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Human dog-mediated rabies in the Circle of Kati, Mali: An epidemiological situation analysis and the stakeholder's knowledge regarding rabies and the One Health approach

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Abstract

Background: Human dog-transmitted rabies remains a serious public health issue in Mali despite efforts to mitigate it. Indeed, several stakeholders have implemented multiple initiatives for years. However, there is still a lack of cooperation among stakeholders. This study was conducted to capture situational data on rabies and One Health practices among key actors involved in the fight against rabies in Mali.

Methods: Data from veterinary and medical services were collected for analysis. Data collection was based on a review of technical documents (epidemiology of rabies in animals and humans and activities conducted to tackle the disease) and stakeholder interviews (awareness of rabies and the One Health approach).

Results: With regard to the epidemiological situation, the findings revealed unsatisfactory vaccination coverage in dogs and low suspected sample collection for laboratory diagnosis. In addition, only half of the exposed individuals received complete post-exposure prophylaxis. A survey carried out by experts in the fields of animal health, human health, and the environment indicated that only 22.47% were well aware of rabies and had never heard of the One Health approach. Overall, there was no significant association between knowledge and participant sector of origin ($p > 0.05$), highlighting the need for operationalization of the One Health approach in Mali.

Conclusion: Therefore, an integrated national action plan for rabies control should be developed with a particular focus on capacity building, particularly in the area of the One Health core competencies.

Keywords: epidemiology, multisectoral engagement, One Health, Public Health priority zoonoses, Stakeholders.

Introduction

Rabies is a deadly zoonotic disease that affects the poorest communities in Latin America, Asia, and Africa, mostly low- and middle-income countries [1]. It remains a major public health threat due to frequent contact between people and unvaccinated animals, especially dogs, which are responsible for approximately 99% of human rabies cases in endemic areas [2]. The global burden of the disease is estimated to cause at least 59,000 deaths per annum, with the majority of cases occurring in Asia and Africa [3].

In many African countries, the fight against rabies is characterized by a low detection and surveillance capacity [4, 5]. Therefore, the chronic lack of data on the epidemiology and the real socio-economic impact of rabies have resulted in the neglect of the disease during the development of health strategies. In addition, most countries do not include rabies in human and animal health strategies and policies. Although the rabies vaccine was developed more than 135 years ago and has been proven effective, rabies still kills people in African countries.

In Mali, an estimated 133 human deaths were reported in 2020 [6]. Despite the lack of a national strategic plan, many actions have been initiated for decades to control rabies, including the development of regulations, dog vaccination, and post-exposure prophylaxis (PEP) for people at high risk of infection [7]. However, rabies remains an important challenge in the country due to several factors, such as low awareness in the general public, physical and

financial inaccessibility to dog vaccination and PEP, increasing stray dog population, and lack of collaboration between medical and veterinary entities to deliver adequate rabies prevention and control services [5, 8]. Regarding the global target of zero cases of human rabies by 2030, these observations raise doubts about the effectiveness of the initiatives implemented to combat the disease. The paradox between the multiplicity of initiatives implemented and the persistence of the disease is probably due to the lack of an operational One Health approach involving key stakeholders. The One Health approach calls for broad interdisciplinary and multi-sectorial cooperation to prevent and mitigate the impact of public health threats at the animal–human–environment interface. In this respect, the partnership established between the World Organization for Animal Health, the World Health Organization, the Food and Agriculture Organization of the United Nations, and the Global Alliance for Rabies Control has resulted in the launch of the United Against Rabies forum, as a global One Health initiative for dog-mediated human rabies elimination [9, 10]. At the West Africa region level, ministerial One Health meetings held in November 2016 (Dakar, Senegal) and June 2017 (Abuja, Nigeria) of the Economic Community of West African States identified the need to work toward the operationalization of One Health to increase the capacity of Member States to prevent, detect, and respond to zoonotic diseases and other public health threats.

In fact, the Mali government has adopted a single health approach. In addition, the country has established a national One Health Coordination platform aimed at promoting integrated and synergistic management of priority zoonoses, including dog-transmitted rabies [11]. The Ministries of human health, livestock, the environment, and wildlife are responsible for the One Health initiative in the country. Regarding the control of rabies, it undertakes to cooperate closely with the relevant ministries, civil society, the private sector, and other partners to create the necessary conditions for planning and implementing integrated measures. Accordingly, this study was conducted to capture situational data on rabies and One Health practices among key actors involved in the fight against rabies in Mali.

