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Makhan Danfakha, Mamadou Aliou Diallo, Oumy Kaltome Boh, Mouhamadou Faly Ba, Rosalie Ndew Seck, Codou Faye, Valéry Ridde

Corresponding author: Makhan Danfakha, Institute of Research for Development, Dakar-Hann BP 1386, Senegal. danf279@gmail.com

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A "One Health" vision of rabies in Saint-Louis in 2024: a study on knowledge, attitudes, and practices among health providers

Makhan Danfakha[1,2,&], Mamadou Aliou Diallo[1,3], Oumy Kaltome Boh[4], Mouhamadou Faly Ba[2], Rosalie Ndew Seck[5], Codou Faye[6], Valéry Ridde[7]

[1]Institute of Research for Development, Dakar-Hann BP 1386, Senegal, [2]Institute of Health and Development, Cheikh Anta Diop University of Dakar, Senegal, Dakar-Fann BP 5005, Senegal, [3]Ministry of Health and Social Action, Dakar, Senegal, Fann Résidence, Rue Aimé Césaire, Dakar BP 4024, Senegal, [4]Department of Animal Biology, Faculty of Science and Technology, Cheikh Anta Diop University of Dakar, Dakar-Fann BP 5005, Senegal, [5]Directorate of Veterinary Services, Ministry of Agriculture, Food Sovereignty, and Livestock, Diamniadio, Senegal, [6]Food and Agriculture Organization of the United Nations (FAO), Emergency Centre for Transboundary

Animal Diseases (ECTAD), LeclercTerminus, Av. A. Fadiga, Dakar, Senegal, [7]Université Paris Cité and Université Sorbonne Paris Nord, IRD, Inserm, Ceped, F-75006 Paris, France

[&]Corresponding author

Makhan Danfakha, Institute of Research for Development, Dakar-Hann BP 1386, Senegal

Abstract

Introduction: *rabies remains a major public health issue in Senegal, with Saint-Louis being one of the most affected regions in 2022. Diagnostic challenges, gaps in case management, and inadequate attitudes and practices among health providers and the population contribute to the increasing risk. This study aimed to assess the knowledge, attitudes, and practices (KAP) of human and animal health providers regarding rabies in the Saint-Louis district.* ***Methods:*** *data were collected using a questionnaire developed on KoboToolbox and analyzed using R software version 4.3.3. This was a cross-sectional and analytical study conducted from July 15 to 28, 2024, with a sample of 161 human and animal health providers. The analyses included descriptive, bivariate, and multivariate assessments of variables, taking into account group comparisons.* ***Results:*** *two out of five participants (41.0%) had sufficient knowledge about rabies, 38.5% demonstrated a positive attitude, while 31.1% adopted good practices in the event of an animal bite. Multivariate analysis revealed that animal health providers were 7.64 times more likely to have sufficient knowledge about rabies compared to their human health counterparts (p = 0.083). Human and animal health providers with sufficient knowledge were 3.41 times more likely to adopt a positive attitude towards rabies (95% CI: [1.01-12.70]). Additionally, human and animal health providers with a positive attitude were 3.23 times more likely to implement good practices in response to an animal bite (95% CI: [1.08-10.70]).*

Conclusion: *the study highlights the need to strengthen the training of human and animal health providers on rabies, emphasizing a "One Health" approach. Enhancing knowledge appears to be a critical lever for positively influencing attitudes and practices, thereby contributing to better management of this zoonosis.*

Introduction

Rabies, an anthropozoonosis caused by a virus belonging to the Rhabdoviridae family and the Lyssavirus genus, is responsible for acute encephalomyelitis [1]. It is among the oldest infectious diseases, affecting both domestic and wild mammals, and is transmitted to humans primarily through the saliva of infected animals during bites or scratches [2,3]. Dogs are responsible for 99% of fatal human rabies cases, particularly affecting children aged 5 to 14 years. The rabies virus also affects other mammals, such as cats, livestock, and wild animals [4].

It is a major zoonotic disease that threatens global public health [5]. It causes approximately 59,000 human deaths per year, affecting more than 150 countries [6]. Asia is the most affected region, followed by Africa [7-9], with an estimated incidence of 24,000 cases per year, nearly 10,000 of which involve children [10]. In sub-Saharan Africa, rabies remains a significant public health issue, with approximately 19,000 human deaths annually, representing a substantial portion of rabies-related deaths on the continent [10].

In Senegal, rabies is one of the six priority zoonotic diseases [11]. It is endemic and remains poorly controlled. It poses a major public health concern, mainly maintained by stray or semi-stray dogs, and to a lesser extent by cats and monkeys [12]. Between 1995 and 2017, veterinary services reported 90 cases of canine rabies, and the Infectious Diseases Clinic at Fann Hospital reported 80 human rabies cases [12]. Despite these notifications, surveillance remains largely passive, and reliable epidemiological data are still

scarce. In 2020, 4,216 cases of animal bites were notified by the Ministry of Health and Social Action [13,14], and 60 animal rabies outbreaks were confirmed across 9 of the country's 14 administrative regions, including Saint-Louis [13]. The trend is increasing, with 16,017 cases of human exposure recorded in 2021, 59% of which involved dogs [14]. From 2009 to 2020, 43 human deaths from rabies were recorded [14,15], although this likely underestimates the true burden due to underreporting.

