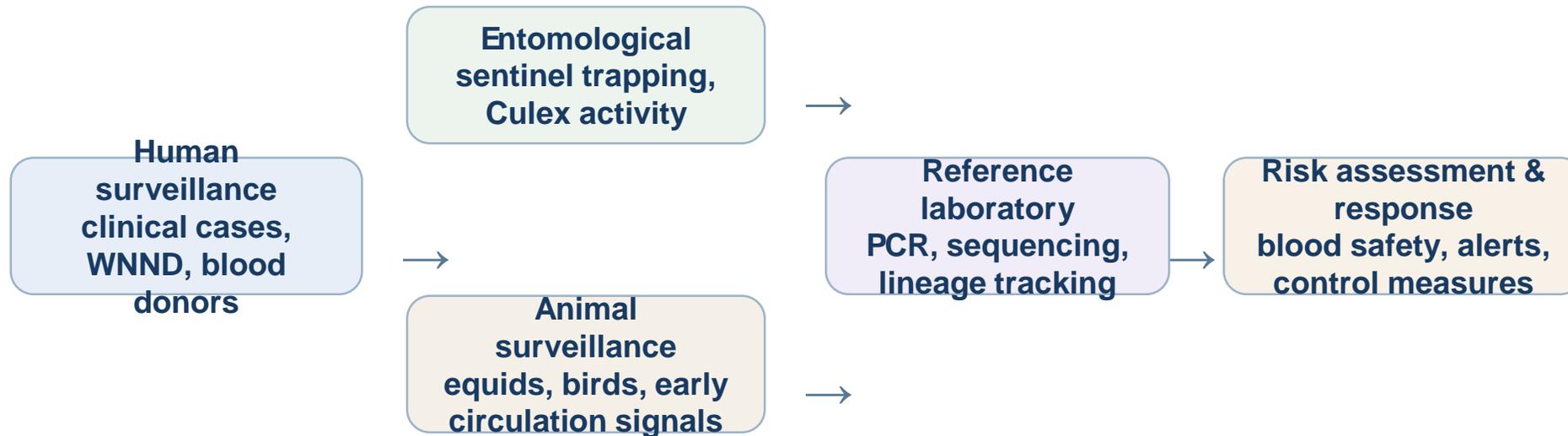
# Contribution of climate change to the spatial expansion of West Nile virus in Europe



# Contribution of climate change to the spatial expansion of West Nile virus in Europe



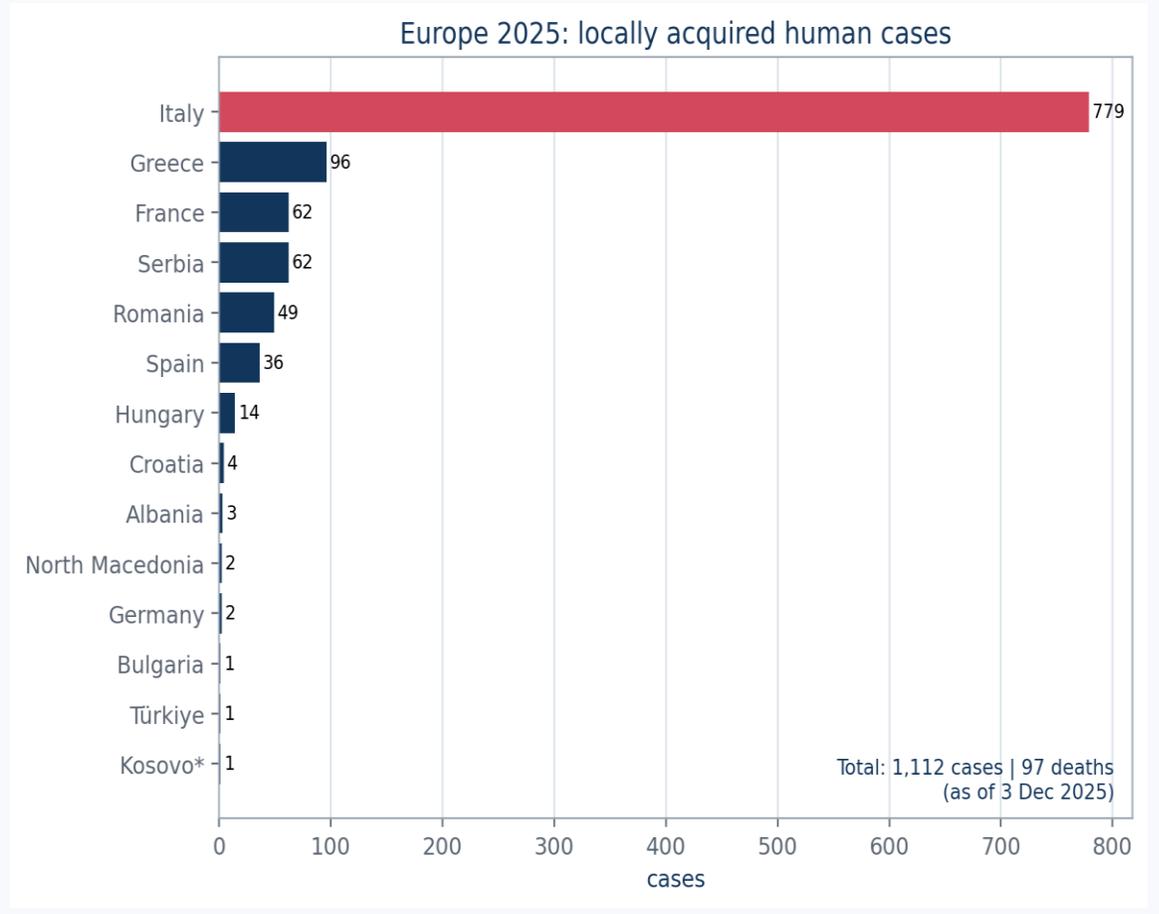
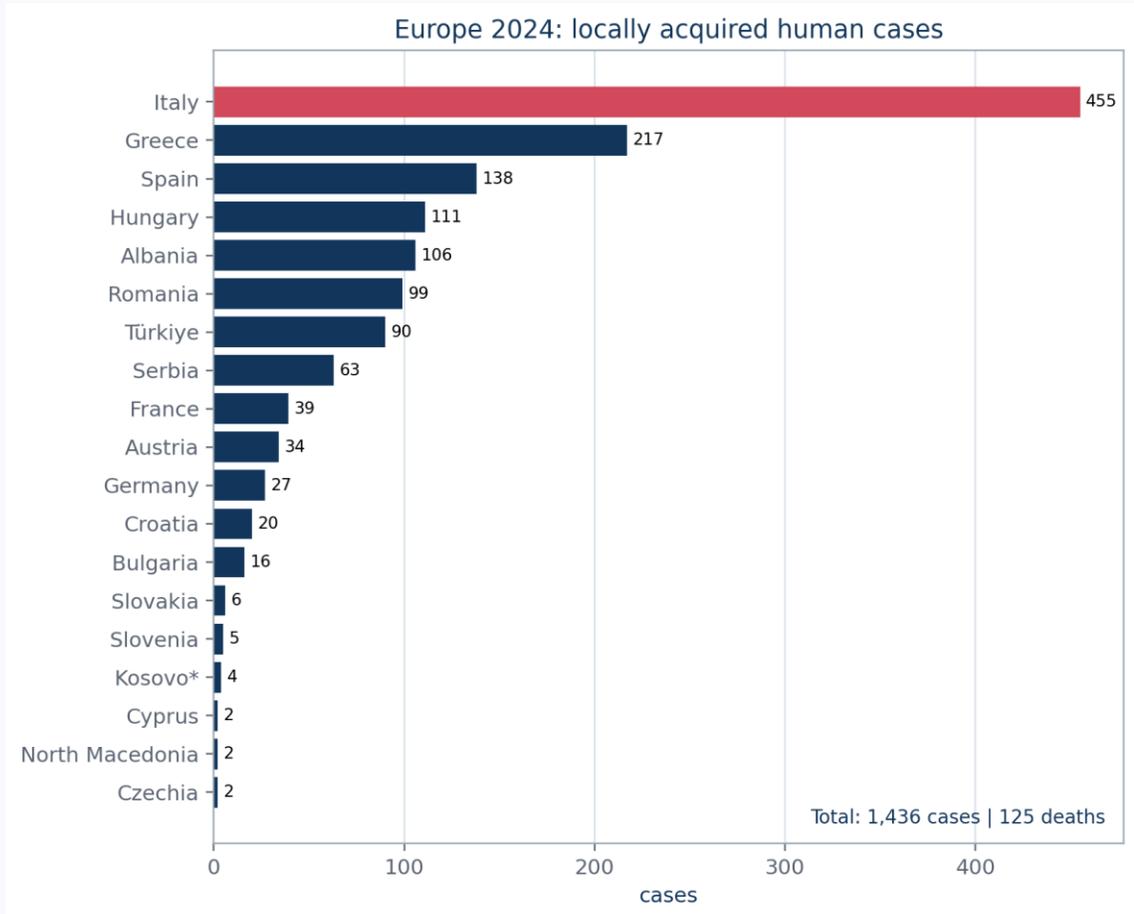
# Operational implications for regional preparedness



- Regional response must combine epidemiology, laboratory capacity and environmental intelligence in near real time.
- Sequencing is useful not only for confirmation but also to distinguish persistence, re-introduction and lineage replacement.
- Preparedness outputs include donor safety measures, targeted communication, vector control prioritisation and support to clinicians.

# The current landscape in Europe. Southern Europe remains the centre of gravity

Human surveillance highlights from the 2024 and 2025 European transmission seasons



2024: 1,436 locally acquired cases, 125 deaths, 19 reporting countries

2025: 1,112 locally acquired cases, 97 deaths, 14 reporting countries (to 3 Dec)

<https://www.ecdc.europa.eu/en/west-nile-fever/surveillance-and-disease->

<https://www.ecdc.europa.eu/en/infectious-disease->

# Italy has become the principal Southern European hotspot



## 2018

618 confirmed cases and 49 deaths in Italy: the first recent European-scale shock year.

