

1 **Cat-borne rabies as the new epidemiology of rabies disease in the Andes**
2 **Mountains**

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20 **SUMMARY**

21 Rabies virus (RABV) is the etiologic agent of rabies, a fatal brain disease in mammals. Rabies
22 circulation has historically involved the dog has the main source of human rabies worldwide.
23 Nevertheless, in Colombia, cats have become a relevant species in the epidemiology of
24 rabies. We aimed to characterize rabies cases in humans in Colombia in the last three decades
25 in the context of the epidemiology of the aggressor animal. We conducted a retrospective
26 longitudinal epidemiological study of human rabies caused by cats' aggression, collecting
27 primary and secondary information. Variables considered included the demography of the
28 patient, symptoms, information about the aggressor animal as the source of infection, and the
29 viral variant identified. We found that the distribution of rabies incidence over the years has
30 been constant in Colombia. Nevertheless, between 2003 and 2012 a peak of cases occurred
31 in rural Colombia where cats were the most frequent aggressor animal reported. Most cats

32 involved in aggression were unvaccinated against rabies. Cat's clinical signs at the time of
33 the report of the human cases included hypersalivation and changes in behavior. Human
34 patients were mostly children and female and the exposure primarily corresponded to bite
35 and puncture lacerations in hands. The RABV lineage detected in most cases corresponded
36 to variant 3, linked to the common vampire bat (*Desmodus rotundus*). The geographical
37 presentation of cat-borne RABV in humans occurred along the Andes mountains,
38 epidemiologically known as the rabies red Andean corridor. By finding cats as the primary
39 source of rabies spillover transmission in Colombia, this report highlights the importance of
40 revising national rabies control and prevention protocol in countries in the Andes region. In
41 conclusion, our results demonstrate that rabies vaccination for outdoor cats needs to
42 prioritized to reduce the number of rabies-related human deaths.

43

44 **KEYWORDS**

45 Bat, rabies, cat, Colombia, epidemiology, RABV.

46

47 **IMPACTS**

48 • A total of 14 cat-borne rabies cases in humans reveal an epidemiological switch from
49 dog-borne to primarily cat-borne rabies in Colombia.

50 • Children (9-13 years old) living in the highlands of Colombia were the most affected.

51 • Cat-borne rabies incidence had a tendency to increase in recent years.

52 • National rabies control strategies in the Andes region should emphasize cat vaccination
53 and humane population control, and strengthen epidemiological surveillance systems.

54

55 **INTRODUCTION**

56 Rabies virus (RABV) is the etiologic agent of rabies, a zoonotic disease reported in all
57 continents but Antarctica. Rabies is considered a neglected tropical disease, mainly affecting
58 low-income populations in hard-to-reach rural areas (WHO, 2022). Rabies incubation period
59 is variable (30-90 days) and may depend on the site of exposure (distance to the brain), but
60 7 days or even up to 6 years have been reported (Hemachudha et al., 2022) and even as long
61 as 25 years (Shankar et al., 2012). The onset of the disease is similar to any febrile illness,
62 including symptoms such as weakness or general discomfort, fever, headache, and stinging
63 or itching feeling at the bite site. The symptomatology progresses to brain dysfunction,
64 anxiety, confusion, agitation, delusions, abnormal behavior (e.g., hallucinations,
65 hydrophobia, insomnia, aggression, and self-mutilation), dysfunction of the cranial nerves,
66 ataxia, weakness, paralysis, convulsions, difficulty breathing, difficulty swallowing,
67 excessive salivation, and finally the death of the patient (CDC, 2019).

68

69 RABV belongs to the genus *Lyssavirus* composed of 16 viral species, and 10 of species have
70 been isolated from bats (Banyard et al., 2014). The virus presents sylvatic and urban cycles
71 of transmission and maintenance. The urban cycle involves the dog as the main host and
72 transmissor of RABV, while the sylvatic cycle includes a variety of wildlife species, ranging
73 from carnivores to bat, transmitting RABV to other species including humans (Cisterna et
74 al., 2005). The idea of an aerial sylvatic cycle has been recently proposed to differentiate
75 transmission among bat species from other non-volant wildlife species (San Miguel de Vera,
76 2016).