Rabies was integrated into the national disease surveillance system in 2008, and reporting requirements were reinforced. The economic burden of rabies is significant. In response, the Government of Senegal announced a national rabies control program in 2017 with a projected budget of 764 million CFA francs, during which more than 32,000 dogs were targered for culling (9,325 domestic and 23,542 stray) [12]. Each year, World Rabies Day is marked by public awareness and free dog vaccination campaigns [15]. However, a 2018 national evaluation by the Global Alliance for Rabies Control (GARC) gave Senegal a score of 1.5 out of 5, indicating that the national rabies control program was still largely ineffective [16]. This low score constrats with the fact that during 2015-2017, only 17 animal rabies cases were identified through surveillance [12], while more than 15,000 doses of post-exposure prophylaxis (PEP) were administered annually, and the estimated number of human deaths from rabies was 168 per year [12].

Laboratory confirmation is provided by national reference laboratories hosted at the Institut Pasteur de Dakar (IPD) and the Senegalese Institute of Agricultural Research (ISRA), which diagnose all suspected human and animal rabies samples. Animal bite cases are jointly managed by veterinary clinics (for observation), the National Livestock and Veterinary Research Laboratory (LNERV, for virologic diagnosis), and human health structures. There are officially three anti-rabies treatment centers (CTARs) in Senegal: at IPD, the SMIT unit at Fann University Hospital, and the Fatick treatment unit [17]. Rabies treatment in health facilities is not free. The cost of PEP is estimated between 26,000 and 39,000 CFA francs (40 to 60 euros) [18], while per capita health spending in Saint-Louis was 34,833 CFA francs (about 53 euros) in 2021 [19], and the national average monthly salary is around 104,000 CFA francs (160 euros) [18]. These costs, compounded by travel and lost income, impose a heavy burden on affected families.

In terms of governance, rabies control in Senegal is managed within a multisectoral framework coordinated by the National High Council for Global Health Security "One Health," established in 2017 [20]. This council facilitates coordinated actions among the human, animal, and environmental health sectors, yet challenges remain, particularly regarding sustainable financing, decentralized coordination, strengthened surveillance capacity, and vaccination coverage [21]. The World Health Organization (WHO) guidelines recommend three crucial steps for post-exposure prophylaxis (PEP): thorough washing of the wound with water and soap or detergent, administration of the rabies vaccine, and infiltration of rabies immunoglobulins into and around the wound [4,22]. Furthermore, through an integrated synergy within the "One Health" approach, rabies can be effectively fought through the integrated management of animal bites, PEP, mass dog vaccination, and community awareness programs [23-26]. Both human and animal health providers play complementary roles in this fight: veterinarians ensure dog vaccination and monitor animal populations, while human health workers treat bite victims by administering PEP and educating communities on prevention. This interdisciplinary collaboration, embedded in the "One Health" approach, strengthens the overall response to rabies by improving coordination between the two sectors [27].

However, despite the existing structures, gaps remain in the capacity of healthcare providers to manage rabies. The fight against rabies requires a good knowledge of the disease on the part of

those involved in the health sector. However, in Senegal, very few studies have been carried out to assess the knowledge, attitudes, and practices of these players about rabies. Thus, our study in the Sokone health district found that only 5.3% of providers had good knowledge of rabies [28]. Another study conducted in Kaffrine showed that the proportion of healthcare providers with sufficient knowledge, positive attitudes, and adequate practices regarding rabies was 35.8%, 26.3%, and 45.3%, respectively [29]. Notably, these studies focused on human health providers only and excluded animal health professionals, missing critical intersectoral insights.

Faced with the heavy public health and economic burden of rabies and persistent deficiencies in intersectoral collaboration, it is urgent to strengthen an integrated response based on the "One Health" approach. Thus, this study aimed to assess the knowledge, attitudes, and practices (KAP) of both human and animal health providers on rabies in the Saint-Louis district to strengthen local strategies for controlling and eliminating this zoonosis. The specific objectives of this study included a description of the socio-demographic characteristics of the providers, assessing their level of knowledge, analysing their attitudes and practices regarding rabies management, and the identification of factors influencing these CAPs, with attention to the "One Health" approach.

Methods

Study area: Saint-Louis Health District: the Saint-Louis Health District, located at the western tip of the region, covers an area of 879 km^2 and is bordered by the Atlantic Ocean to the west, Mauritania to the north, the Richard-Toll district to the east, and the Sakal district to the south. In terms of healthcare, it has a variety of facilities: one regional hospital, two health centers, 18 health posts, 27 private structures, and 29 pharmacies. In terms of livestock, there is a regional and departmental livestock service, as well as around fifteen veterinary posts and practices [30]. The district's human resources include 10 doctors and 70 paramedics, with a core team of 9 members specialized in neglected tropical diseases and epidemiological surveillance. Community staff are present, including 192 "Badienou Gokh," neighborhood sponsors responsible for promoting maternal and child health, and 210 community relays who play a key role in awareness and support. The Saint-Louis Public Health Establishment (EPS) employs 73 doctors, 21 of whom are university-trained, with 10 working in the emergency department. The paramedical team consists of 30 nurses and 38 nurse assistants. The Saint-Louis Health District also has 4 veterinarians, 5 livestock technicians, and 2 livestock engineering technicians. In the private and semi-public structures in the area, there are approximately 20 doctors and around 40 paramedics.

