Vital Surveillances

# Surveillance and Analysis of Animal Rabies — China, 2004–2024

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## ABSTRACT

**Introduction**: Rabies is a zoonotic disease caused by rabies viruses(RABV). China is a high-risk country for rabies. To address China's rabies situation, the Chinese Ministry of Agriculture and Rural Affairs issued the National Animal Disease Surveillance and Epidemiological Investigation Plan. This study systematically summarized animal rabies surveillance data from the past two decades based on the Program.

**Methods**: Suspected rabies cases collected through the Program between 2004 and 2024 underwent confirmatory diagnosis at the National Reference Laboratory (NRL) for animal rabies using national standard protocols: direct fluorescent antibody testing (FAT) and real-time RT-PCR. Epidemiological data from confirmed cases were analyzed using Geographic Information System (GIS) mapping and statistical evaluation methods.

**Results**: Laboratory diagnosis confirmed 331 of 433 suspected cases (76.44%) as rabies-positive. These confirmed cases originated from 15 provincial-level administrative divisions (PLADs) and revealed two distinct transmission patterns: a) dog-mediated rabies, accounting for 47.13% of cases and predominantly endemic in southern PLADs, where it poses ongoing human exposure risks; and b) wildlife-mediated rabies in livestock, comprising 52.87% of cases and primarily transmitted by foxes in northern PLADs, with the Inner Mongolia Autonomous Region (IMAR) experiencing the highest burden.

**Conclusions**: This nationwide surveillance has elucidated current rabies transmission dynamics across China, revealing persistent threats from dog rabies to human health in southern PLADs and emerging threats from wildlife-mediated rabies to livestock in northern border regions. These findings underscore the critical need for enhanced surveillance systems and targeted vaccination strategies addressing both domestic dog populations and wildlife reservoirs to achieve effective rabies control.

Rabies is a zoonotic disease caused by viruses of the genus *Lyssavirus* in the family *Rhabdoviridae* of the order *Mononegavirales* (*1*–*2*). Rabies virus (RABV) infects nearly all warm-blooded animals (*2*). Rabies remains a significant public health concern, particularly in Asia and Africa, which account for the majority of human cases (*2*). China is still a high-risk country for rabies, with persistent transmission in both human and animal populations (*3*–*4*). To estimate the rabies threat and implement control measures effectively, the Chinese Ministry of Agriculture and Rural Affairs issued the National Animal Disease Surveillance and Epidemiological Investigation Plan (*5*), mandating comprehensive monitoring of rabies in animals, including dogs, cats, and other potential reservoirs. Surveillance efforts focus on animals exhibiting suspected rabies signs, particularly within key reservoir hosts such as canids, felids, and mustelids. Under this national surveillance framework, suspected animal rabies samples were collected by provincial and municipal animal disease control centers and submitted to our NRL for confirmatory diagnosis and further epidemiological analysis. This study aims to elucidate the current trends, risk factors, and spatial distribution of animal rabies, providing strong and critical evidence to support data-driven prevention and control strategies for rabies elimination in China.

## METHODS

Suspected rabies cases exhibiting clinical abnormalities, aggressive behavior, or unexplained mortality were identified by local Animal Disease Control Centers and Forestry and Grassland Administrations. For post-mortem examination, brain tissue samples were collected using the straw method or by submitting entire animal heads. The majority of specimens were transported under cold chain conditions (refrigerated or frozen) to the NRL for confirmatory

diagnosis. Brain tissue specimens underwent examination using FAT with fluorescein isothiocyanate (FITC)-conjugated monoclonal antibody against rabies virus nucleocapsid protein (Fujirebio Diagnostics, Inc., Philadelphia, USA) and Taqman real-time RT-PCR according to National Standard for the Diagnosis of Rabies in Animals (*6*). Epidemiological information for these animal rabies cases from 2004 to 2024 was also collected for analysis. Map data were retrieved from the Ministry of Natural Resources of the People's Republic of China (http://bzdt.ch.mnr.gov.cn/). Figure editing was performed using ArcGIS 10.8 software (Environmental Systems Research Institute, Inc. Redlands, USA) and GIS mapping techniques. All statistical analyses were performed using Microsoft Excel 2007 (Microsoft Corp., Redmond, USA).