77

78 Dog have been historically considered as the main source of human rabies worldwide.
79 Nevertheless, cats are also a relevant species in rabies epidemiology (Tierradentro-García et
80 al., 2022). The predatory and nocturnal behavior of cats facilitates their direct contact with
81 bats, and their role as pets facilitates zoonotic transmission (Grisi-Filho et al., 2008) (Figure
82 1).

83



84

85 **FIGURE 1. The domestic-wildlife interface of rabies transmission involving cats and**
 86 **bats.** Rabid bats could change their behavior to approach other animals and be fearless. The
 87 cat hunts a rabid bat maybe with more success than hunting a healthy bat. The rabid bat bites
 88 the cat and RABV enters the cat's body through the wound by infiltration of the infected
 89 bat's saliva. RABV replicates in the peripheral muscles of the cat, near the wound, and
 90 migrates to the central nervous system. RABV is then distributed to other organs and finally
 91 reaches the cat's salivary glands. The rabid cat now shows behavioral changes and
 92 predisposed to attack humans and infect other animals. Direct infection from the bat to the
 93 human can also occur.

94

95 MATERIALS AND METHODS

96

97 **TABLE 1.** A summary of fatal cases of human rabies due to different animal sources in
 98 Colombia (1990-2021)

Year	Number cases/province (municipality)	of Sex years)	(age in years)	Aggressor animal	Viral variant (host)
1990	1/ Caldas (Aguadas)		Female (9)	Cat	N/A
	1/Putumayo (Orito)		Female (6)		
1999	2/Magdalena (Pedraza- Ciénaga)		Male (5, 9)	Dog	V1 (dog)
2000	1/Putumayo (Orito)		Female (24)	Dog	V1 (dog)
2003	1/Cundinamarca (Quipile)	Male (13)		Cat	V8 (skunk)
			Female (3, 7, 8*, 9), Male (4, 5, 6**, 7, 8*, 12)		
2004	14/Chocó (Pizarro)				V3 (vampire bat)
2005	3/Chocó (Bajo Baudó)		Female (13), Male (12, 14)	Bat	V3 (vampire bat)
2006	2/Magdalena (Santa Marta)	(Santa Marta)	Male (14, 29)	Dog	V1 (dog)
	2/Magdalena (Santa Marta)		Male (3, 20)	Dog	V1 (dog)
2007	1/Casanare (San Luis de Palenque)		Female (N/A)	Bat	V3 (vampire bat)
	2/Cauca (Santander de Quilichao)		Female (12), Male (10)	Cat	V3 (vampire bat)
2008	1/Santander (Floridablanca)		Male (15)	Bat	

	1/Bolívar (San Jacinto del Cauca)	Female (9)	Cat	
2009	1/Boyacá (Moniquirá)	Female (76)	Cat	V4 (insectivorous bat)
	1/Santander (Barrancabermeja)	Female (N/A)	Bat	V3 (vampire bat)
	1/Santander (Enciso)	Female (13)	Cat	V3 (vampire bat)
2010	1/Santander (Piedecuesta)	Female (46)	Bat	
	1/Tolima (San Luis)	Male (11)	Cat	
2012	1/Valle del Cauca (Roldanillo)	Female (19)	Cat	V4 (insectivorous bat)
2015	1/Cundinamarca (Mesitas del colegio)	Male (9)	Cat	V3 (vampire bat)
2016	1/Cundinamarca (Girardot)	N/A	Cat	Atypical variable, AV1 (vampire bat)
2017	1/Cundinamarca (Tena)	N/A	Cat	Atypical variable, AV1 (vampire bat)
2020	1/Huila (Neiva)	Female (26)	Cat	V3 (vampire bat)
2021	1/Huila (La Argentina)	Male (29)	Cat	V3 (vampire bat)

99 Source: <https://sirvera.panaftosa.org.br/>

100 *Two cases each; ** Three cases each; N/A: Not Available.