With a departmental population estimated at 387,368 inhabitants in 2023 [31], the main economic activities are agriculture, fishing, livestock farming, trade, and tourism. Artisanal fishing is the primary economic activity, influenced by significant Senegalese-Mauritanian migratory flows, with a large, displaced population living in densely populated neighbourhoods such as Langue de Barbarie, Pikine, Bango, and Ngallèle. Coastal erosion causes the displacement of many families each year to resettlement sites [30]. Regarding the canine population, the Saint-Louis department is characterized by a significant presence of stray and semi-stray dogs, particularly in urban and peri-urban neighborhoods, which constitutes a major risk factor for rabies transmission. In rural areas, dogs are often kept in semi-freedom, while in urban areas, they are mainly used for guarding but may still roam outside, thereby increasing contact with other animals and humans. Several rabies control initiatives have already been implemented in the area, including occasional mass dog vaccination campaigns - notably during World Rabies Day - and community awareness activities on preventive

measures, although these interventions remain limited in time and coverage [29].

Study type and period: this was a cross-sectional, descriptive, and analytical study. Data were collected from July 15 to 28, 2024.

Study population: the study population consisted of human and animal health providers from public and private structures operating within the Saint-Louis Health District.

Sampling: the statistical unit was represented by all the human and animal health personnel present in the Saint-Louis Health District.

Inclusion criteria: the following inclusion criteria were defined for respondents from both categories of providers who voluntarily agreed to participate in the study: i) an animal health provider present and working in the Saint-Louis district at the time of the survey at the visited veterinary station. ii) a qualified human health provider, such as a nurse, nurse assistant, doctor, or pharmacist, present and working in the Saint-Louis district at the time of the survey in the visited healthcare facility

Non-inclusion criteria: providers who were absent during the data collection phase, who refused to participate, or who did not provide complete data were not included in the study.

Sample: the comprehensive list of 164 eligible human and animal healthcare professionals for the study was provided by the district´s human resources department and the Regional Livestock Directorate of Saint-Louis. To ensure better representativeness and avoid selection bias, an exhaustive recruitment was carried out to include all 164 eligible human and animal health providers. This included professionals from public healthcare structures (EPS, health centers, and health posts), veterinary service providers, and professionals from private and semi-public structures that provided authorization (Figure 1). In the end, 161 providers were enrolled in the study.

Data collection

Data collect tools: we used a questionnaire (Annex 1) adapted from a previous study published by Ba *et al.* [29], aimed at human and animal health professionals and based on the CAP model. This questionnaire, previously tested with the health staff at the regional hospital of Saint-Louis (who were not included in our sample), was used to assess the clarity, relevance, and understanding of the questions. It aimed to collect information on the sociodemographic characteristics of the respondents as well as their knowledge, attitudes, and practices regarding rabies, structured as follows:

Sociodemographic characteristics: these data included information on the workplace, age, sex, level of education, job position, years of experience, and pet ownership.

Knowledge: sixteen (16) questions were used to assess the respondents' knowledge of rabies (from the cause of the infection to its management), according to a method described by Koruk *et al.* [32].

Attitudes: ten questions measured the providers' attitudes towards rabies [7], rated on a 5-point Likert scale (from 1 for "strongly disagree" to 5 for "strongly agree").

Practices: this section explored the respondents' behaviors and actions in response to concrete animal bite situations.

Data collection method: six enumerators conducted the data collection through face-to-face individual interviews with the providers in the visited structures (Figure 1).

Data analysis: the data collected from KoBocollect was exported in Microsoft Office 2016 Excel format, then validated before being subjected to statistical calculations. A scoring system was used,

and scores were assigned according to the accuracy of responses. The scoring methods for each section were as follows:

Knowledge: each of the 16 questions was equally weighted. Each correct answer scored 1 point, and incorrect answers scored 0 points. Knowledge was defined as a binary variable (sufficient vs. insufficient). Sufficient knowledge was assigned when the total score was higher than the average score of all respondents, following the definition used by Monje *et al.* [7] and the method described by Koruk *et al.* [32].

Attitudes: each of the 10 questions was rated on a 5-point Likert scale (5 = strongly agree to 1 = strongly disagree). For each question, "Strongly agree" and "Agree" responses scored 1 point, while all other responses scored 0 points. Attitude was defined as a binary variable (positive vs. negative). As suggested in previous studies [7,22]. Providers who scored 86% or higher (i.e., 9 or 10 points) were considered to have a positive attitude.

Practices: questions were adapted to the professional profile (human or animal health). For human health professionals, the practices assessed included immediate wound washing with water and soap for at least 15 minutes, disinfection, tetanus prevention, rabies risk assessment, case categorization, initiation of post-exposure prophylaxis if needed, and notification using the standard form. For animal health professionals, the practices assessed included observing the dog for 15 days, referring the patient to a physician or head nurse, wound washing, animal euthanasia where applicable, vaccination of bitten animals, reporting to the administrative authority, and official case notification. All questions were rated on a 5-point Likert scale. Practices were defined as a binary variable (good vs. poor), with "good" assigned when all responses complied with existing literature on rabies prevention and control [4,33].