Materials and Methods

Ethical approval

The study objectives were explained to the participants before each interview. Each participant has been informed that participation in the study is free of charge and that they have the right to withdraw at any time. Only participants who provided verbal informed consent were interviewed.

Study period and location

This cross-sectional study was conducted from August to December 2020 in the administrative circle of Kati, Mali. This administrative circle is located in the peri-urban area of Bamako, the administrative capital of the country (Figure-1). With regard to human population, Kati is the most populated circle in the country, with an estimated density of 42 inhabitants per square kilometer. Conventionally, in many African countries, local communities' own dogs for a variety of socio-economic purposes (property, housekeeping, companionship, and hunting). The dog population size was estimated to be 1660 owned dogs in the study area [12].

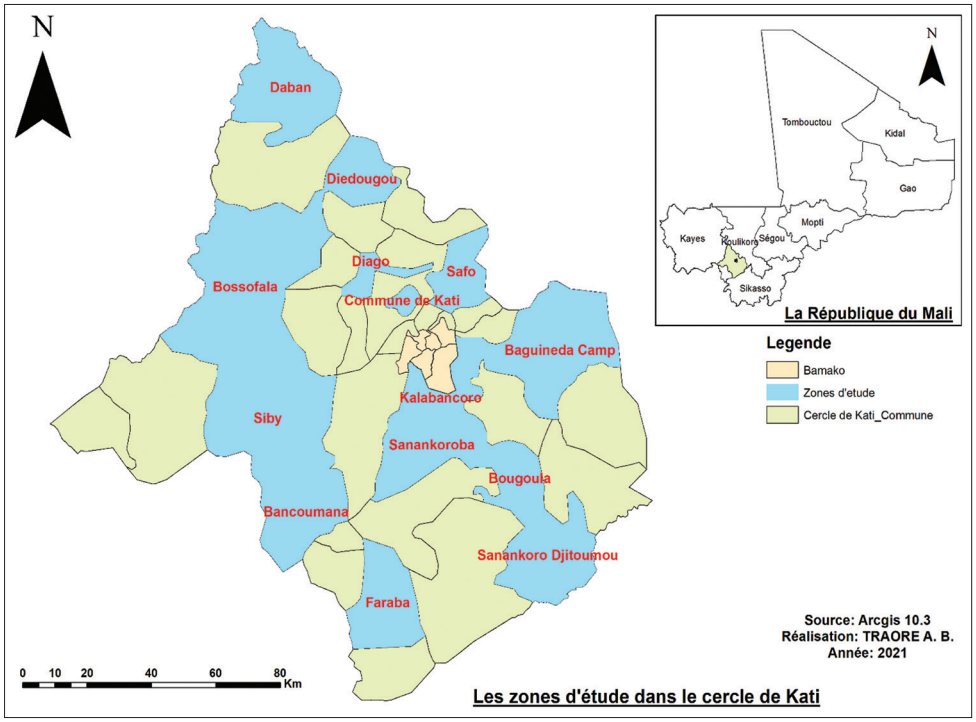


Figure-1: Geographical location of the Circle of Kati and the study sites [Source: https://biogeo.ucdavis.edu/data/diva/adm/MLI_adm.zip].

Sampling and questionnaire interviews

Data were collected through individual interviews conducted with professionals involved in rabies control in the study area, such as animal health workers (AHWs), human health workers (HHWs), and environment and wildlife workers (EWWs). In the absence of data on these professionals and the level of their involvement in rabies-related activities, snowball sampling was used to recruit participants. First, the interviews began with participants from the Central Veterinary Laboratory (Laboratoire Central Vétérinaire, LCV), which was well known to the research team for its role in rabies diagnosis. Then, 89 participants were interviewed as follows: AHWs (n = 30), HHWs (n = 53), and EWWs (n = 6). Then, initial participants were introduced to other relevant actors involved in activities related to animal and human rabies prevention and control. Due to logistical and resource convenience, the dual sampling approaches used were effective and appropriate for this study.

Face-to-face interviews were conducted with each participant using a structured questionnaire. Demographic and professional data (gender, professional category, professional position, and professional experience), knowledge of rabies as a zoonotic disease, involvement in rabies control, knowledge of the One Health approach, and perceptions about the implementation of the One Health approach for rabies control in the study area were collected.

Rabies epidemiology and control data collection

The research team collected data on the epidemiology status of rabies in both dogs and humans during the interviews in the technical offices visited. In addition, we collected data on rabies prevention and control activities, including dog vaccination, PEP, and veterinary observation of biting dogs. These data were collected by reviewing all documents and technical reports available at the technical offices visited (laboratory, veterinary, and healthcare).