101

102 First, data on rabies cases in humans were collected from the Regional Information System
 103 for the Epidemiological Surveillance of Rabies (SIRVERA) during the 1990-2021 period
 104 CITE. SIRVERA is a data repository of the epidemiology of rabies in the Americas and is

105 updated monthly by health authorities in countries across the Americas CITE. We recovered
106 SIRVERA data using the following inclusion criteria, country=Colombia, types of
107 cases=human, date of notification=1990-2021, and target species=human.

108

109 A more detailed retrospective longitudinal epidemiological assessment of the cases was
110 carried out, collecting information from primary (i.e., Ministry of Health of Colombia) and
111 secondary sources (i.e., scientific publications and news describing the cases). Variables
112 considered for the data collection included year of the report, epidemiological week,
113 municipality, province, type of settlement (i.e., rural, urban). In addition, information on the
114 cat (i.e. sex, age in months, vaccination status, behavior, and clinical signs at the time of the
115 report) and the human patient (i.e. sex, age in years, occupation, clinical signs). For the
116 human clinical signs we also accounted for the date of animal aggression, onset of signs,
117 request for medical care, and of death, the time elapsed between the aggression and the onset
118 of clinical signs, and the time elapsed between the aggression and the death in days. When
119 available, we also collected the type and site of exposure, description of the aggression,
120 clinical features of the case, diagnostic tests results, and the RABV variant identified.

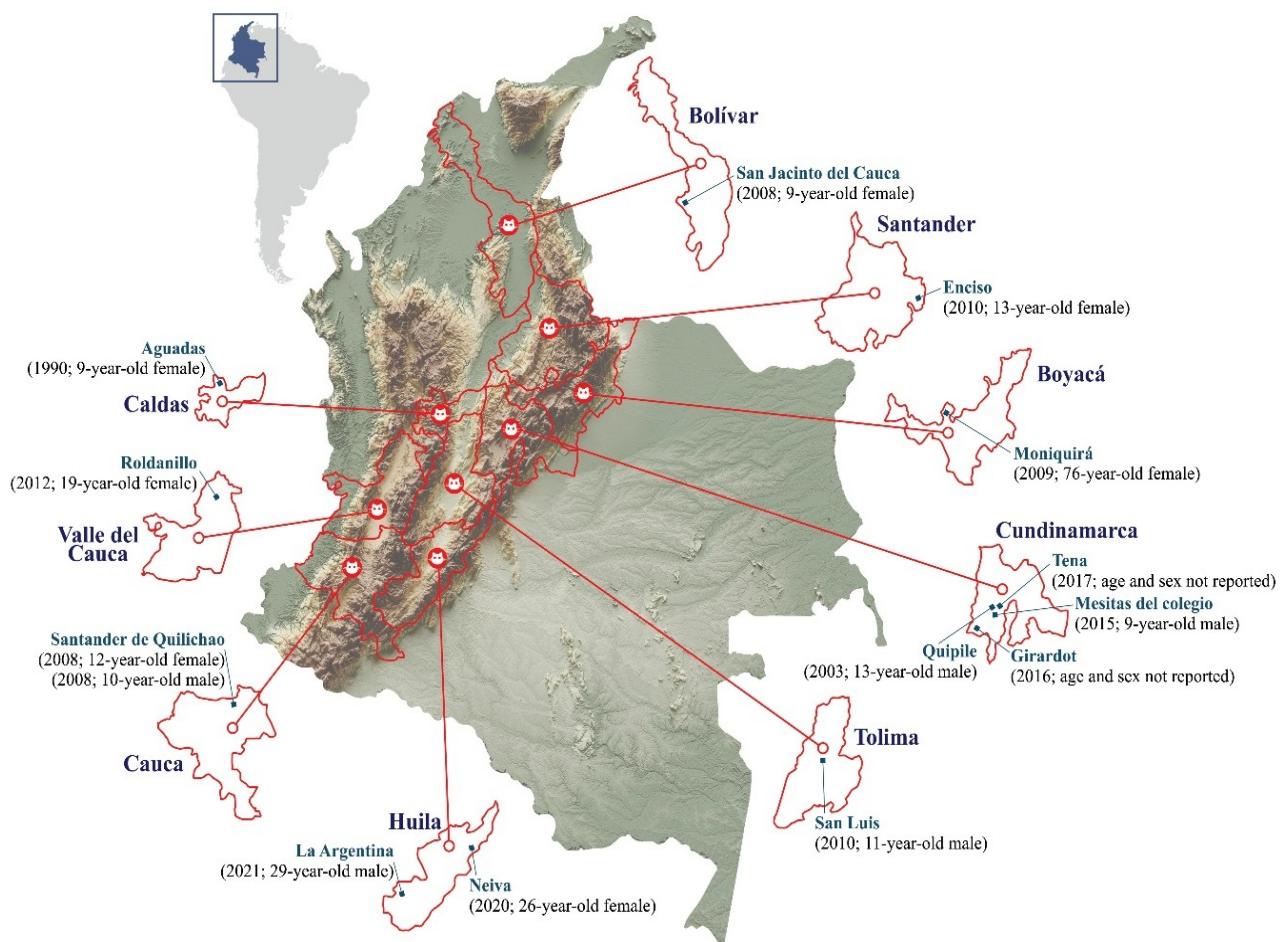
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122 **RESULTS**