The data were analyzed using R software version 4.3.3. A descriptive analysis was performed on all the collected data. Quantitative variables were described by the mean with its standard deviation, and qualitative variables by absolute and relative frequencies. In the bivariate analysis, Chi-square tests and Fisher's exact tests were performed according to the applicability conditions. These tests were used to search for pairwise associations with a 5% alpha risk. The following comparisons were made: i) knowledge (binary variable) as the dependent variable and sociodemographic characteristics as the independent variable; ii) attitude (binary variable) as the dependent variable and sociodemographic characteristics plus knowledge as the independent variable; iii) practice (binary variable) as the dependent variable and sociodemographic characteristics plus attitude and knowledge as the independent variable. To control for confounding factors, a binary logistic regression was performed. All variables used in the bivariate analysis were included in our models.

Ethics: this study was approved by the National Committee for Ethics in Health Research (CNERS) in Senegal (Reference No. 0000177/MSAS/CNERS/SP dated July 10, 2024).

Results

Descriptive analysis

Sociodemographic characteristics: in the study, male healthcare providers accounted for only 34.2%, resulting in a sex ratio of 0.47 (M/F). The average age was 34.6 years with a standard deviation of 9.2 years. On average, providers had been in service for 8.1 ± 7.3 years. The analysis revealed that 46.6% of the providers owned a domestic animal, and only 6.2% had received refresher training on rabies Male healthcare providers accounted for only 34.2%, resulting in a sex ratio of 0.47 (men/women). The average age was 34.6 years with a standard deviation of 9.2 years. On average, providers had been in service

for 8.1 ± 7.3 years. The analysis revealed that 46.6% of the providers owned a domestic animal, and only 6.2% had received refresher training on rabies. Regarding professional categories, among the 151 human health professionals surveyed, the distribution was as follows: 38 (25.1%) physicians, 1 (0.6%) pharmacist, 35 (23.1%) midwives, 47 (31.1%) nurses, and 28 (18.5%) assistant nurses. In the animal health sector (n = 10), respondents included 4 veterinarians, 4 animal health technicians, and 2 livestock engineering technicians. Two respondents belonged to other professional categories. These details are presented in Table 1, which summarizes the distribution of respondents by sociodemographic and professional characteristics (Table 1).

Knowledge: in the study, 98.8% of the providers stated that they had good knowledge of rabies. Generally, the providers demonstrated good knowledge about the pathogen responsible for rabies (72.7%), the species affected by rabies (72.7%), the modes of transmission (98.8%), as well as questions related to the groups most at risk of rabies and the first aid given to patients after being bitten by a potentially rabid animal, with proportions exceeding 60.0%. However, the providers' knowledge was weak regarding questions related to the period of contagiousness and the incubation period, as well as the vaccination schedules for animals and humans against rabies (Annex 2). The average knowledge score of the providers on rabies was 7.1 ± 2.0, with scores ranging from 3 to 14. Table 2 shows the distribution of providers according to their knowledge of rabies and their professional field. The knowledge score ranged from 3 to 14 among human health providers and from 7 to 12 among animal health providers. Based on the operational definition, providers with sufficient knowledge of rabies accounted for 41.0% of the study population.

Attitudes: the average attitude score of the providers towards rabies was 8.1 ± 1.1, with scores ranging from 5 to 10. Among human health providers, the attitude scores ranged from 5 to 10, while they ranged from 6 to 10 among animal health providers (Table 2). Based on the operational definition, providers with a positive attitude towards rabies represented 38.5% of the study population.

Practices: only 1.2% of providers had participated in a rabies campaign in the district before the survey, and only 20.5% had heard of the "One Health" approach. Similarly, 11.8% of providers reported having had a collaboration effort between medical and veterinary services to combat rabies or to manage a suspected rabies case. For human health providers, the only question related to the management of suspected rabies cases with less than 60.0% agreement was the one concerning treatment by disinfection using an antiseptic solution (35.7%) (Annex 2). For the questions directed at animal health providers, the proportions who strongly agreed/agreed with observing the dog for 15 days and referring the patient to a doctor or community health worker (ICP) were both 100.0% for these two measures. However, animal health providers largely disagreed or strongly disagreed with vaccinating the biting animal and vaccinating the bitten animal, with 80.0% and 70.0% disagreement, respectively (Annex 2). The proportion of providers demonstrating good practices when faced with an animal bite case was estimated at 31.1%.

Bivariate analysis

Knowledge: the proportion of animal health providers with sufficient knowledge about rabies was 90.0%, compared to 37.7% among human health professionals (p = 0.002). Additionally, among providers who had attended a training session or refresher workshop on rabies, 80.0% had sufficient knowledge, compared to only 38.4% of those who had not attended training (p = 0.016) (Table 3).

Attitudes: the proportion of male providers with a positive attitude towards rabies was 50.9%, while it was 32.1% among female providers (p = 0.031).

Furthermore, among providers with sufficient knowledge about rabies, 48.5% had a positive attitude, compared to only 31.6% among those with insufficient knowledge (p = 0.045) (Table 3). These results show a statistically significant association between gender, the level of knowledge about rabies, and the providers' attitudes towards this disease.

Practices: the proportion of human health providers demonstrating good practices in response to an animal bite case was 33.1%, while none of the animal health providers exhibited good practices (p = 0.032). Additionally, among providers with less than 10 years of experience, 38.0% demonstrated good practices, compared to only 17.0% among those with 10 or more years of experience (p = 0.012) (Table 3). These results indicate a statistically significant association between the role, experience of the providers, and their practices in the context of animal bite cases.