## 2022

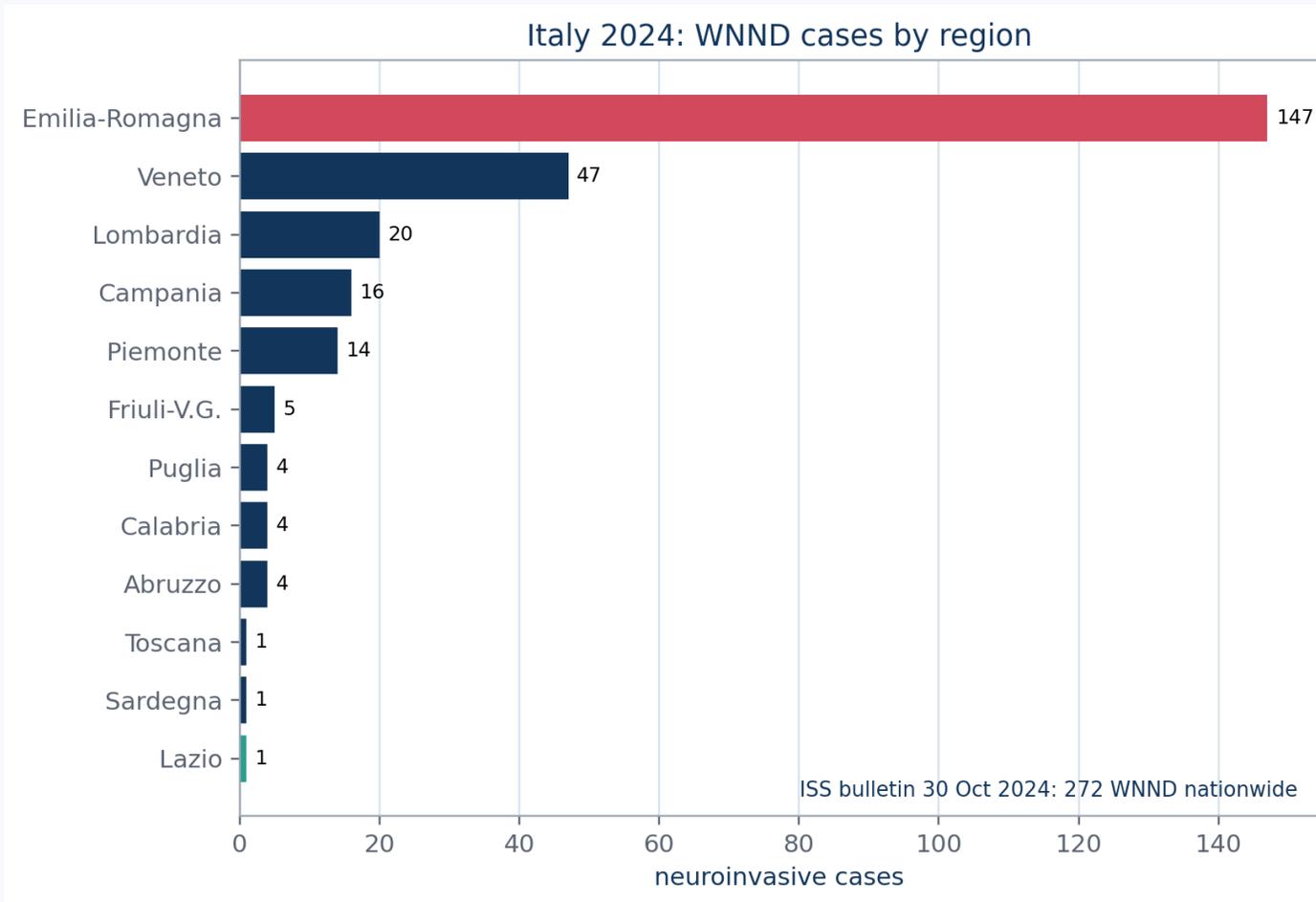
728 confirmed cases and 51 deaths: early season, heatwave context, and lineage co-circulation in northern Italy.

## 2025

779 human cases and 72 deaths reported to the 3 Dec 2025 ECDC/EFSA monthly report — the highest annual burden reported by Italy so far.

Interpretation: the Italian trajectory is no longer episodic. It now shows a recurrent high-burden pattern with periodic step changes.

# 2024 in Italy: a high-burden season still dominated by the north-east



**484**  
total cases

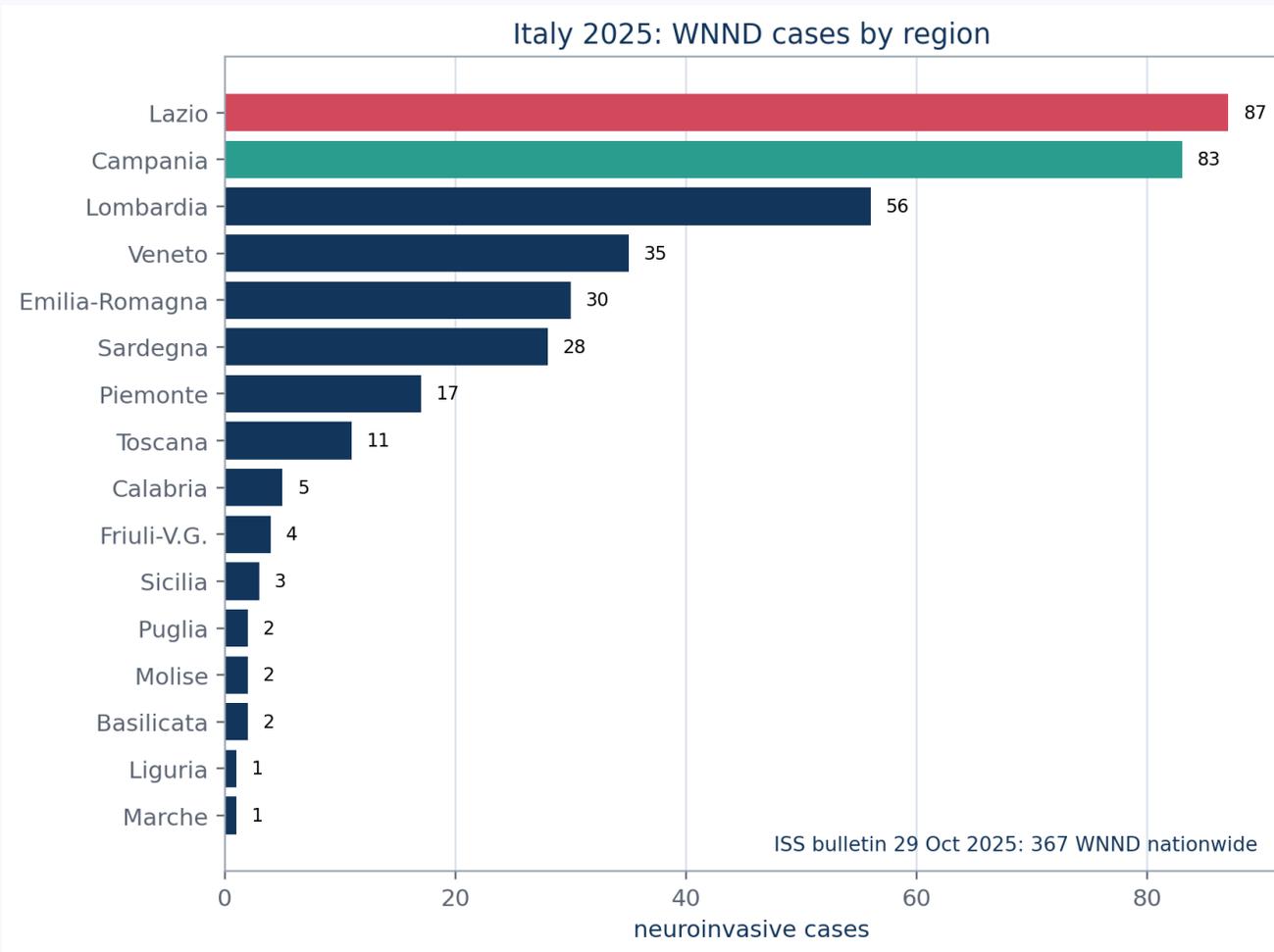
**266**  
WNND

**36**  
deaths

**Regional signal:** WNND was heavily concentrated in Emilia-Romagna (147) and Veneto (47), with only one WNND case reported from Lazio in the last ISS bulletin of the season.

**Interpretation:** 2024 still fits the classic northern-Italian pattern, but the season was broad enough to foreshadow wider ecological suitability and a potential southward shift.

# 2025 in Italy: an unprecedented season with a south-central redistribution



**779**  
human cases  
(as of 3 Dec)

**367**  
WNND  
(ISS 29 Oct)

**72**  
deaths

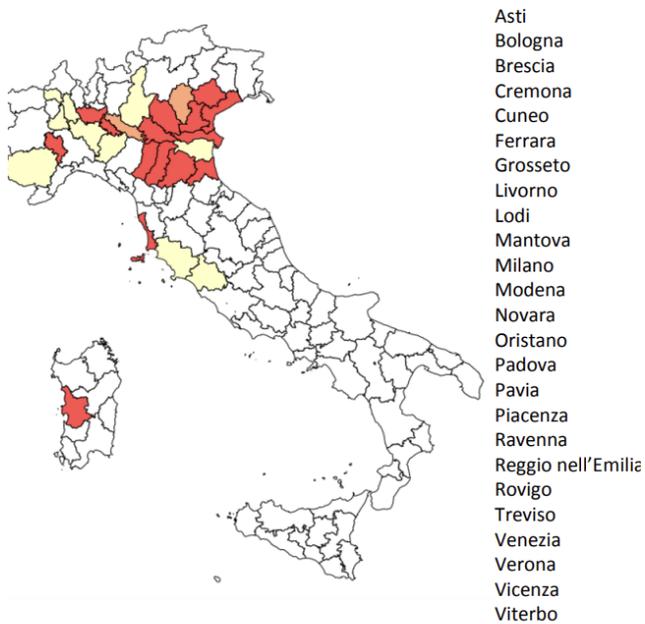
**Regional shift:** Lazio (87 WNND) and Campania (83 WNND) nearly matched the combined northern traditional hotspots.

**First-ever reporting regions:** E CDC/E FSA highlighted multiple Italian first-ever affected regions in 2025, including Latina and Frosinone, supporting genuine geographic expansion rather than only better ascertainment.