## RESULTS

Between 2004 and 2024, brain tissues from 433 suspected animal rabies cases were collected across 20 provincial-level administrative divisions (PLADs) and submitted to the NRL for analysis. Laboratory confirmation identified 331 cases (76.44%) as RABV positive using both FAT and real-time RT-PCR methodologies (Table 1). These confirmed cases originated from 75 counties distributed across 15 PLADs. Dogs emerged as the predominant reservoir species, accounting for 47.13% of all confirmed cases (156/331) (Figure 1 and Table 1). Animal rabies cases were documented consistently throughout the entire study period from 2004 to 2024. The notable increase in case numbers primarily resulted from a severe rabies epidemic that occurred in Inner Mongolia Autonomous

TABLE 1. Animal rabies case confirmation in China, 2004–2024 (positive/total).

| PLAD | | Dog | Cat | Livestock | | | | | | Wild Animals | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Cattle | Sheep | Camel | Pig | Horse | Donkey | Fox | Badger | Racoon dog | Wolf* | |
| North | IMAR | 10/14 | − | 75/83 | 22/27 | 17/18 | 1/2 | 2/6 | − | 25/35 | 3/3 | 3/3 | − | 158/191 |
| | SX | 12/13 | − | 1/1 | 3/3 | − | − | − | 1/1 | − | − | − | − | 17/18 |
| | XUAR | 3/3 | − | 2/3 | 8/11 | 2/2 | − | − | − | 1/1 | − | − | − | 16/20 |
| | TJ | 4/5 | − | 2/2 | − | − | − | − | − | − | − | − | − | 6/7 |
| | SD | 1/1 | − | 3/3 | − | − | − | − | − | − | − | − | − | 4/4 |
| | HA | 2/3 | − | − | − | − | − | − | − | − | − | − | − | 2/3 |
| | HL | 0/1 | − | 1/1 | − | − | − | − | − | 1/1 | − | − | − | 2/3 |
| | GS | 1/2 | − | − | − | − | − | − | − | − | − | − | − | 1/2 |
| | SN | 0/2 | − | − | − | − | − | − | − | − | − | − | − | 0/2 |
| | HE | 0/1 | − | − | − | − | − | − | − | − | − | − | − | 0/1 |
| South | CQ | 65/80 | − | − | − | − | − | − | − | − | − | − | 0/2 | 65/82 |
| | SH | 31/39 | − | − | − | − | − | − | − | − | − | − | − | 31/39 |
| | HN | 12/19 | − | − | − | − | 2/2 | − | − | − | − | − | − | 14/21 |
| | JS | 5/6 | 0/1 | − | − | − | − | − | − | − | − | − | − | 5/7 |
| | GZAR | 4/6 | − | − | − | − | − | − | − | − | − | − | − | 4/6 |
| | ZJ | 3/11 | − | − | − | − | − | − | − | − | − | − | − | 3/11 |
| | GD | 3/5 | − | − | − | − | − | − | − | − | − | − | − | 3/5 |
| | HI | 0/9 | − | − | − | − | − | − | − | − | − | − | − | 0/9 |
| | HB | 0/1 | − | − | − | − | − | − | − | − | − | − | − | 0/1 |
| | JX | − | − | 0/1 | − | − | − | − | − | − | − | − | − | 0/1 |
| Total | | 156/221 | 0/1 | 84/94 | 33/41 | 19/20 | 3/4 | 2/6 | 1/1 | 27/37 | 3/3 | 3/3 | 0/2 | 331/433 |

Note: Ratios represent positive/total samples submitted. −: No sample submitted.
Abbreviation: IMAR=Inner Mongolia Autonomous Region; CQ=Chongqing Municipality; SH=Shanghai Municipality; SX=Shanxi Province; XUAR=Xinjiang Uyghur Autonomous Region; HN=Hunan Province; TJ=Tianjin Municipality; JS=Jiangsu Province; GZAR=Guangxi Zhuang Autonomous Region; SD=Shandong Province; ZJ=Zhejiang Province; GD=Guangdong Province; HA=Henan Province; HL=Heilongjiang Province; GS=Gansu Province; HI=Hainan Province; SN=Shaanxi Province; HE=Hebei Province; HB=Hubei Province; JX=Jiangxi Province; PLAD=provincial-level administrative division.
* Two deceased wolves were submitted by a zoological facility.