Multivariate analysis: animal health providers were 7.64 times more likely to have sufficient knowledge about rabies compared to their human health counterparts, although this association was not statistically significant (p = 0.083) (Table 4). Men were 2.12 times more likely to have a positive attitude toward rabies compared to women, with a statistically significant association (p = 0.035). Providers with sufficient knowledge about rabies were 2.01 times more likely to have a positive attitude toward rabies (p = 0.042) (Table 4). Providers with 10 or more years of service experience were 0.24 times as likely to demonstrate good practices in the event of an animal bite, with a significant association (p = 0.0016) (Table 4).

Discussion

The results of our study showed that more than half of the human healthcare providers (62.3%) had insufficient knowledge of rabies, a result similar to those obtained in Uganda (44%, n=147) [7], Chad (42%, n = 245) [34], Senegal (Sokone 5.6%, n = 38; Kaffrine 38.5%, n=95) [29,30], and Turkey, where only 44% of doctors surveyed knew that contact with the mucous membranes of a rabid animal could also lead to transmission (n = 84) [32]. In contrast, studies conducted in Vietnam and the United States reported moderate and high levels of knowledge among human healthcare providers [35,36]. These differences may be attributed to a lack of continuous training on rabies in Senegal, where only 6.2% of professionals had ever attended a course or workshop on rabies. The lack of awareness by healthcare providers about the real impact of rabies on communities could also partly explain these results. However, it is imperative to improve continuous training for both human and animal healthcare providers, as insufficient knowledge can compromise the management and prevention of rabies. Although human healthcare professionals are aware of the risks, their training on the management and prevention of rabies remains insufficient, requiring capacity-building interventions [37].

In contrast, the majority of animal healthcare providers (90.0%) had sufficient knowledge about rabies, which aligns with the findings of similar studies conducted in the United States and Uganda [7,36]. Moreover, our multivariate analysis results showed that animal healthcare providers were 7.64 times more likely to have sufficient knowledge compared to their human counterparts. However, studies conducted in Tanzania and Chad reported lower knowledge rates among veterinarians [38,34]. These variations may be explained by the fact that veterinarians are often more exposed to the risks of zoonotic diseases in their daily practice, unlike human healthcare providers, for whom this represents a small component of their work. In this regard, studies conducted in the United States and Australia have shown that, overall, animal healthcare providers were better informed about rabies than human healthcare providers [36,39,40]. This could be explained by the fact that veterinarians perform continuous

assessments of zoonotic disease risks as part of their daily professional practice, whereas for human healthcare providers, it is a small component of their clinical practice. These findings highlight the need for a closer integration of the two healthcare systems and greater intersectoral collaboration in a "One Health" perspective.

Regarding attitudes, most of the healthcare providers surveyed had a negative attitude towards rabies management. These results were consistent with findings from Uganda and Kenya [7,41]. The latter study recommended that public health workers need more knowledge, correct attitudes, and appropriate skills to enable them to carry out surveillance and teach the public about zoonotic disease control measures. The analysis showed that male providers were more likely to have a positive attitude compared to females, and those with a good level of knowledge were more likely to adopt a positive attitude. These results align with those observed in Uganda [7], where respondents with a degree were 7 times more likely (OR = 7.23, 95% CI) to have a more positive attitude than those with lower qualifications (diplomas or certificates).

Regarding practices, less than half of the healthcare providers (31.1%) had adequate practices in the event of a suspected animal bite. This rate is lower than that reported by Faly *et al.*in Kaffrine (45.3%) [29], highlighting the need to strengthen practical skills in the management of animal bites. Interestingly, providers with 10 or more years of service were more likely to have good practices in the case of an animal bite. This contrasts with the study by Faly *et al.* which found no significant link between seniority and practices [29]. These differences could be explained by the differing representativeness of the samples in each study.

The World Health Organization recommends immediately starting post-exposure prophylaxis (PEP) with thorough wound cleaning, local treatment, a series of rabies vaccine doses, and the administration of immunoglobulins as indicated [4]. This approach is crucial to prevent the virus from progressing to the nerves [27]. It is essential to strengthen synergy between medical and veterinary services. In our study, only 11.8% of professionals collaborated with veterinary services for a suspected rabies case, and only 20.5% had heard of the "One Health" approach, which reveals the urgent need to operationalize this approach. Concrete examples, such as initiatives in Vietnam, have shown that integrating efforts between human health services, veterinary services, and local authorities following the "One Health" approach can significantly strengthen the management of suspected rabies cases, improve surveillance, and limit transmission risks [42]. Current best practices recommended by the World Health Organization (WHO) and the World Organization for Animal Health (WOAH) emphasize intersectoral collaboration, particularly in the context of community awareness campaigns and animal vaccination [7]. This "One Health" approach allows for more integrated rabies management by bringing together human and animal health professionals, as well as other key actors, for better coordination of resources and expertise [43].