# Increasing spread of arboviral diseases in Italy – West Nile virus

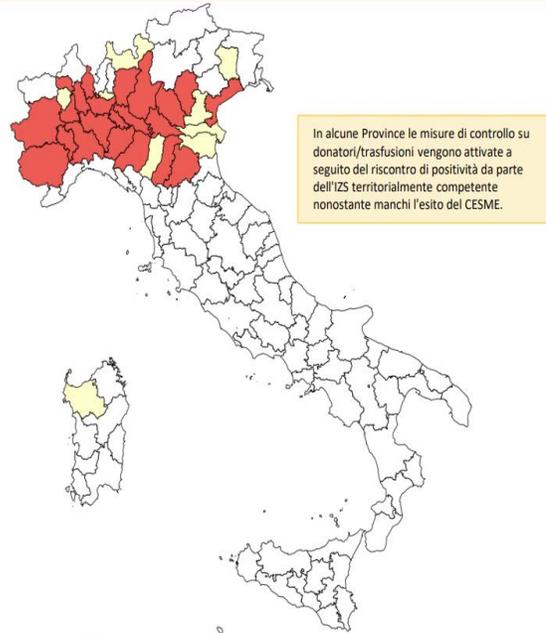
2017

**Figura 1.** Province con dimostrata circolazione di WNV in vettori, animali e uomo (donatori asintomatici, febbri e casi neuroinvasivi confermati)



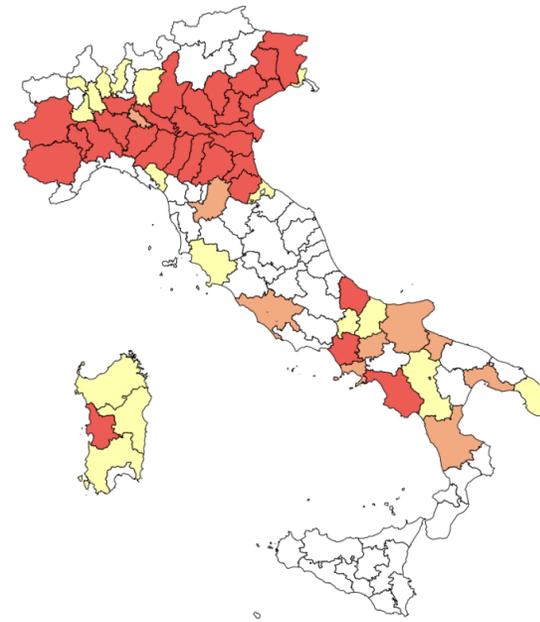
2020

**Figura 1.** Province con dimostrata circolazione di WNV in vettori, animali e uomo (donatori asintomatici, febbri e casi neuroinvasivi confermati)



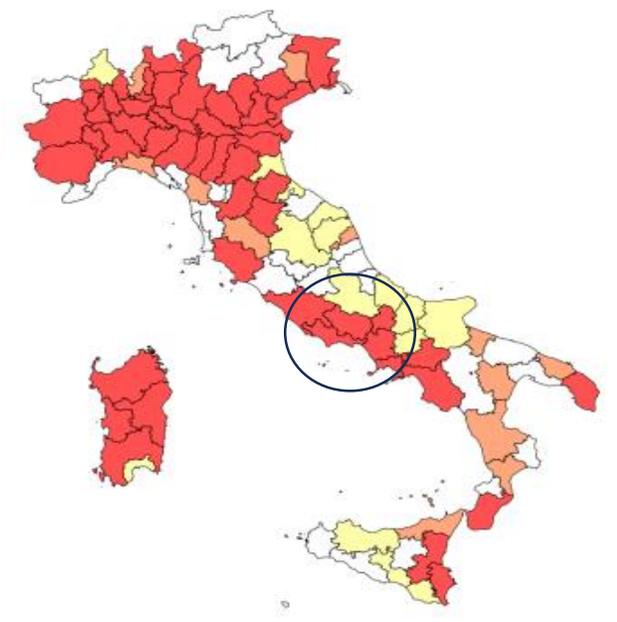
2024

**Figura 1.** Province con dimostrata circolazione di WNV in vettori, animali e uomo (donatori asintomatici, febbri e casi neuroinvasivi confermati)



2025

**Figura 1.** Province con dimostrata circolazione di WNV in vettori, animali e uomo (donatori asintomatici, febbri e casi neuroinvasivi confermati)



Province a dimostrata circolazione di WNV nell'uomo e nell'animale/vettore

Province a dimostrata circolazione di WNV solo nell'uomo

Province a dimostrata circolazione di WNV solo nell'animale/vettore

Province a dimostrata circolazione di WNV nell'uomo e nell'animale/vettore

Province a dimostrata circolazione di WNV solo nell'uomo

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Province a dimostrata circolazione di WNV nell'uomo e nell'animale/vettore

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Province a dimostrata circolazione di WNV nell'uomo e nell'animale/vettore

Province a dimostrata circolazione di WNV solo nell'uomo

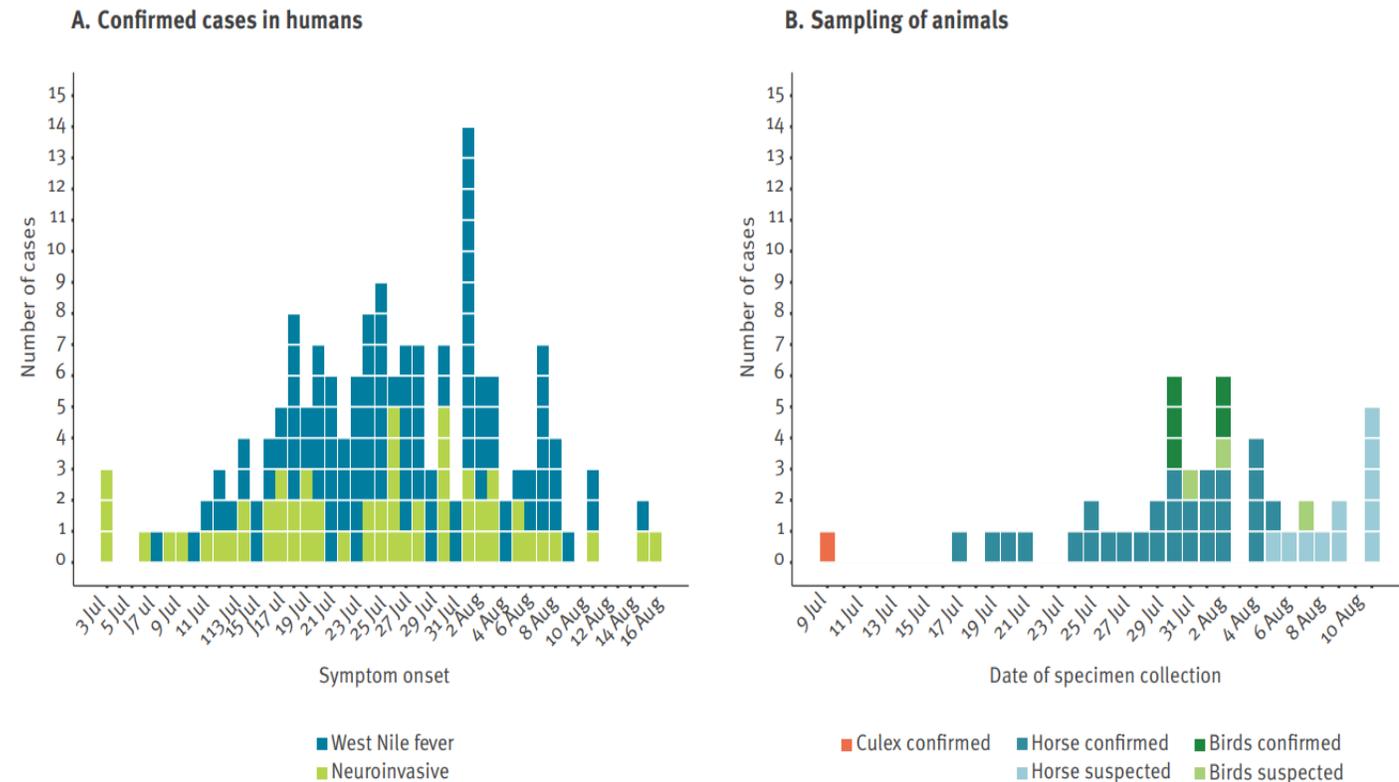
Province a dimostrata circolazione di WNV solo nell'animale/vettore

# Outbreak of autochthonous West Nile virus infection in Lazio region, 2025

- Most cases occurred in the province of Latina (already considered at high risk for WNV).
- Genomic characterization identified lineage 2 as the cause of the WNV outbreak described in humans, birds, mosquitoes, and equines.