123 Forty-three human rabies cases have been reported in Colombia, from 1990 to 2021, with a
124 greatest presentation of bat-borne RABV transmitted by cats in the last decade (n=14) (Table
125 1). Rabies cases in which the dog was considered an aggressor were eight for the last decade.
126 Human rabies cases involving cats were constant between 2003 and 2012 and occurred across
127 Andean provinces (Figure 2). Rural area was a great contributor to the number of cases
128 (6/14). All aggressor cats were reported as unvaccinated for rabies, and cat vaccination status
129 was not known by the owners or people related to the patient for most cases. Cat's clinical
130 signs described at the time of the report of the identification of the human case were
131 predominantly related to hypersalivation and irritability. Human patients were mainly
132 females (7/12) and the type and site of exposure corresponded to bite (4/14) and puncture
133 laceration in hands (7/14). Variant 3, linked to vampire bats, was the most frequent RABV
134 lineage identified (7/13). Although data was not available for all cases, detailed information

135 of the known rabid human patient linked to a cat as the aggressor animal are summarized
136 geographically (Figure 2) and temporally (see below).

137



138

139 **FIGURE 2. Geographical distribution of the 14 fatal human cases with laboratory-**
140 **confirmed rabies transmitted by cats in Colombia (1990-2021).** Map denotes elevational
141 gradients across the Colombian territory with areas of low (dark green) and high (brown)
142 elevations. Specific localities where cases occurred (blue squares) were grouped at the
143 municipality level (red polygon). The year of the report and demographic information of the
144 case was recorded (parenthesis).

145

146 **1990s decade (1990-1999): One case.** In 1990, a 9-year-old female from the rural
147 municipality of Aguadas, province of Caldas, was bitten in the left thumb by an unvaccinated
148 cat when she was trying to separate it from attacking a chicken. The cat died three days after
149 the aggression. Seven days after the attack, the patient showed clinical signs and died seven

150 days later. The patient was taken to medical services but the history of aggression by the cat
151 was not mentioned. The patient's physician diagnosed a viral infection and gave palliative
152 treatment for it. Three days later, the patient was taken back to the hospital due to both neck
153 and left arm paralysis. The cat aggression was mentioned in the second visit to the hospital
154 and rabies-related interventions were carried out (e.g., post-exposure vaccination). The
155 confirmation of rabies was given after the death of the patient. The viral variant was not
156 identified or reported. The patient died 14 days after the aggression occurred (Observatorio
157 de Salud de Caldas, 2020).