Our study showed that healthcare professionals' knowledge influences their attitudes, which in turn determines their practices in rabies management. These findings are consistent with those found in Uganda [7] and the conclusions of Mascie-Taylor *et al.* [44]. These observations suggest that it is necessary to improve healthcare providers' knowledge about rabies to influence their attitudes and practices against rabies. Our study was conducted in a single district out of the 79 in Senegal, although most health districts are organized similarly, and professionals are trained in the same schools with some degree of homogeneity [45]. Additionally, the sample of animal health professionals was small, even though we selected the entire population. Despite these limitations, this survey provided useful data to guide public health efforts in the fight against rabies in health districts. The results obtained

could serve as a foundation for implementing targeted training programs in the Saint-Louis region, as well as in other at-risk areas of Senegal. These programs would improve the management of animal and human bites while strengthening rabies control. Furthermore, the observed gaps highlight the need for joint educational interventions and enhanced interprofessional collaborations to improve human and animal health outcomes.

Several strategic areas can be targeted to improve rabies control in the Saint-Louis region and generally in Senegal. First, scaling up mass dog vaccination campaigns remains a cornerstone of rabies elimination, as recommended by WHO and WOAH [46,47]. These campaigns should be coupled with sustainable dog population management strategies, including sterilization programs and responsible dog ownership education, to reduce the number of unvaccinated free-roaming dogs. Second, ensuring universal (free of charge) and timely access to post-exposure prophylaxis (PEP) is critical, particularly in rural areas, through better supply chain management, decentralization of vaccine storage, and healthcare provider training on WHO PEP protocols. Third, community awareness and engagement should be strengthened via culturally adapted information campaigns on bite prevention, early reporting, and prompt health-seeking behavior, leveraging schools, local leaders, and mass media. Fourth, epidemiological surveillance systems must be reinforced to include systematic reporting of animal bites, suspected rabies cases, and laboratory confirmation of animal and human cases, thus improving data quality and early outbreak detection. Finally, these actions should be embedded into national public health and veterinary policies under a formal One Health framework, fostering institutionalized collaboration between the Ministry of Health, the Ministry of Livestock, local authorities, and civil society. This integrated approach has been successfully implemented in countries such as Vietnam and the Philippines, where coordinated actions have led to substantial reductions in rabies incidence [48].

Conclusion

Rabies is a major public health challenge in Senegal, particularly in the Saint-Louis health district, where it remains a threat to both human and animal populations. This study provided a detailed assessment of the knowledge, attitudes, and practices of human and animal healthcare providers in Saint-Louis, Senegal. It also highlighted disparities in knowledge and practices, and identified factors such as training and professional experience. These elements offer a better understanding of the levers to activate to improve the fight against rabies in an integrated and sustainable manner. Through the results of our study, it is clear that additional efforts are needed to strengthen the capacities of healthcare professionals, harmonize care practices, and promote intersectoral collaboration within the framework of the "One Health" approach. Furthermore, the lessons learned from this survey will inform adjustments to existing policies and actions and will provide valuable indicators to assess the effectiveness of the national rabies elimination program. These results could also serve as a reference point for other countries with similar socio-economic contexts, to eliminate rabies by 2030, in line with global objectives.

What is known about this topic

- *Rabies is a deadly zoonosis that remains a major public health problem in developing countries, including Senegal, where it is still endemic and poorly controlled;*
- *Despite WHO recommendations, significant gaps persist in the knowledge, attitudes, and practices (KAP) of health providers, limiting the effectiveness of disease prevention and management strategies;*

- *The "One Health" approach is often highlighted as essential for strengthening coordination between the human and veterinary sectors in the fight against rabies.*

What this study adds

- *We found that 62.3% of human health providers had insufficient knowledge of rabies, whereas 90.0% of animal health providers had sufficient knowledge;*
- *Only 11.8% of human health providers had collaborated with veterinary services for a suspected rabies case, and that only 20.5% were aware of the "One Health" approach, underlining critical gaps in intersectoral collaboration;*
- *Targeted interventions are needed, focusing on capacity-building, harmonization of case management practices, community awareness, and improved access to post-exposure prophylaxis.*

Competing interests

The authors declare no competing interests.

Authors' contributions

Conceptualization: Makhan Danfakha, Mamadou Aliou Diallo, Oumy Kaltome Boh. Methodology: Makhan Danfakha, Mamadou Aliou Diallo, Oumy Kaltome Boh. Validation: Mouhamadou Faly Ba, Valéry Ridde, Codou Faye, Rosalie Ndew Seck. Formal analysis: Makhan Danfakha, Mouhamadou Faly Ba. Investigation: Makhan Danfakha, Oumy Kaltome Boh, Rosalie Ndew Seck. Data curation: Makhan Danfakha. Writing - original draft: Makhan Danfakha, Oumy Kaltome Boh, Mamadou Aliou Diallo. Writing - review and editing: Valéry Ridde, Codou Faye, Mouhamadou Faly Ba. Supervision: Valéry Ridde, Mamadou Aliou Diallo. All authors have read and approved the final version of the manuscript.