**FIGURE 1**

Timeline of symptom onset of human cases with West Nile virus infection (n = 167) (A) and sampling of animals (B), Lazio region, Italy, July–18 August 2025



# 2025 Regional Risk Classification



## HIGH RISK (Red Zone)

Viterbo (VT)

Roma (RM)

Latina (LT)

## LOW RISK (Green Zone)

Frosinone (FR)

Rieti (RI)

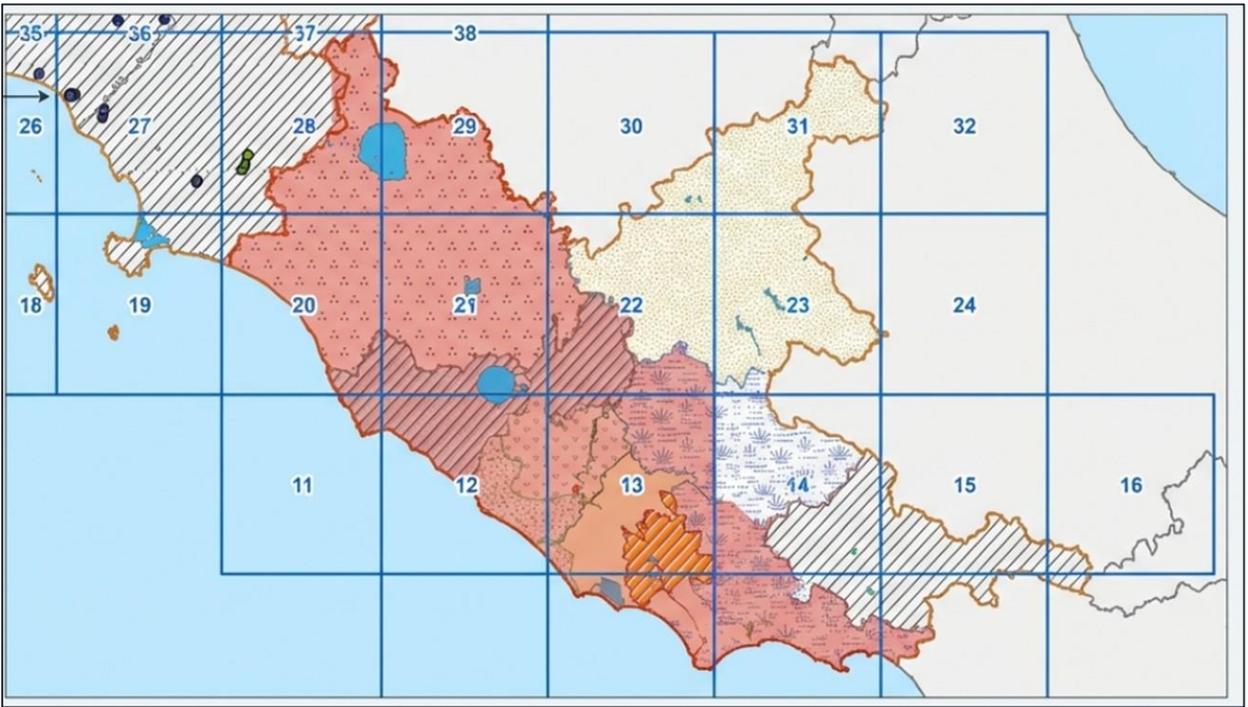
# WND Regional Surveillance Plan (RSP)— Lazio 2025 “VET” RSP



## 1. Avian (Reservoir)

Targeting resident synanthropic birds acting as viral amplifiers.

**40 Km x 40 Km**



Active Surveillance	Targeted capture of Synanthropic birds (Magpie, Crow, Jay).
Target Volume	100 specimens per grid cell.
Season	March – November.
Passive Surveillance	Recovery and testing of dead wild birds (Region-wide / Year-round).
Contingency	Sentinel chickens in rural farms if active yield is insufficient.

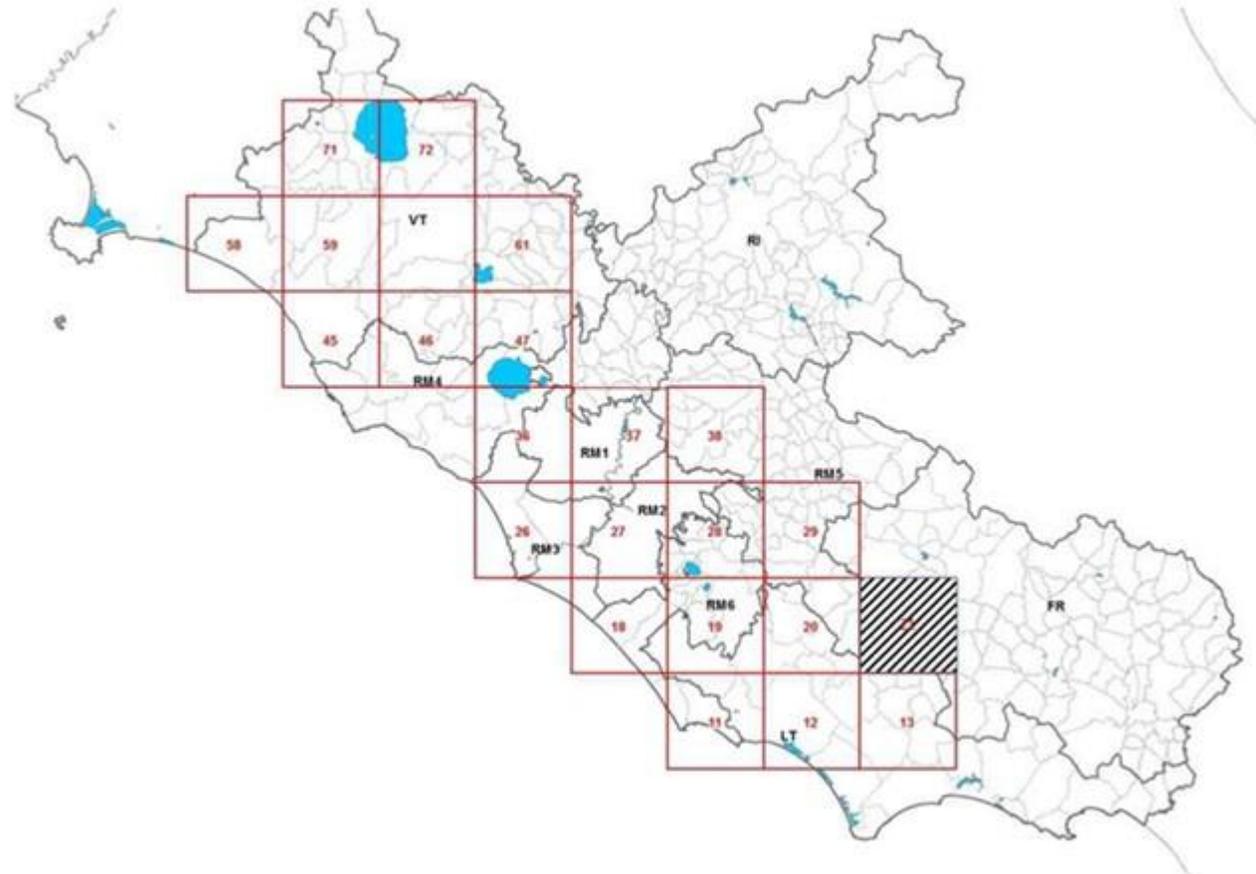
# WND Regional Surveillance Plan (RSP)— Lazio 2025 “VET” RSP



20 Km x 20 Km

## 2. Entomological (Vector)

Targeting mosquito pools to detect the virus



Season	April – November (Biweekly captures).
Method	CDC/Gravid traps.
Analysis	Species ID + Viral testing on mosquito pools.

### Geographic Scope

**High Risk (Red Zone):** Systematic grid activation.

**Low Risk (Green Zone):** 1 identified risk site per province.

# WND Regional Surveillance Plan (RSP)— Lazio 2025 “VET” RSP



## 3. Equine

Targeting susceptible hosts as a passive warning system.

### Protocols

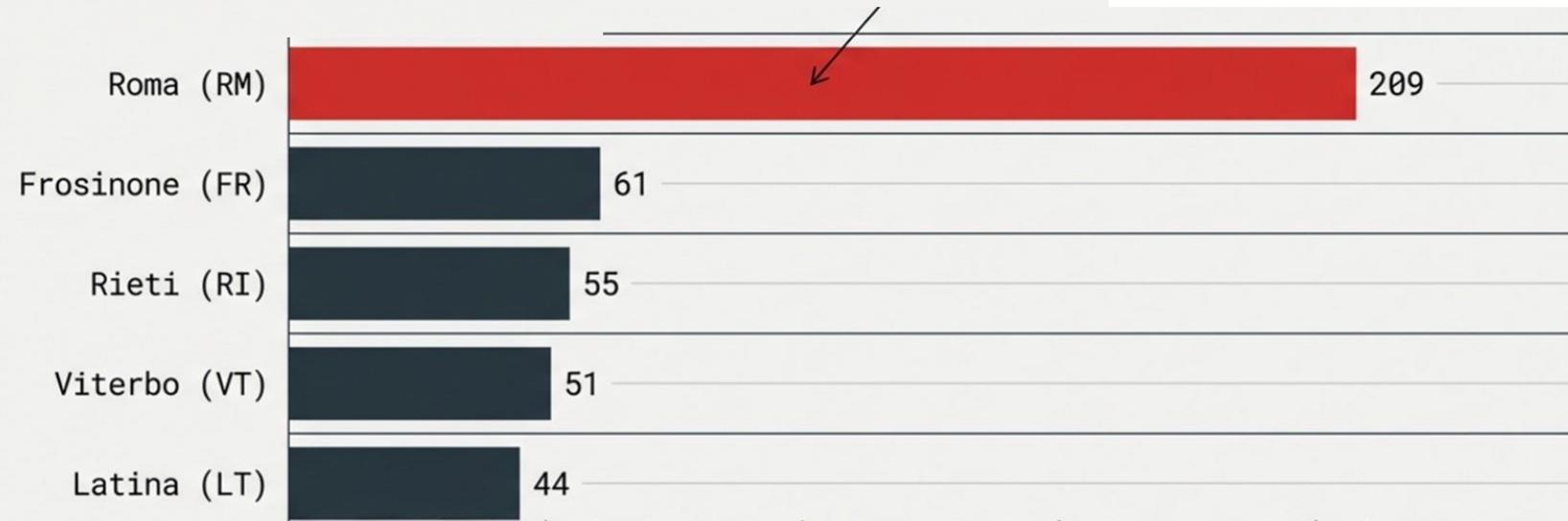
Passive: Mandatory reporting of nervous symptoms (Year-round).

Active: Monthly sampling of 420 sentinel equines.