158

159 **2000s decade (2000-2009): Five cases.** In 2003 (epidemiological week 44), a 13-year-old
160 male patient from the municipality of Quipile, province of Cundinamarca, was diagnosed
161 with rabies V8, a rabies lineage linked to skunks (MinSalud, 2016). Three additional cases
162 were reported in 2008, when the same cat attacked a 10-year-old male patient and a 12-year-
163 old female patient. Thirty-five days later, the male patient showed clinical signs, including
164 odynophagia, neck pain, and fever. Physical examination revealed acute tonsillitis,
165 dicloxacillin and acetaminophen were prescribed. Two days after the first examination, the
166 patient returned with pruritic wheals on the body, being handled as a case of urticaria, and
167 was sent home with azithromycin. Three days after the second exam, the patient presented
168 mild trismus with loss of muscle tone in the left upper limb, odynophagia, neck pain, fever,
169 cervical lymphadenopathy, and suppurative hypertrophic tonsils. Subsequently, difficulty
170 speaking, anesthesia in the left upper limb without muscle tone, cyanosis, convulsions, and
171 respiratory distress were observed. The patient died 49 days after the aggression.

172

173 The female patient showed clinical signs 30 days after the attack and consulted a health center
174 due to a 5-days history of right upper limb pain and fever. The patient was sent home with a
175 prescription for analgesics. The next day, the patient returned to the clinic due to persistent
176 symptoms of headache, emesis, pain, and decreased strength in the upper limbs, being
177 diagnosed with scarlet fever, treatment with cephalexin and acetaminophen was initiated.
178 The patient was readmitted due to right upper limb pain and fever, osteomyalgia, headache,
179 pain with decreased strength in the upper limbs, emesis, generalized muscle weakness,
180 drooling, cyanosis, respiratory distress, tonic-clonic seizures in the inferior limbs,

181 cardiorespiratory arrest, and finally, brain death. The patient died 41 days after the
182 aggression. In both cases, the rabies variant was V3, linked to vampire bats (INS, 2008; Páez
183 et al., 2009).

184

185 The third case in 2008 occurred in July when a 9-year-old female from the rural area of the
186 municipality of San Jacinto del Cauca, province of Bolívar, was attacked by a cat at the hands.
187 After the attack, the cat was killed and buried in the same rural area. The girl consulted the
188 health services and specific treatment for rabies was initiated. The patient, however, did not
189 return to continue the immunization protocol. The patient then returned to the health services
190 with neurological symptoms, including an inability to walk, numbness of arms and feet,
191 irritability, and excessive salivation. The viral variant recovered from the patient was V3
192 (Periódico El País, 2008; Periódico El Tiempo, 2008; Revista Portafolio, 2008; MinSalud,
193 2012).

194

195 In 2009 (epidemiological week 21), a 76-year-old female from the rural area of the
196 municipality of Moniquirá, province of Boyacá, was bitten by her own cat on the left hand.
197 The cat was 24 months old and unvaccinated, and was absent from home for three days before
198 the attack. The cat was reported to have behavioral changes, excessive salivation, and loss of
199 appetite, staying away from people. The patient was assaulted while trying to feed the cat
200 that refused to eat. The cat disappeared from the home two days after the attack. On the same
201 day of the attack, a 5-year-old dog in the same locality and with no previous rabies
202 vaccination, died after losing his appetite for a few days. Thirty-two days after the attack by
203 the cat, the patient showed clinical signs. The patient died 16 days later after the start of the
204 signs. The report mentioned that immediately after the attack, the patient applied lime and
205 salt to the wound. Two weeks later, the patient consulted the medical service due to
206 symptoms of diarrhea, emesis, and headache but did not comment on the bite. One month
207 later, the patient presented tingling in her left arm and initiated with headache that intensified
208 until taken to a physician, referring to blood pressure problems. Relatives told the physician
209 about the cat's bite. The physician did not link the cat's aggression with the symptoms. The
210 patient began to lose mobility in the left arm and the pain spread to the entire arm, back, and
211 head. Three days later, the patient presented emesis and severe general pain, and the health