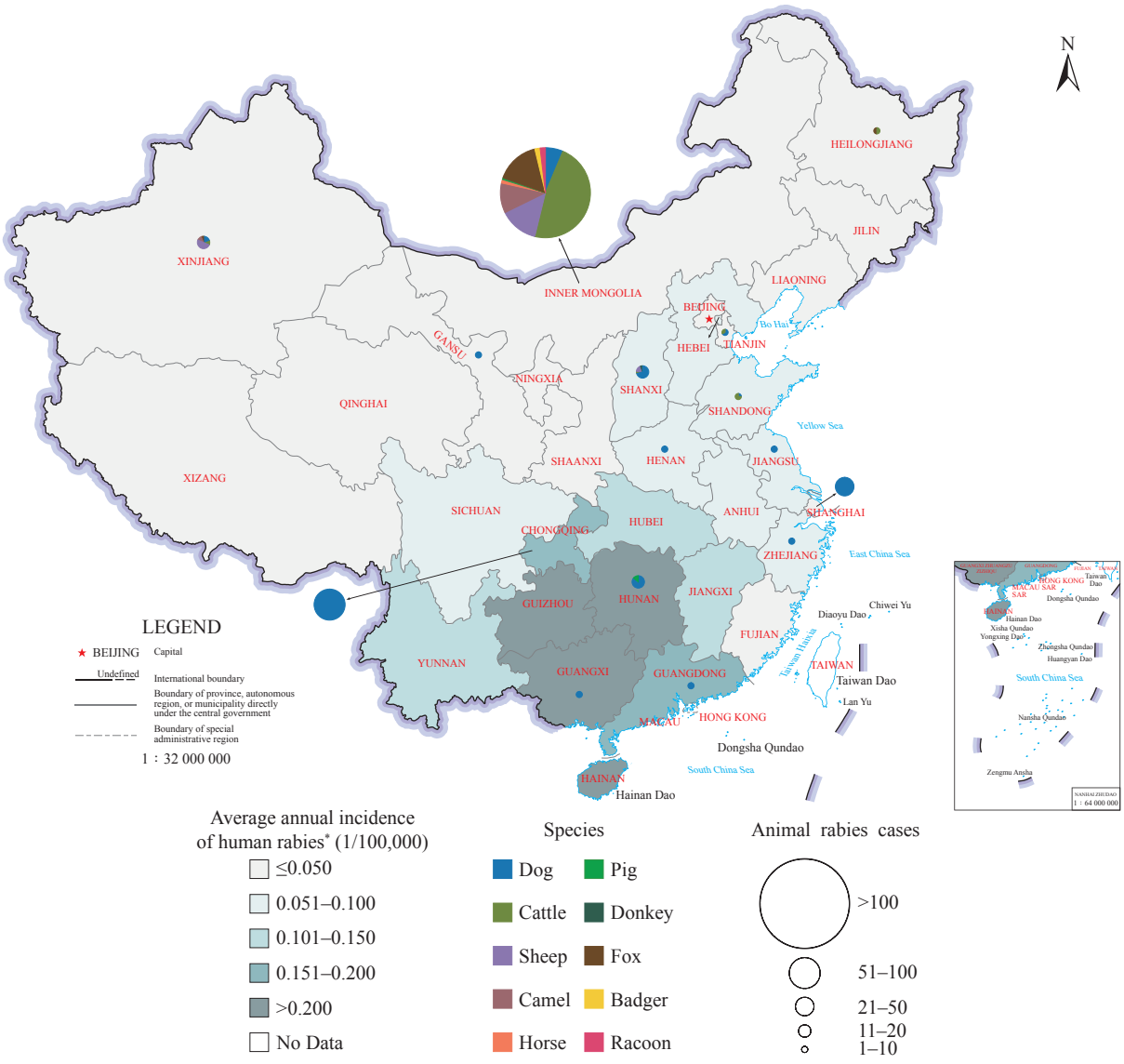


FIGURE 1. Distribution of confirmed animal rabies cases from 2004 to 2024.
Note: Figure encompassed dogs (156), livestock (142 cattle, sheep, camels, pigs, horses, and donkeys), and wildlife (33 foxes, badgers, and raccoon dogs). Map approval number: GS 京 (2025) 1687.
* Annual average incidence of human rabies in provincial-level administrative divisions (PLADs) from 2004−2020 (3).