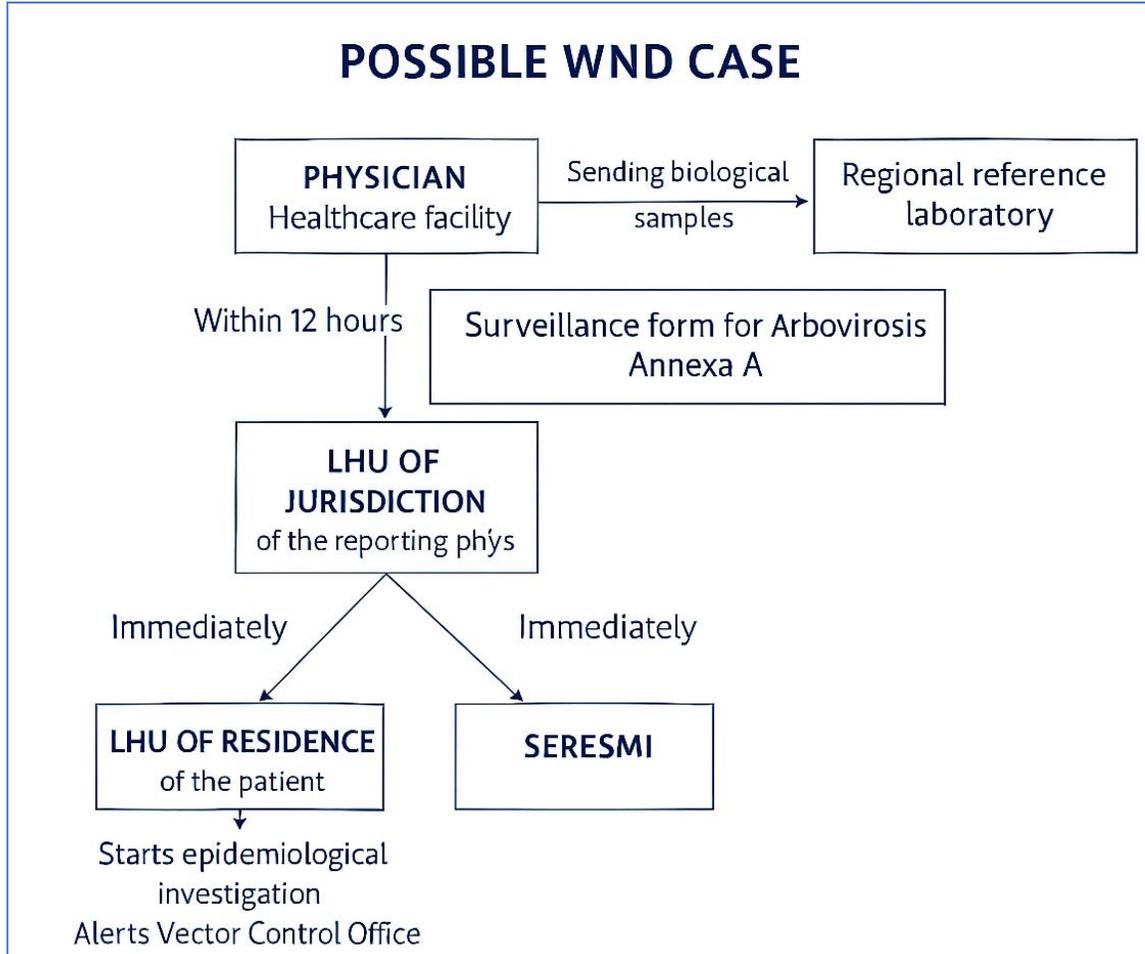
Start Date: July 2025.

### Sentinel Selection Criteria

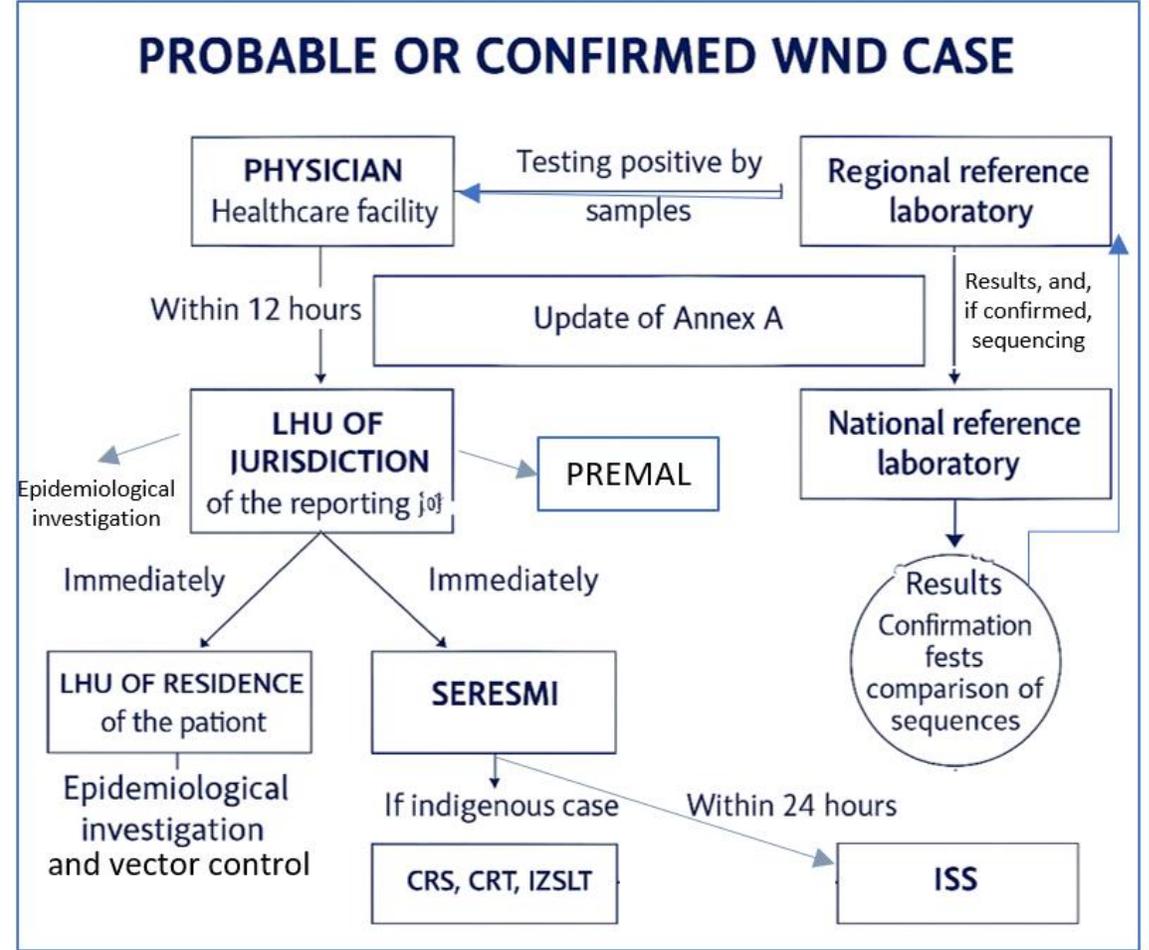
- Must be Unvaccinated.
- Location <800m above sea level.
- Proximity to wetlands/risk factors.



# WND Human Surveillance algorithm — Lazio 2025



LHU: Local health unit



PREMAL: National infectious disease reporting system coordinated by the Ministry of Health

CRT: Regional transplant center CRS: Regional blood center

ISS: Italian National Institute of Health IZSLT: Experimental Zooprohylactic Institute of Lazio and Tuscany

# LAZIO 2009-2024 WNDV Cases N=21



Horses  
N=20

Magpies  
N=1



# Background – Lazio up to 2024



**Human Cases Recorded  
(Historic)**

## Status

Lazio is not an endemic area but is subject to seasonal incursions

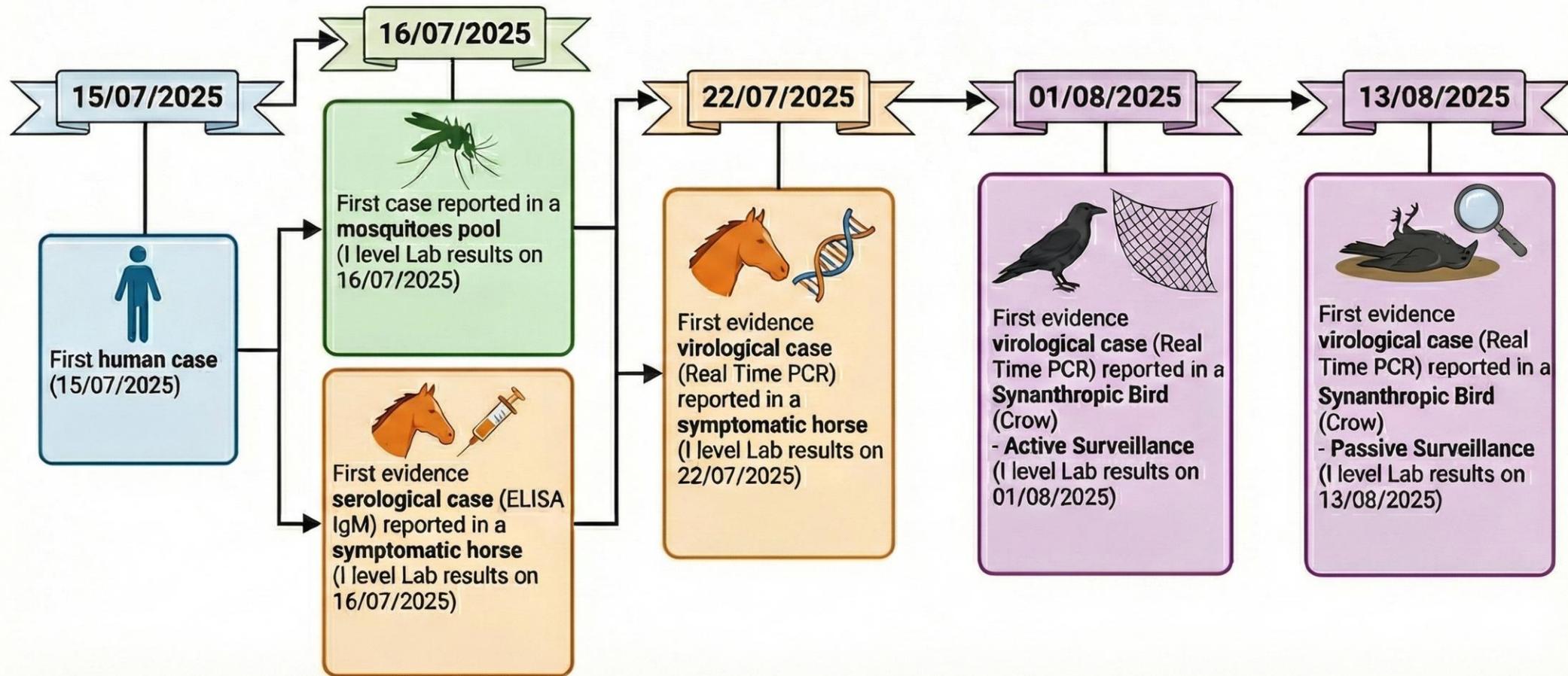
## History

Sporadic cases recorded in horses and birds. Lower vector abundance compared to Northern Italy.