212 condition worsened. The patient could not keep her head steady, showed aggressiveness,
213 drooled, lost their memory at times, vomited, screamed, and talked to herself. The patient
214 died 48 days after the aggression and the confirmation of rabies was given after the death by
215 direct immunofluorescence. The rabies variant recovered was V4, linked to insectivorous
216 bats (INS, 2009; Periódico El Tiempo, 2009).

217

218 **2010s decade (2010-2021): Eight cases.** Two cases were reported in 2010. The first case
219 occurred in August when a 13-year-old female patient from the municipality of Enciso,
220 province of Santander, was attacked by a cat. The patient died in August (Santander Hoy,
221 2010; Vanguardia, 2010). The second case occurred in December when an 11-year-old male
222 from a rural area of the municipality of San Luis, province of Tolima, was attacked by a cat.
223 The viral variant was V3 in both cases (Radio Santa Fe, 2010). In 2012 (epidemiological
224 week 21), a 19-year-old female from the municipality of Roldanillo, province of Valle del
225 Cauca, was attacked by a cat and after four months showed clinical signs and died 131 days
226 after the original report of the aggression. The viral variant was V4 (MinSalud, 2012; INS,
227 2012).

228

229 In 2015, a 9-year-old female patient in a rural area of the municipality of Mesitas del Colegio,
230 province of Cundinamarca, was scratched by a cat and received clinical attention but died 11
231 days later, the viral variant was V3 (Periódico El Tiempo, 2015; MinSalud, 2017; El Paciente
232 Colombiano, 2019; Cediel, 2020). In 2016, a case of human rabies linked to a cat attack in
233 Girardot, province of Cundinamarca, was reported. The viral variant was an atypical variant
234 related to vampire bats (AV1) (INS, 2019). In 2017 (epidemiological week 3), a case of
235 human rabies linked to a cat attack in the municipality of Tena, province of Cundinamarca,
236 was reported. The viral variant was AV1 (INS, 2019; Cediel, 2020; Observatorio de Salud
237 de Caldas, 2020).

238

239 In 2020 (epidemiological week 5), a case of human rabies linked to a cat attack in the
240 municipality of Neiva, province of Huila, was reported in a 26-year-old female. The patient
241 was attacked by their own cat. The cat was absent from home for one day before the incident
242 and presented irritability and hypersalivation. Twenty-three days after the attack, the patient

243 showed clinical signs, dying 30 days after the aggression. The viral variant was V3 and the
244 confirmation of rabies was given after the death of the patient by direct immunofluorescence,
245 biological test, immunohistochemistry, biological test, and immunohistochemistry (Cediel,
246 2020; Revista Semana, 2020).

247

248 In 2021, a 29-year-old male patient from the rural area of the municipality of La Argentina,
249 province of Huila, was bitten by their own unvaccinated two-months-old female kitten. The
250 patient showed clinical signs 22 days after the attack and consulted a health center due to
251 right arm pain and headache. A few days later the patient presented odontalgia, and paresis
252 and paresthesia on the right upper limb, right hemicrania paresis, hallucinations,
253 psychomotor agitation, difficult swallowing, nystagmus, and right-hand decreased strength,
254 as well as aggressive behavior. The patient was then referred to the ICU with hyporeactive
255 isochores, persistent nystagmus, and a super refractory status. Two days later, bilateral
256 paresis, absence of corneal reflex, areflexia of the upper limbs, bilateral neutral plantar
257 response, no meningeal or cranial activity signs, and endocranial hypertension were observed
258 until his death 41 days after the aggression. The confirmation of rabies was given after the
259 death of the patient by direct immunofluorescence. Although, a PCR-negative result was
260 reported, immunohistochemistry revealed RABV variant V3 (ICA, 2021).