Statistical analysis

All collected data were entered into Microsoft Excel 2016 (Microsoft Office, Washington, USA) for processing and calculation. The proportions and means of rabies epidemiology and control data were calculated using R× 3.6.3 software (https://cloud.r-project.org/bin/windows/base/old/3.6.3/R-3.6.3-win.exe). On the basis of their accuracy and completeness, the answers to the questions on a participant's knowledge of rabies and the One Health approach were classified as either "satisfactory" or "unsatisfactory," respectively.

Participants' knowledge of rabies was described based on their understanding of characteristics such as the type of pathogen responsible (viruses, parasites, or bacteria), animal vectors, transmission routes, and appropriate procedures if a person is bitten by a suspect animal. With respect to the One Health approach, participants' knowledge was measured by their capacity to correctly describe an example of a multi-sectorial activity conducted in Mali in the framework of zoonotic disease control.

The Chi-square test and Fisher's exact test with a 95% confidence level were used to determine the statistical association between participant characteristics and the dependent variables (rabies knowledge and One Health approach knowledge) using R× 3.6.3 software. Statistical significance was set at $p < 0.05$ for these tests.

Results

Characteristics of interviewed participants

Participants were from different professional disciplines: veterinarians and veterinary paraprofessionals (livestock engineers, livestock technicians, and veterinary laboratory officers), physicians and medical paraprofessionals (nurses, midwives, health technicians, and hygiene officers) as well as environment and wildlife professionals (water and forest engineers, water and forest technicians). Most of the participants (68.54%) had less than 10 years of professional experience.

Dog vaccination and confirmed rabies cases in dogs

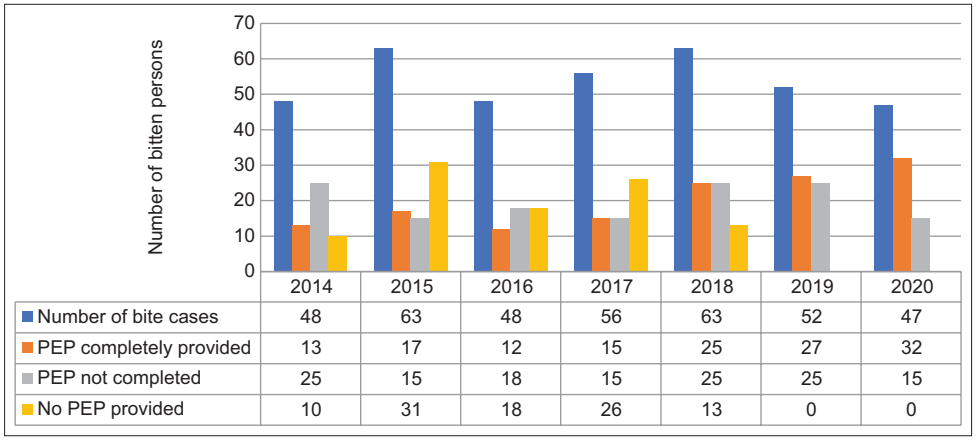
According to the data provided by the local veterinary office, an average of 363 owned dogs are vaccinated annually, resulting in an estimated vaccination coverage of 21.87%. Dog rabies data were collected from the Central Veterinary Laboratory, in charge of rabies confirmation in samples collected and shipped from various regions of Mali. From 2014 to 2020, 477 dog samples (sampled from dogs biting humans) were tested using fluorescence antibody. Overall, 25.16% (ranging from 20.63 in 2015 to 32.76 in 2018) of the samples were confirmed positive for rabies.

Biting occurrence, PEP, and management of biting dogs

Figure-2 presents data on human dog bite cases and PEP delivery in the study area. From 2014 to 2020, 377 bite cases were reported, representing an average of 53.86 ± 6.96 cases registered annually. Only 50.54% of the exposed persons received a complete PEP based on Zagreb's system. In addition, 25.99% of the bitten persons did not receive PEP. The study area reported an average of 1.14 ± 0.90 human rabies cases annually. During the same period, only 130 out of the 165 registered biting dogs (78.79%) underwent veterinary examination as required by bite case management procedures.