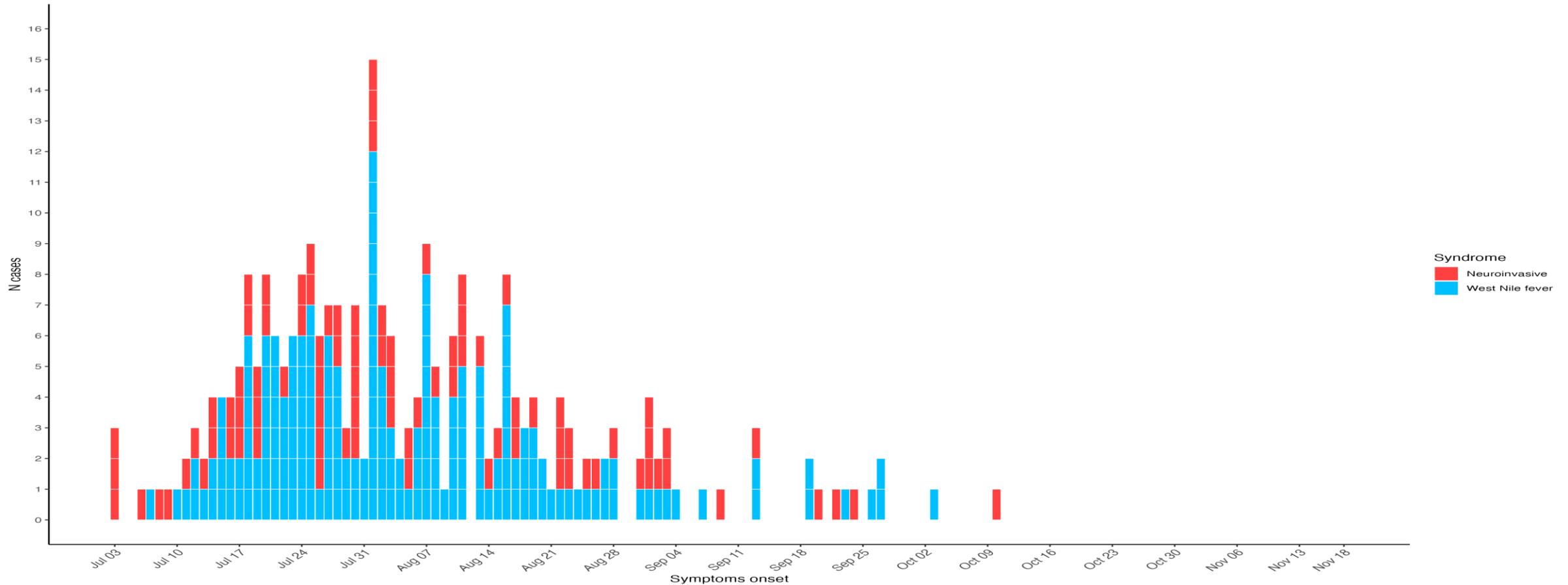
## Goal

Early warning detection through integrated veterinary and entomological channels to prevent spillover.

# TIMELINE: index cases reporting by surveillance component



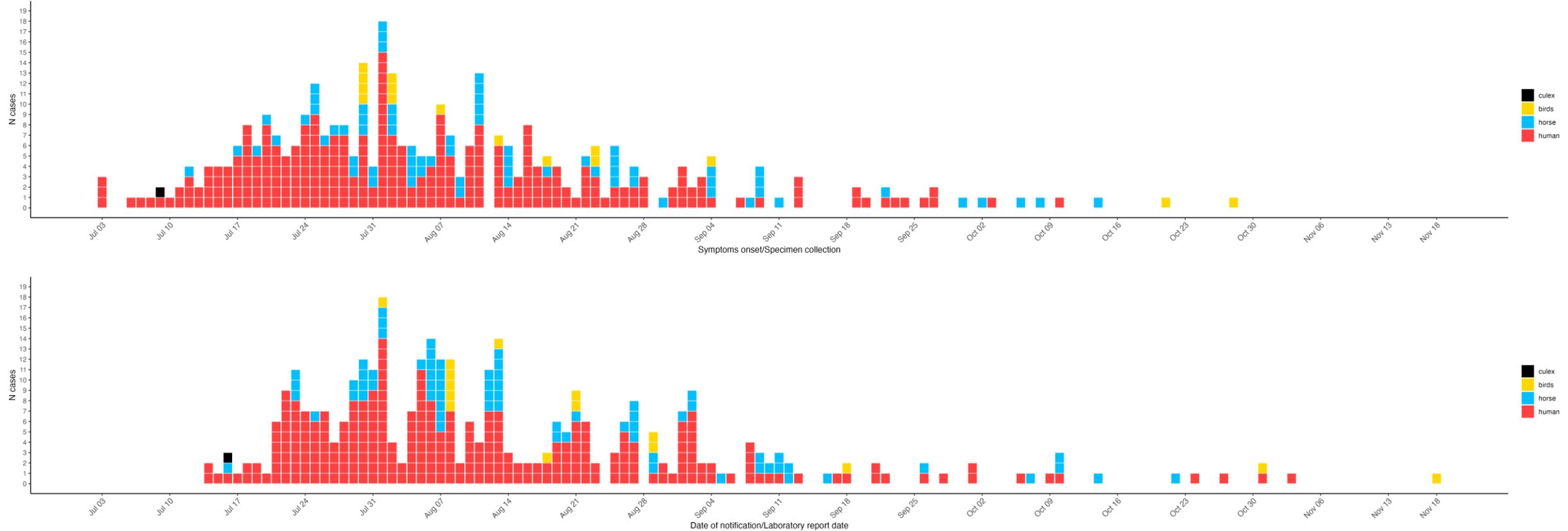
# WNDV LAZIO: final picture – Human Surveillance - Epidemic Curve by WNV Syndrome



Epidemic Curve of Confirmed Human Cases (n=263) by Symptom Onset and Syndrome Classification

<b>Characteristics</b>	<b>West Nile neuroinvasive disease (WNND) (n = 88)</b>	<b>West Nile fever (WNF) (n = 174)</b>	<b>Blood donors (n = 11)*</b>	<b>Total (n = 273)</b>
Age, years, median (IQR)	76 (69–82)	54 (43–66)	55 (41–60)	60 (48–74)
Sex, n (%)				
Female	35 (40)	93 (53)	0	128 (47)
Male	53 (60)	81 (47)	11 (100)	145 (53)
Healthcare setting, n (%)				
Managed at home	2 (2)	121 (70)	11 (100)	134 (49)
Hospitalized	86 (98)	53 (30)	0	139 (51)
Intensive care unit admission, n (%)	14 (16)	–	–	–
Deaths, n (%)	17 (19)	2 (1.1)	0	19 (7)

# WNDV LAZIO: final picture – integrated surveillance Epidemic Curve

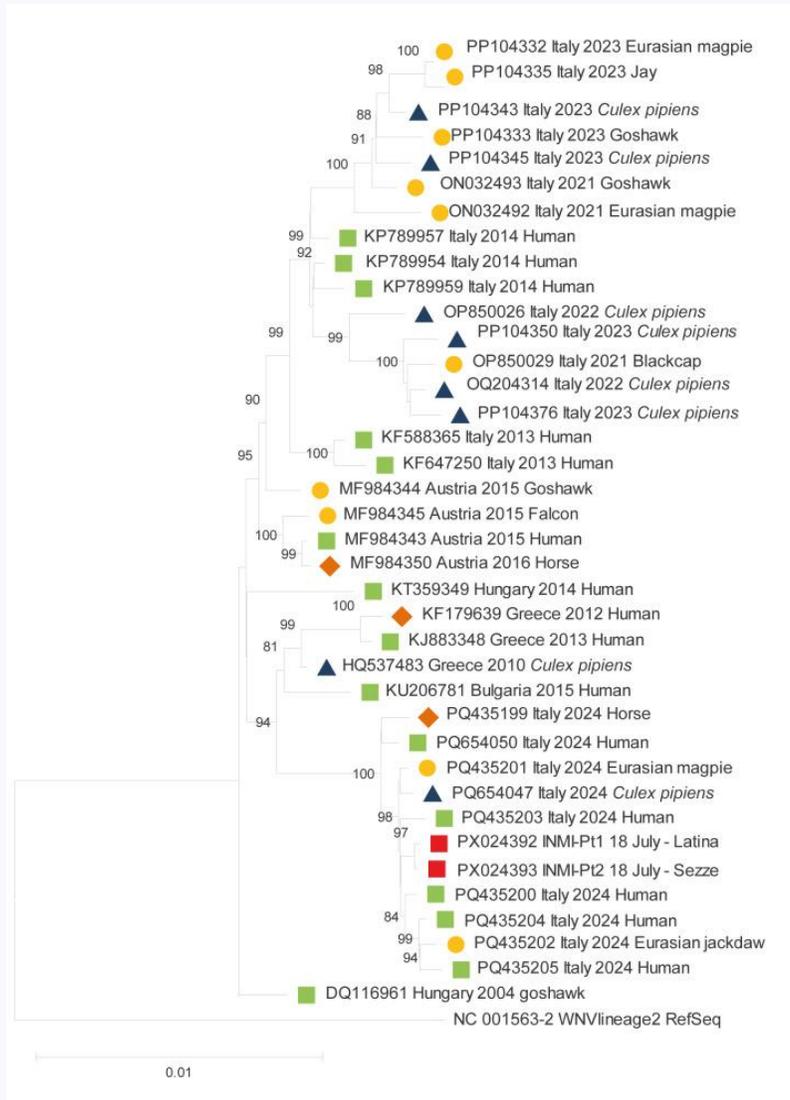


# Hypothesis on the drivers of the outbreak

- Overwintering female *Culex pipiens* may have emerged from their hibernacula earlier, and upon the arrival of sub-Saharan migrants, there may have been more than normal numbers, thus triggering unprecedented viral circulation. But....
- Autumn 2024: arrival of many migrants returning from Northern Europe with the virus. Mosquitoes bite them, they hibernate, causing the virus to overwinter, and circulation begins in March. Why different from previous years?
- ????