261

262 **DISCUSSION**

263 Rabies virus spillover transmission from animals to humans has historically focused on dogs
264 as the main aggressor and source of the infection in Colombia. Between 2004 and 2022,
265 animal rabies in Colombia draw attention to a significant concentration of the urban lineage
266 (V1) in the province of Magdalena. During that period there were 27 outbreaks of dog rabies
267 variant V1 in various municipalities. Meanwhile, wildlife RABV lineages exhibited 1357
268 outbreaks in livestock along the Atlantic coast in the provinces of Santander, Norte de
269 Santander, Arauca, Orinoquia, and Amazonia, including their mountains. In addition, 13
270 outbreaks of bat RABV lineages were recorded in cats, dogs, and bats in the provinces of
271 Antioquia, Cundinamarca, Huila, Tolima, Valle, Casanare, Magdalena, Meta, and Sucre.
272 Forty cases of human rabies were reported between 2000 and 2022 in the country, with the

273 latest cases recorded in Neiva and La Argentina, province of Huila, in 2020 and 2021,
274 respectively.

275

276 Since 2015, rabies in humans have been clustered in central Colombia, involving the wild
277 lineage of RABV as the pathogen and cats as sources of infection for four rabies cases in
278 humans in the province of Cundinamarca and two in the province of Huila (INS,2022). As
279 such, data presented here support a new epidemiology of rabies where cats are the main
280 transmitter of RABV to humans. This new epidemiology of rabies is not particular to
281 Colombia. There was a marked increase of 17.6% in positive cases of rabies in cats in 2020
282 in the United States, reaching a total of 288 cases compared to the 245 reported in 2019. This
283 increase in rabid cats was reflected in a significantly higher percentage of rabies incidence in
284 cats (1.7%) compared to the average incidence of the previous five years (1.2%; 95%CI: 1.1-
285 1.2). Notably, nearly 70% of rabid cats were concentrated in six specific states, main in
286 Pennsylvania (19.8%), followed by Maryland, New York, Virginia, Texas, and New Jersey.
287 In the United States, RABV was characterized in only 32.3% of the cases, form which 68
288 cats were infected with RABV from the Eastern raccoon and 25 with RABV from the Central
289 skunk (Ma et al., 2022). Thus, cat vaccination should be considered the first front of rabies
290 prevention considering the broad RABV circulation in wildlife.

291

292 Regarding the risk derived from animal aggressions to humans, a retrospective analysis in
293 Ukraine showed a higher report of dog bites with low human rabies prevalence (0.86%),
294 while cat bites resulted in a higher rabies prevalence (3.7%) (Makovska et al., 2018). In
295 Colombia in 2020, 108,633 animal aggressions to humans with potential RABV exposure
296 were reported in 2020, 23% more compared to 2019 (Observatorio de Salud de Caldas, 2020).
297 Rabies control strategies in Colombia are based on animal attacks or exposure to animal
298 species of risk. Since 2008, this responsive approach has been included within the public
299 health surveillance system (SIVIGILA) (INS, 2018).

300

301 In the Americas, there has been a successful reduction in the incidence of human rabies
302 transmitted by dogs. Nevertheless, in the last decade there has been an increase in human
303 rabies involving RABV of wildlife origin. The common vampire bat (*Desmodus rotundus*)

304 is emerging as the primary source of RABV to other species (Velasco-Villa et al., 2017). The
305 epidemiological trend of RABV in Colombia, however, includes cats as a source of infection
306 to human rabies, but not vampire bats. Since bats are common prey of domestic and feral cats
307 (Welch and Leppanen, 2017), bat RABV lineages now lead the epidemiology of rabies in
308 Colombia over dog RABV lineages (Table 1).