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Tables and figure

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Figure 1: geographical distribution of medical and veterinary health facilities visited during the survey within the Saint-Louis Health District, Senegal, July 2024

Annexes

Annex 1: rabies questionnaire for healthcare providers in Saint-Louis (PDF - 110 KB)

Annex 2: distribution of providers by characteristics related to rabies knowledge (PDF - 169 KB)

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Table 1: distribution of 161 human and animal healthcare providers by sociodemographic and professional characteristics in the Saint-Louis health district, Senegal, July 2024	
Sociodemographic characteristics	**n (%)**
Gender	
Female	106 (65.8%)
Male	55 (34.2%)
Age (mean ± Standard deviation)	34.6 ± 9.2
Marital status	
Married	110 (68.3%)
Single	46 (28.6%)
Other	5 (3.1%)
Education level	
Secondary	24 (14.9%)
Tertiary-non university	43 (26.7%)
Tertiary-university	94 (58.4%)
Type of qualification	
Human health professional	151 (93.8%)
Animal health professional	10 (6.2%)
Professional category	
Physician	38 (23.6)
Pharmacist	1 (0.6)
Midwife	35 (21.7)
Nurse	47 (29.2)
Assistant nurse	28 (17.4)
Veterinarian	4 (2.5)
Animal health technician	4 (2.5)
Livestock engineering technician	2 (1.2)
Other	2 (1.2)
Years of service	
≤ 10 ans	112 (69.6%)
> 10 ans	49 (30.4%)
Ownership of domestic animals	
No	86 (53.4%)
Yes	75 (46.6%)
Participation in a training or refresher course on rabies	
No	151 (93.8%)
Yes	10 (6.2%)
N: represents the total number of healthcare professionals surveyed; n%: indicate the proportion of participants within each sociodemographic category	

Table 2: distribution of human and animal healthcare providers by rabies knowledge and attitude scores in the Saint-Louis health district, Senegal, July 2024 (N = 161)			
Total Score	**Human health providers (%)**	**Animal health providers (%)**	**All (%)**
	N=151	N=10	N=161
Rabies knowledge score (scores shown are the total of the 16 knowledge items)			
3	7 (4.6%)	0 (0.0%)	7 (4.3%)
4	6 (4.0%)	0 (0.0%)	6 (3.7%)
5	16 (10.6%)	0 (0.0%)	16 (9.9%)
6	36 (23.8%)	0 (0.0%)	36 (22.4%)
7	29 (19.2%)	1 (10.0%)	30 (18.6%)
8	29 (19.2%)	2 (20.0%)	31 (19.3%)
9	14 (9.3%)	3 (30.0%)	17 (10.6%)
10	5 (3.3%)	2 (20.0%)	7 (4.3%)
11	6 (4.0%)	0 (0.0%)	6 (3.7%)
12	2 (1.3%)	2 (20.0%)	4 (2.5%)
14	1 (0.7%)	0 (0.0%)	1 (0.6%)
Percent of good knowledge	57 (37.7%)	9 (90%)	66 (41.0%)
Percent lack of knowledge	94 (63.3%)	1 (10%)	95 (59.0%)
Rabies attitudes score (scores shown are totals after dichotomizing each of the 10 Likert items)			
5	4 (2.6%)	0 (0.0%)	4 (2.5%)
6	4 (2.6%)	1 (10.0%)	5 (3.1%)
7	35 (23.2%)	1 (10.0%)	36 (22.4%)
8	52 (34.4%)	2 (20.0%)	54 (33.5%)
9	46 (30.5%)	5 (50.0%)	51 (31.7%)
10	10 (6.6%)	1 (10.0%)	11 (6.8%)
Percent of positive attitude	56 (37.1%)	6 (60%)	62 (38.5%)
Percent of negative attitude	95 (63.9%)	4 (40%)	99 (61.5%)
ALL: all human and animal health providers combined; N: total number of respondents in each category; rabies knowledge score: measured on a scale of 0 to 16, where a score ≥ 8 indicates good knowledge; rabies attitude score: measured on a scale of 0 to 10, where a score ≥ 9 indicates a positive attitude towards rabies control			

Table 3: distribution of human and animal healthcare providers by sufficient knowledge, positive attitudes, and their sociodemographic characteristics in the Saint-Louis health district, Senegal, July 2024 (N = 161)

Socio-demographic characteristics	Sufficient connaissance (%)	p-value knowledge	Positive attitude (%)	p-value attitude	Good practices (%)	p-value practices
Sex						
Female	40 (37.7%)	0.318	34(32.1%)	**0.031**	31 (29.2%)	0.610
Male	26 (47.3%)		28(50.9%)		19 (34.5%)	
Age						
≤ 35 ans	37 (37.8%)	0.380	35(35.7%)	0.457	34 (34.7%)	0.285
> 35 ans	29 (46.0%)		27(42.9%)		16 (25.4%)	
Education level						
Secondary	9 (37.5%)	0.879	8 (33.3%)	0.736	6 (25.0%)	0.648
Tertiary	57 (41.6%)		54(39.4%)		44 (32.1%)	
Role						
Human health providers	57 (37.7%)	**0.002**	56(37.1%)	0.186	50 (33.1%)	**0.032**
Animal health providers	9 (90.0%)		6 (60.0%)		0 (0.0%)	
Years of service						
< 10 ans	41 (38.0%)	0.344	41(38.0%)	0.975	41 (38.0%)	**0.012**
≥ 10 ans	25 (47.2%)		21(39.6%)		9 (17.0%)	
Pet ownership						
No	30 (34.9%)	0.127	34(39.5%)	0.901	27(31.4%)	1.000
Yes	36 (48.0%)		28(37.3%)		23 (30.7%)	
Rabies training						
No	58 (38.4%)	**0.016**	60(39.7%)	0.319	49 (32.5%)	0.175
Yes	8 (80.0%)		2(20.0%)		1(10.0%)	