# Genomics: lineage 2 and continuity with 2024 central-southern Italy

The phylogenetic signal supports expansion of a lineage already circulating in the Italian peninsula



## Sequencing output

Full-length WNV genomes were obtained from urine samples of two autochthonous Lazio cases with 99.3% genome coverage.

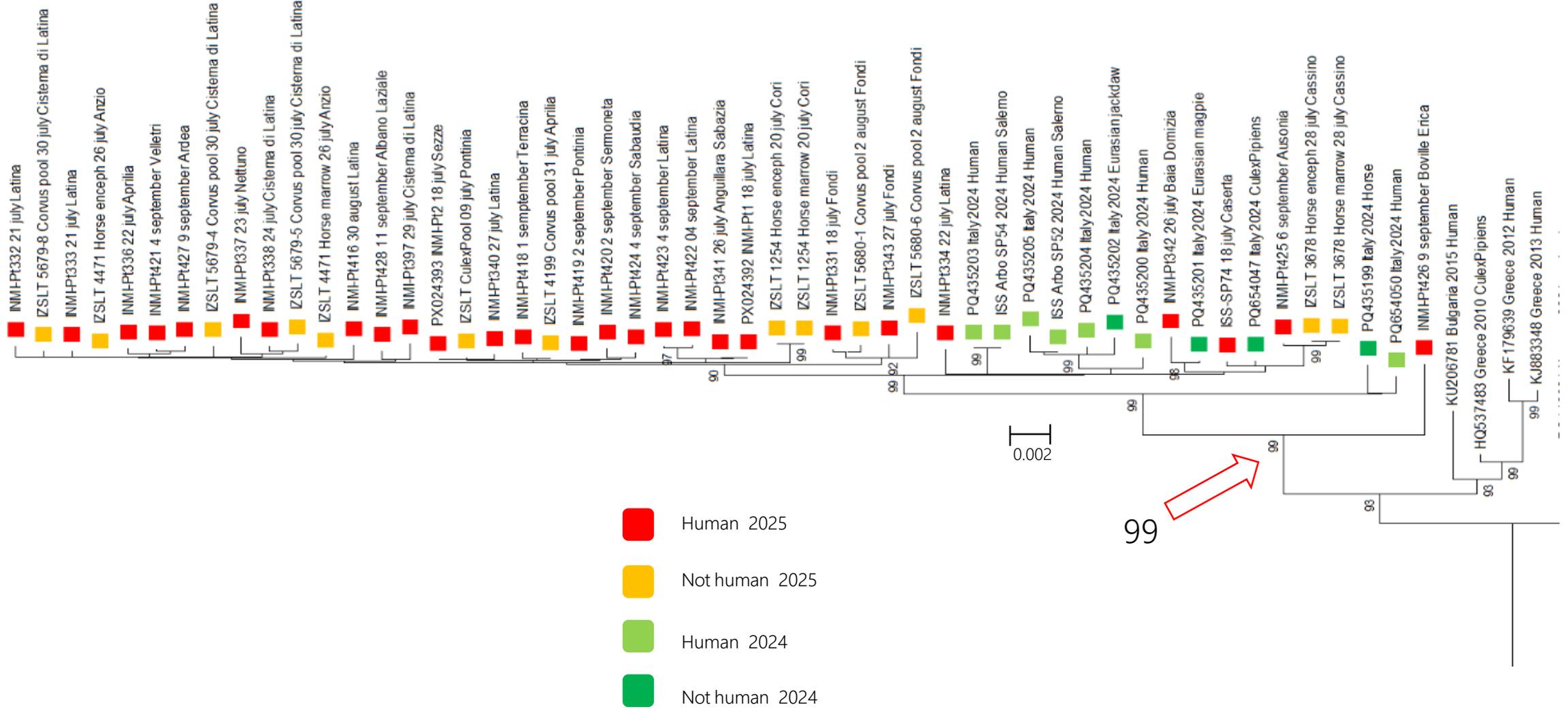
## Phylogenetic interpretation

The genomes were lineage 2 and showed 98.5% identity, clustering with sequences reported in 2024 in central-southern Italy (Campania region).

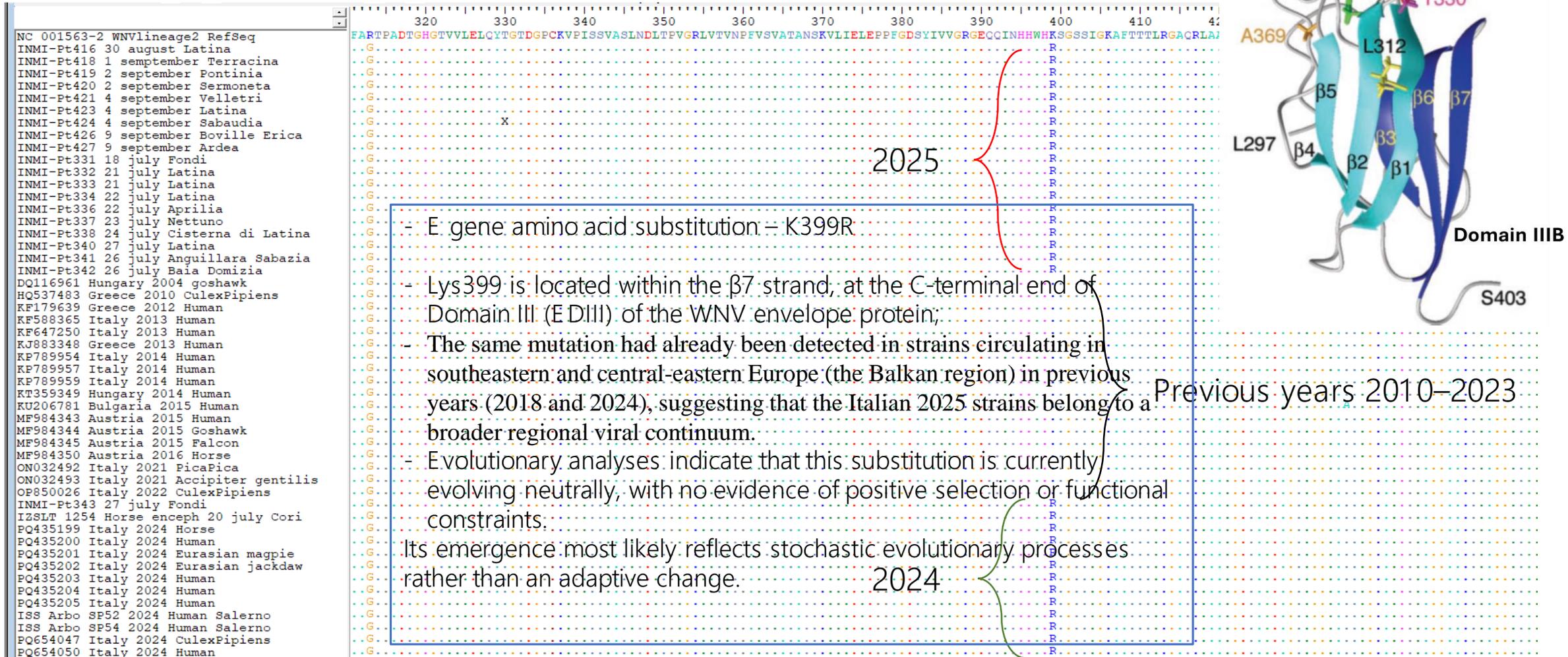
## Epidemiologic meaning

The Lazio outbreak was biologically coherent with south-to-central spread inside Italy, not an isolated "accidental" event without ecological continuity.

# Phylogenetic analysis of WNV cases in Lazio, 2025

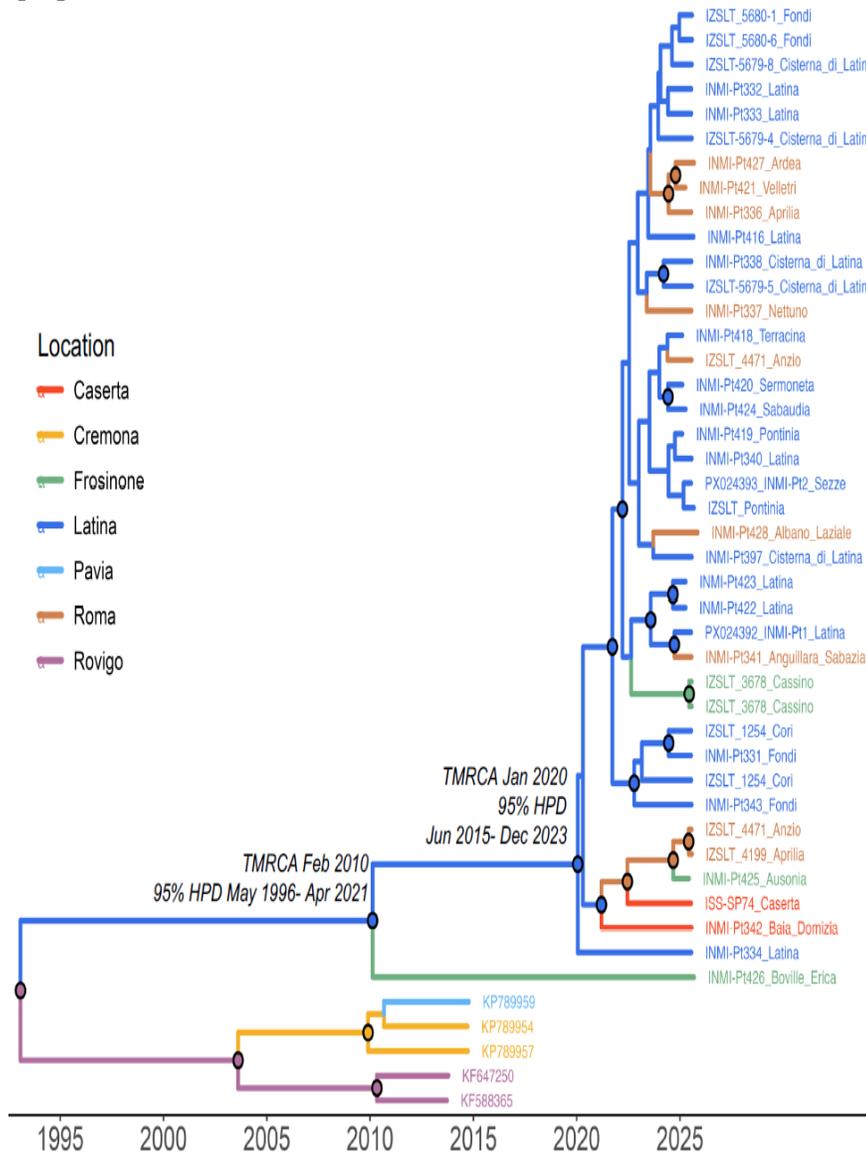


# E gene amino acid substitution – K399R



# Bayesian & phylogeographic analysis

- Strong evidence of viral movement between Italian provinces.
- The best-supported dispersal events included Latina to Frosinone, Latina to Caserta, and Latina to Rome (BF >100), indicating repeated spread southward and into central regions.
- Transitions with moderate support (BF 5–100) linked northern provinces such as Pavia, Cremona, and Rovigo, suggesting an interconnected transmission network in the Po Valley.