Region (IMAR) between 2020 and 2024. Sample submission decreased in 2022 due to the impact of the coronavirus disease 2019 (COVID-19) pandemic (Figure 2). Among the 142 confirmed livestock cases, cattle demonstrated the highest infection rate (25.38%, 84/331), followed by sheep (9.97%, 33/331), camels (5.74%, 19/331), pigs (0.91%, 3/331), horses (0.60%, 2/331), and donkeys (0.30%, 1/331). Within the 33 wildlife cases, foxes (*Vulpes vulpes*) served as the predominant transmission vectors (8.16%, 27/331), followed by badgers (*Meles leucurus*) (0.91%, 3/331) and raccoon dogs (*Nyctereutes procyonoides*) (0.91%, 3/331) (Table 1). Geographically, dog rabies exhibited higher prevalence rates in southern PLADs, whereas livestock and wildlife rabies cases were predominantly concentrated in IMAR (Figure 1 and Table 1). Further epidemiological analysis revealed that infected dogs, particularly free-roaming and stray animals, constituted the major transmission sources in rural environments (94/156). The rural-to-urban distribution ratio for infected dogs was 1.52 (94∶62). Notably, 67.86% of rabid dogs (76/112) attacked multiple individuals, with one documented case involving a single dog that caused 63 separate bite incidents. All bite victims received timely post-exposure prophylaxis, preventing human rabies development. Livestock infections were

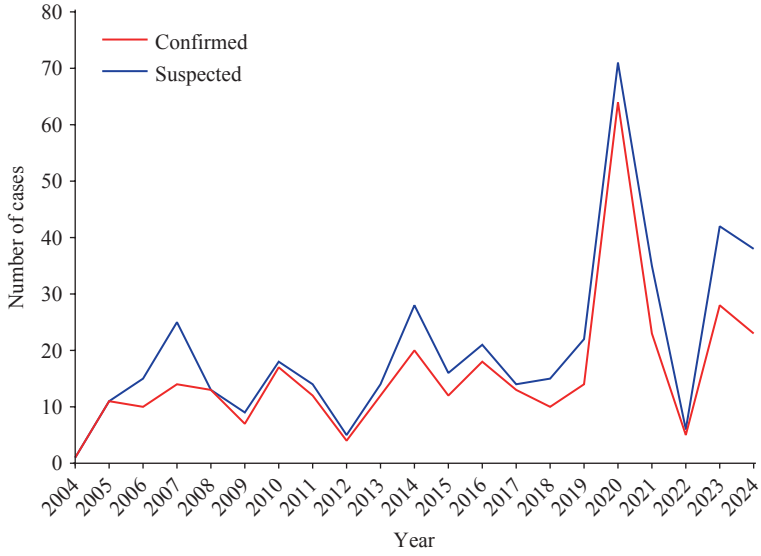


FIGURE 2. Confirmed animal rabies cases in China from 2004 to 2024.

disproportionately concentrated in IMAR (117/142, 82.39%), primarily affecting cattle (25.38%) and sheep (9.97%), with 91 cases epidemiologically linked to fox exposures. Wildlife cases totaled 33 (9.97%), with foxes dominating this category (27 cases, including 25 in IMAR). These wildlife cases demonstrated progressive inland spread from border regions, ultimately reaching the Ningxia Hui Autonomous Region by 2025. Wildlife rabies has been expanding continuously, particularly among foxes, raccoon dogs, and badgers since 2007, representing an emerging zoonotic threat. Thirty-one of the 33 wildlife cases occurred within IMAR, with spillover events documented in Xinjiang Uyghur Autonomous Region (XUAR) in 2014, and Heilongjiang Province in 2022.