Participant's knowledge of rabies and prevention measures

All the participants said that they had heard of rabies before. With regard to the description of rabies, only 22.47% were able to describe the disease correctly. Participants with < 10 years of professional experience were more likely to be unaware about rabies ($p < 0.05$, Table-1). Most participants' agencies (human



	2014	2015	2016	2017	2018	2019	2020
Number of bite cases	48	63	48	56	63	52	47
PEP completely provided	13	17	12	15	25	27	32
PEP not completed	25	15	18	15	25	25	15
No PEP provided	10	31	18	26	13	0	0

Figure-2: Number of bite cases and provision of post-exposure prophylaxis from 2014 to 2020 in the Circle of Kati.

Table-1: Association between the participants' characteristics and their level of awareness about rabies (n = 89).

Variables	Ability to describe rabies		p-value
	Unsatisfactory	Satisfactory	
Gender			0.005
Female	62.22	37.78	
Male	61.36	38.64	
Professional experience (in years)			0.03
<10	62.30	37.70	
>10	62.96	40.74	
Sector			0.06
Environment	83.33	16.67	
Animal health	26.67	73.33	
Human health	79.25	20.75	

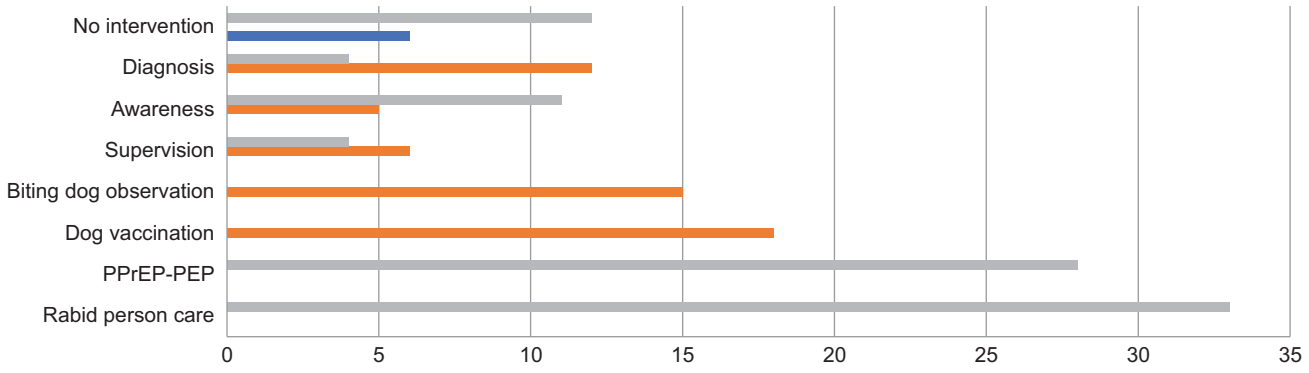
health, animal health, environment, and wildlife) were reportedly involved in various rabies control activities, including prevention, detection, surveillance, and response (Figure-3). According to AHWs, their institutions are mainly involved in the surveillance of rabies (laboratory testing and observation of biting dogs), the prevention of rabies (awareness-raising and vaccination of dogs), and the supervision of partner interventions.

Participant knowledge and perceptions regarding the One Health approach and implications for rabies control

The findings indicated that most participants were not satisfactorily aware of the One Health approach (Table-2). Overall, 22.47% reported having heard about One Health. In addition, male and animal health participants were more likely to be aware of the One Health approach compared to female participants and participants from human and environmental health sectors. However, there was no significant association between knowledge of One Health and gender ($p > 0.05$). Interviewees with over 10 years of professional experience were more likely to hear about One Health. However, having heard about One Health was not significantly related to the participants' experience. Moreover, younger participants were more likely to describe the One Health approach and its implications for improving rabies control compared to those with more than 10 years of professional experience ($p < 0.05$).

Discussion

Human dog-transmitted rabies can be eliminated in middle- and low-income countries [13]. Several countries in North America and Europe, which have previously been identified as endemic areas, have become free from rabies. Human dog-transmitted rabies has been eliminated in Mexico since 2019 [14]. Dog-mediated human rabies elimination requires a multi-sectorial effort covering several intervention areas, including mass dog vaccination, intensive awareness-raising and community engagement, appropriate management of bite cases, and appropriate access to pre-exposure and PEP [15, 16]. The previous experience has shown that rabies can be eradicated in a given area if 70% of rabies-susceptible dogs are vaccinated against rabies. However, there was a very low vaccination coverage in the study area. Investigations on dog vaccination coverage have identified the lack of information about dog vaccination and the remoteness of vaccination sites as the main constraint of access to vaccination [7, 17]. In addition, rabies remains endemic throughout Mali, as positive cases of rabies have been detected in dog samples. These observations highlight the risk of transmitting rabies to humans in the event of dog bites. Of the 53 bite cases registered annually in the Circle of Kati, only 50% of them received adequate PEP. Low access to PEP has previously been reported in several African countries, which has been attributed to a lack of awareness on bite case management, high cost of biological products (vaccines and rabies immunoglobulins) and frequent shortages of PEP [13, 18–20]. Unfortunately, Mali is not immune to this situation. In addition, at least one human death is reported every year. Having been neglected for a very long time [4, 17], rabies remains under-reported in the country, suggesting that the number of cases of bites and human deaths could be higher in reality. This highlights the urgent need