N: total number of respondents in each category; p-value: statistical probability measuring the association between socio-demographic characteristics, level of knowledge, attitude, and practice (in bold if p < 0.05, indicating a statistically significant difference)

Table 4: results of the multivariate logistic regression analysis of factors associated with sufficient knowledge and positive attitudes towards rabies among human and animal healthcare providers in the Saint-Louis health district, Senegal, July 2024 (N = 161)

Characteristics	Knowledge model			Attitude model			Practice model		
	OR1	95% CI1	p-value	OR1	95% CI1	p-value	OR1	95% CI1	p-value
Sex									
Female	1.00	—		1.00	—		1.00	—	
Male	1.08	0.52, 2.22	0.826	2.12	1.06, 4.32	0.035	1.25	0.58, 2.69	0.565
Age:									
> 35 ans	1.00	—		1.00	—		1.00	—	
≥ 35 ans	1.08	0.40, 3.00	0.886	0.65	0.24, 1.71	0.380	0.57	0.19, 1.62	0.29
Education level									
Secondary	1.00	—		1.00	—		1.00	—	
Tertiary	1.30	0.50, 3.58	0.595	1.29	0.50, 3.54	0.605	1.33	0.49, 4.06	0.592
Role									
Human Health provider	1.00	—			—			—	
Animal Health provider	7.64	1.04, 1.61	0.083						
Years of service									
< 10 ans	1.00	—		1.00	—		1.00	—	
≥ 10 ans	1.29	0.46, 3.64	0.624	0.80	0.29, 2.14	0.656	0.24	0.07, 0.74	0.0016
Pet ownership									
No	1.00	—		1.00	—		1.00	—	
Yes	1.43	0.73, 2.82	0.297	0.70	0.35, 1.39	0.316	1.06	0.52, 2.17	0.870
Follow-up of previous rabies training or refresher workshop									
No	1.00	—					1.00	—	
Yes	2.42	0.37, 19.5	0.354				0.28	0.01, 1.84	0.264
Knowledge									
Insufficient				1.00	—		1.00	—	
Sufficient				2.01	1.03, 3.96	0.042	0.71	0.33, 1.49	0.369
Attitude									
Negative							1.00	—	
Positive							1.20	0.57, 2.51	0.630

1OR = Odds Ratio; CI = confidence interval; p-values: statistical probability measuring the association between socio-demographic characteristics, level of knowledge, attitude, and practice (in bold if p < 0.05, indicating a statistically significant difference)

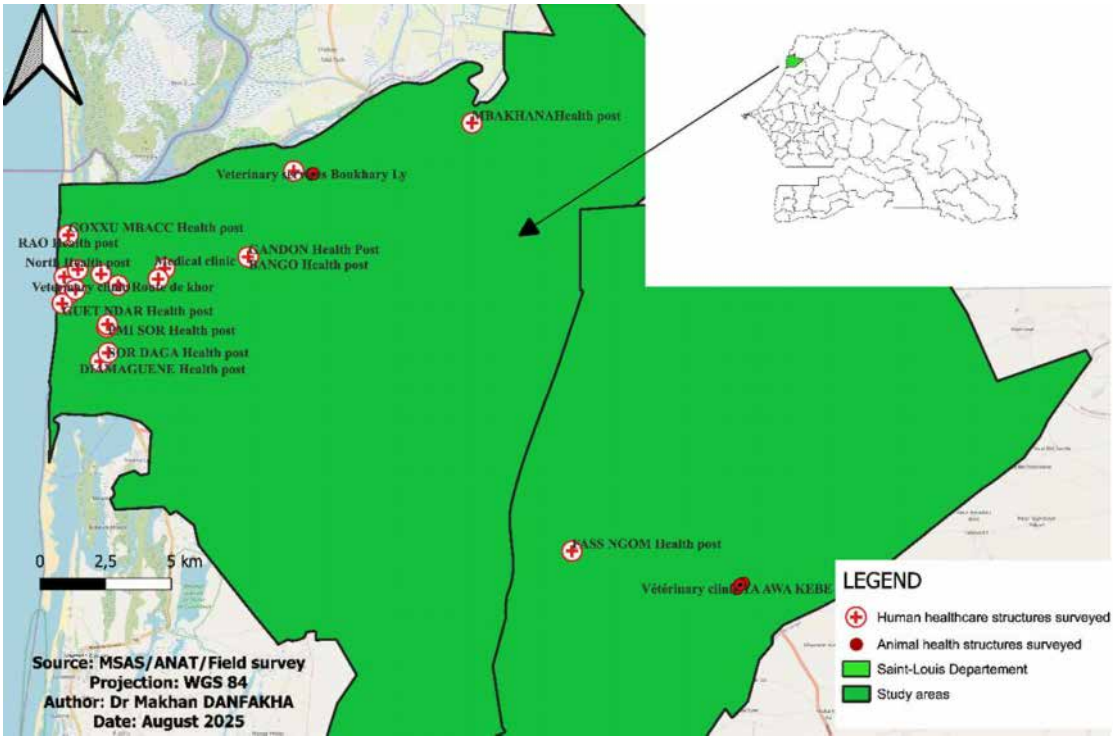

Figure 1: geographical distribution of medical and veterinary health facilities visited during the survey within the Saint-Louis Health District, Senegal, July 2024