309

310 The role of cats in human societies has evolved over history, from being a symbol of sacred
311 origin in ancient Egypt to becoming a preferred pet for families worldwide (Serpell, 2014).
312 Cats can be classified based on their socio-environmental situation where feral cats denote
313 cats that have returned to the wild or developed without human contact, stray cats refer to
314 lost or abandoned cats that maintain a tolerance to humans, domestic cats as those living with
315 their owners indoors, and semidomestic cats as animals under human care but allowed to
316 roam freely outdoors (Turner, 2017). These changing dynamics have led to an increase in the
317 cat population in urban and rural areas, raising the likelihood of encounters with wild species
318 and the risk of various diseases. Nevertheless, the main factor driving cats situation is their
319 owners' who often abandon their pets, contributing to the growth of stray cats and increasing
320 their exposure to diseases (Makovska et al., 2018).

321

322 In Latin America, vampire bats and frugivorous bats (e.g., *Artibeus* spp.) have been identified
323 as RABV reservoirs (Castelo-Branco et al., 2023). Vampire bats feed on the blood of
324 livestock, wildlife, and humans, and are typically found in rural habitats. Insectivorous and
325 frugivorous bats, however, have been identified as potential sources of RABV in urban areas
326 (Nunes et al., 2017). In urban areas, stray and feral cats, generally lacking rabies vaccination
327 and basic veterinary care, could be particularly exposed to bat-borne rabies. This situation
328 underscores the importance of addressing the lack of preventive veterinary medicine for
329 urban cats as a means to reduce the risk of bat-borne rabies to humans.

330

331 The geographical presentation of rabies cases in humans in Colombia has a well-defined
332 distribution restricted to an Andean corridor (Figure 2). The Andean rabies corridor can be
333 linked to the presence and abundance of bat reservoirs (perhaps presenting a similar dynamic
334 to that mentioned in Brazil), sustaining the sylvatic cycle of RABV in these areas or a high

335 density of outdoor cats with access to infected bats. Alternatively, this geographic pattern
336 could highlight a biased epidemiology influenced by higher detectability of cases in sites of
337 the higher human densities as occurs in the highlands of Colombia.

338

339 In conclusion, the epidemiological patterns reported here should be used to update our
340 understanding of the epidemiology of rabies. Human population dynamics have changed in
341 recent decades in the Colombian highlands, likely influencing the population of cats in urban
342 and rural areas, and disturbing the ecology of local bat colonies. Higher human density can
343 lead to higher densities of unvaccinated cats with access to outdoors in areas with the
344 presence of bats, with cats narrowing the human-wildlife interface.

345

346 Epidemiological information of cats involved in human rabies cases was found to be
347 generally lacking and scattered, limiting effective and timely patient management after
348 exposure. As such, it is essential to promote improved disease management protocols aiming
349 to enhance early detection of cat attacks and strengthen epidemiological surveillance of cat-
350 borne rabies. In addition, laboratory characterization of RABV lineages linked to outbreaks
351 should be decentralized and mandatory at the government level to elucidate the sources of
352 infections. Most rabies cases occurred in children (9-13 years old) living in the highlands,
353 which emphasizes the need to revise mass vaccination programs in areas of risk. We argue
354 that establishing pet vaccination in the Andes should be mandatory and prioritizing cats,
355 especially outdoor cats. Our findings suggest that cats under three months of age should be
356 considered in vaccination programs. Mass cat vaccination could lead to reduce the risk of
357 rabies infection in cats and the consequent spillover transmission to humans.

358

359 **CONFLICT OF INTEREST**

360 The authors declare that no conflict of interest exists.

361

362 **DATA AVAILABILITY STATEMENT**

363 The data that support the findings of this study are available from references cited and also
364 from the corresponding author upon request.

365

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