	Rabid person care	PPrEP-PEP	Dog vaccination	Biting dog observation	Supervision	Awareness	Diagnosis	No intervention
Human health	33	28	0	0	4	11	4	12
Animal health	0	0	18	15	6	5	12	0
Environment	0	0	0	0	0	0	0	6

Figure-3: Rabies control activities conducted by animal health, human health, and environment sectors (PEP=Post-exposure prophylaxis; PrEP=Pre-exposure prophylaxis).

Table-2: Association between participants' characteristics and their level of awareness about the One Health approach.

Variables	Having heard about the One Health approach (n = 89)		p-value	Ability to describe the One Health approach (n = 20)		p-value	Usefulness of the One Health approach for rabies control (n = 20)		p-value
	No (%)	Yes (%)		Unsatisfactory (%)	Satisfactory (%)		No (%)	Yes (%)	
Gender			0.06			0.08			0.06
Female	91.11	8.89		75.00	25.00		50.00	50.00	
Male	63.64.	36.36		62.50	37.50		43.75	56.25	
Professional experience (years)			0.12			0.03			
<10	88.52	11.48		57.14	42.86		28.57	71.43	0.01
>10	53.57	46.43		69.23	30.77		53.85	46.15	
Sector			0.11			0.10			0.12
Environment	83.33	16.67		100.00	0.00		100.00	0.00	
Animal health	43.33	56.67		58.82	41.18		35.29	64.71	
Human health	96.23	3.77		100.00	0.00		100,00	0.00	

for endemic countries to strengthen surveillance and detection capacities to better inform decision-makers in the field of animal health and public health, as well as policies and strategies for rabies control.

Strengthening capacity should focus on building an integrated system on the basis of the principles of the One Health approach. The findings indicate that rabies control involves professionals from different disciplines and sectors. Similar observations have been reported in Chad [21] and Burkina Faso [17, 22]. However, most participants did not have a satisfactory level of awareness of the disease and prevention methods, which can explain the challenging situation of rabies control in the medical and veterinary sectors. Rabies is a priority zoonotic disease in Mali [23] and requires a higher multi-sectorial commitment through an operationalized One Health approach to achieve zero dog-transmitted human rabies cases by 2030. In response to the question of what One Health means, less than a quarter of participants said that they had never heard of such an approach before. In view of the low capacity of professionals, in particular professionals in the field of human health and the environment, to explain the One Health approach and how it could improve the control of rabies, stakeholders need to be trained on the core competencies of One Health. The previous studies have also reported low participation of human health and environment stakeholders [24]. In addition to technical capacity building, the staff of One Health should be equipped with soft skills in leadership and management, systems thinking, communication, behavior change, and One Health advocacy. Mbaipago *et al.* [21] observed increased participation of the human health stakeholders after One Health training sessions were provided to the One Health workforce in Chad. In addition, Mali should develop

and implement a national multi-sectorial rabies strategic plan to ensure sustainable and effective rabies control and achieve zero human rabies cases transmitted by dogs by 2030. In conclusion, an increased mobilization of civil society stakeholders appears to be a real opportunity for effective community engagement towards achieving the global zero by 2030 [25].

Conclusion

Dog rabies remains endemic in Mali, with a high risk of community infection due to low vaccination coverage and limited access of bitten persons to PEP. As a priority zoonotic disease, the control strategy requires close cooperation between all relevant stakeholders. However, the current situation is characterized by an unsatisfactory knowledge of rabies and the One Health approach, especially in the field of human health and environmental health. These findings highlight the need for Mali to develop an integrated strategic plan enabling multi-sectorial commitment and staff training for rabies control.

Authors' Contributions

ADBT, MS and RBA: Conceptualized the study. ADBT: Collected and analyzed data. MS and NDD: Provided the academic support and relevant research materials needed for the manuscript. ZT and RBA: Provided overall support and guidance during the study and development of the manuscript. All authors have read, reviewed, and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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