## Additional strong Hypothesis

The sudden emergence of human cases in 2025 therefore appears to reflect a convergence of factors: the presence of an established viral lineage capable of overwintering, the ecological suitability of the 2025 season—likely involving temperature anomalies, vector abundance, and avian host dynamics—and repeated viral introductions along migratory routes that may have contributed additional seeding events.

### **This observation is complemented by:**

- the documented ability of WNV to persist in both resident birds and diapausing mosquitoes;
- the unusually mild winter of 2024–25 may have favoured earlier emergence of diapausing *Cx. pipiens* females, accelerating their reproductive cycle and producing a larger vector population already at the beginning of spring;
- this probably facilitated earlier and more intense viral circulation in areas characterized by a high density of amplifying bird species, ultimately contributing to outbreak onset.

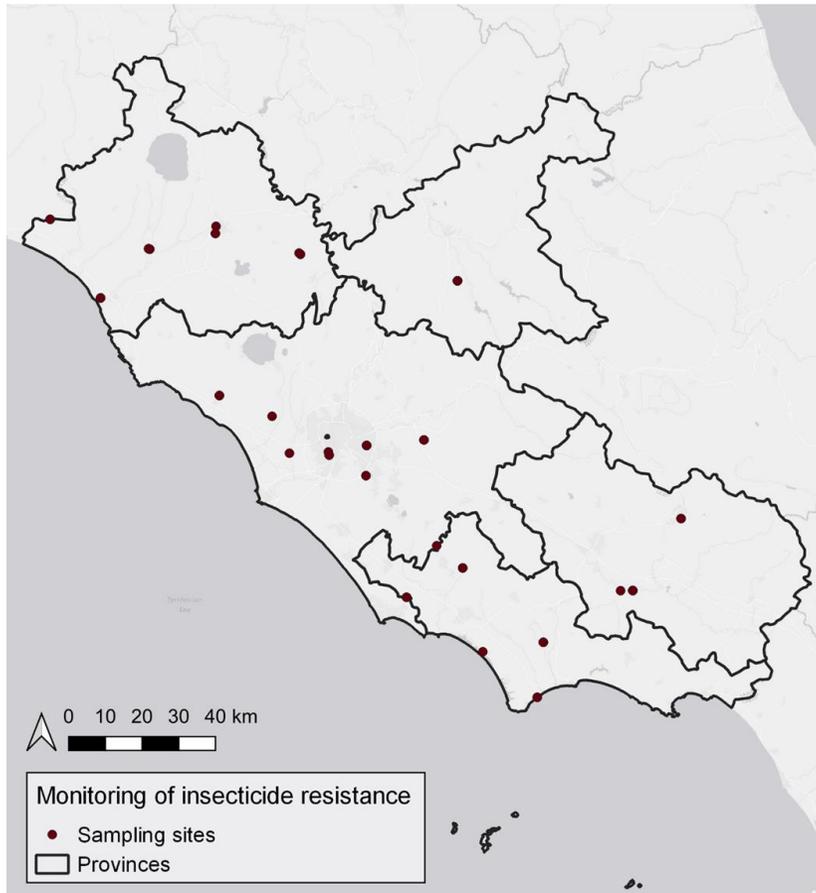
(ecological and epidemiologic evidence)

# WNDV LAZIO: final picture – integrated surveillance distribution of cases in time and space



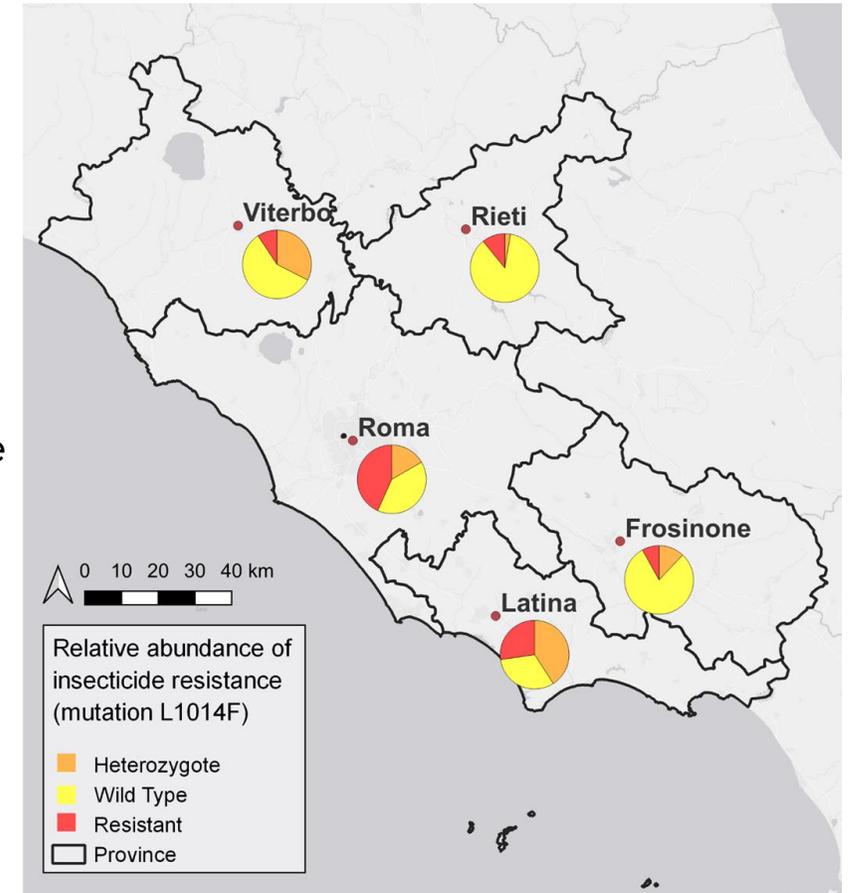
# WNDV LAZIO: Following the end of the epidemic – preparing for 2026

## Monitoring insecticide resistance



### The PNA 2020-2025 recommended the monitoring of insecticide resistance

Genotyping of mutations linked to pyrethroid resistance in *Cx. pipiens* was performed in order to acquire baseline data on spatial distribution.



# Lazio 2025: the response package was genuinely multi-sectoral

The operational value of SERESMI lay in linking reference diagnostics with public-health action

## Clinical and surveillance response

- Retrospective case reviews
- Syndromic monitoring in emergency departments focused on neuroinvasive symptoms
- Alert levels raised when birds or horses turned positive in new areas
- Webinars and targeted communication to healthcare professionals

## Vector and environmental response

- Vector control targeted *Cx. pipiens*
- Larvicides, adulticides and source reduction
- Treatments within 200 m of probable exposure sites
- Polygon-based extension of interventions in urban clusters with >3 cases
- Intensified entomological monitoring and bird surveillance

## Blood safety and risk communication

- NAT screening for donors who stayed in Latina province activated on 16 Jul
- Screening extended to all blood donations in Lazio on 24 Jul
- AppIO messaging reached 29% of the local population in Latina
- Public materials focused on personal protection and mosquito control participation

This is a useful outbreak template for Southern Europe: laboratory confirmation, healthcare mobilisation, vector control and donor safety must move together, not sequentially.

# Future risks: Southern Europe is facing persistence plus expansion, not a temporary anomaly

Recent attribution and projection studies make the climate signal harder to dismiss

## Attribution evidence (Nature 2024)

Climate change was identified as a critical driver behind the heightened risk of WNV circulation in Europe; current hotspots can be largely attributed to climate change.

## Projection evidence (One Health 2023)

Up to 5-fold increase in WNV risk for 2040–2060 in Europe compared with 2000–2020, with 161–244 million additional people potentially at risk depending on scenario.

## Geographic implication

Western Europe may face the largest relative increase, but Southern Europe remains the leading ecological engine and sentinel zone for the continent.

## What this means for Southern Europe

- Earlier seasonal onset and longer transmission windows
- Increased probability of south-central foci becoming recurrent rather than exceptional
- More donor-screening pressure and broader affected-area management
- Higher WNND burden in ageing populations
- Greater need for subnational forecasting instead of generic national alerts

*The correct framing is no longer “will WNV remain in Southern Europe?”, but “which regions will become the next stable nodes of transmission?”.*

# Some conclusions and research questions

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- West Nile virus has become an established seasonal public health threat in Southern Europe, with recurrent transmission driven by the interaction between climate, vector ecology, bird–mosquito amplification cycles, and human exposure.
- The epidemiology is increasingly heterogeneous across countries and regions, with marked inter-annual variability but a clear trend toward wider geographic expansion and earlier seasonal activity.
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- Italy represents a paradigmatic setting of persistent WNV circulation, where integrated human, veterinary, entomological, and blood safety surveillance has shown substantial value for early detection and risk mitigation. **Strengthen fever surveillance?**
- The progressive establishment of endemic transmission highlights the need to move from a reactive response to a sustained preparedness approach, integrating surveillance, forecasting, clinical awareness, and vector control.
- In the coming years, the main challenge will be not only detecting outbreaks, but anticipating transmission intensity, protecting vulnerable populations, and adapting public health systems to a changing eco-epidemiological context.

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/ SERESMI, surveillance teams,  
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**Thanks for your attention**

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