## DISCUSSION

China's estimated 80 to 200 million domestic dogs represent a substantial reservoir for rabies transmission, with canine-mediated infections accounting for approximately 95% of human rabies cases (*7*). Our surveillance findings confirm that dogs remain the predominant rabies vector across central, eastern, and southern China, responsible for the majority of human bite exposures requiring post-exposure prophylaxis. However, current animal rabies surveillance systems suffer from significant limitations, operating through passive reporting mechanisms that result in substantial underreporting. This surveillance gap becomes evident when comparing human and animal case detection: while human rabies cases were documented in 101 counties across 17 PLADs during 2023 (*8*), only 28 animal rabies cases received laboratory confirmation from 12 counties in 4 PLADs during the same period. This dramatic disparity — with human cases outnumbering confirmed animal cases by nearly 4∶1 — highlights critical deficiencies in animal surveillance infrastructure, as only a small fraction of aggressive or suspect animals undergo diagnostic testing. Multiple factors contribute to this underreporting, including limited regional diagnostic capacity, inconsistent compliance with sample submission protocols, inadequate reporting awareness among veterinary professionals, and substantial logistical barriers in remote and resource-constrained areas. Consequently, our confirmed case numbers likely represent a significant underestimate of the true animal rabies burden across China.

Although China harbors an estimated 80–200 million dogs, canine rabies continues to pose a substantial public health threat, accounting for approximately 95% of human rabies cases (*7*). Our surveillance data confirm that dogs remain the predominant rabies vector across central, eastern, and southern China, responsible for the majority of human bite exposures. However, wildlife rabies — particularly among foxes — has emerged as an increasingly significant concern in northern border PLADs (IMAR, XUAR, and Heilongjiang Province), creating substantial spillover risks to livestock populations. Red foxes now represent the primary wildlife reservoir, while recent rabies detections in raccoon dogs and badgers suggest an expanding host range. This epidemiological pattern aligns with global

trends, where wildlife rabies has resurged in numerous countries despite successful canine vaccination programs implemented across Europe and North America (*9*). Although rare, human rabies cases linked to wildlife exposures are increasingly documented throughout China. Since 2012, sporadic cases have been attributed to ferret badgers (Jiangxi, Anhui, and Zhejiang provinces), bats (Jilin Province), and foxes (XUAR, 2016) (*10*–*11*). Most notably, the first confirmed badger-mediated human rabies case occurred in Xilingol League (IMAR) in 2020 (*12*). These incidents underscore the critical need for enhanced wildlife rabies surveillance, particularly in northern border regions where cross-species transmission to livestock occurs frequently. Unlike canine rabies, which can be effectively controlled through mass vaccination campaigns, wildlife serve as natural RABV reservoirs with extensive movement ranges that complicate large-scale vaccination efforts. Wildlife rabies, therefore, requires alternative control strategies, including comprehensive surveillance programs and oral rabies vaccination (ORV) campaigns targeting foxes and other reservoir species. Europe's successful elimination of fox-mediated rabies through ORV programs provides a proven model for implementation in China (*13*). To contain viral circulation within these natural foci and prevent spillover into human and domestic animal populations, establishing robust immune barriers in surrounding areas remains essential. This objective can be achieved through enhanced canine vaccination campaigns in and around identified endemic regions, where high vaccination coverage will create protective buffers that interrupt transmission chains at the wildlife-domestic animal-human interface.

To effectively address animal rabies challenges in China, comprehensive strategies must be implemented within a One Health framework that combines enhanced surveillance, targeted wildlife vaccination programs, and strengthened cross-sector collaboration: 1) Improve both passive and active surveillance systems to significantly reduce underreporting of animal cases. 2) Strengthen cross-border and cross-sector collaboration while implementing real-time data sharing between animal health, forestry, and public health agencies to enhance outbreak response capabilities. 3) Establish species-specific wildlife vaccination strategies by developing oral rabies vaccines tailored for foxes, raccoon dogs, and badgers, building upon existing ORV technologies (*13*). 4) Conduct comprehensive ecological studies to map wildlife movement patterns and optimize bait distribution strategies for maximum vaccination coverage. 5) Establish a rabies-free pilot region across Hainan Province as a national demonstration model, leveraging its low dog rabies prevalence and natural island geography that provides an effective barrier against rabies transmission from China.

**Conflicts of interest**: No conflicts of interest.

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