Madi SAVADOGO

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Analyse systémique de la faisabilité technique et socio-économique du contrôle de la rage humaine transmise par les carnivores domestiques au Burkina Faso

Université de Liège
Faculté de Médecine Vétérinaire
Département de Gestion Vétérinaire des Ressources Animales
Service de Socio-Economie de la Santé et des Productions Animales,
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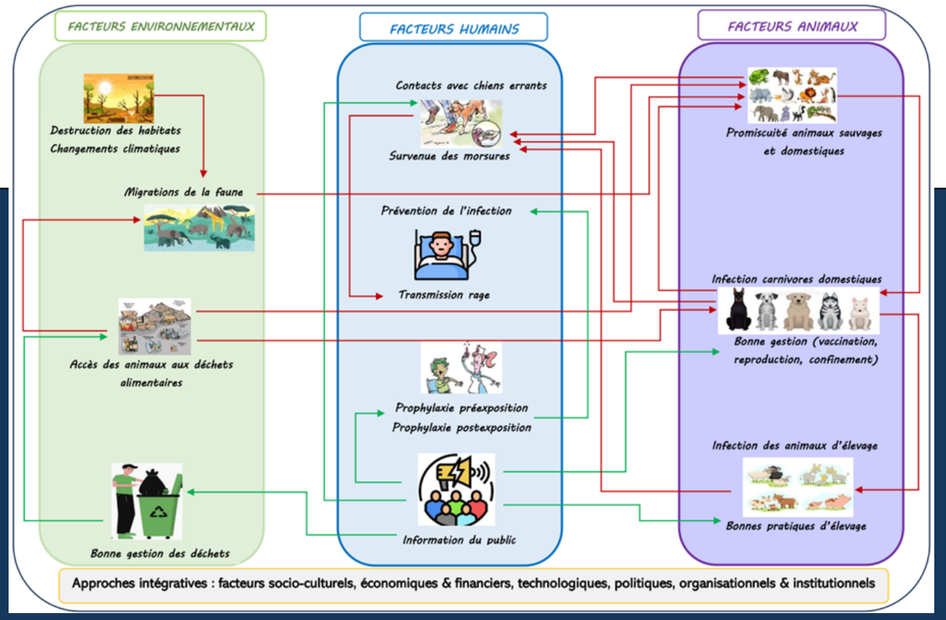

Systemic analysis of the technical and socio-economic feasibility of domestic carnivore-mediated human rabies control in Burkina Faso

Madi SAVADOGO

Thèse présentée le 11 février 2026 en vue de l'obtention
du grade de Docteur (PhD) en Sciences Vétérinaires
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UNIVERSITE DE LIEGE

FACULTE DE MEDECINE VETERINAIRE

DEPARTEMENT DE GESTION VETERINAIRE DES RESSOURCES ANIMALES

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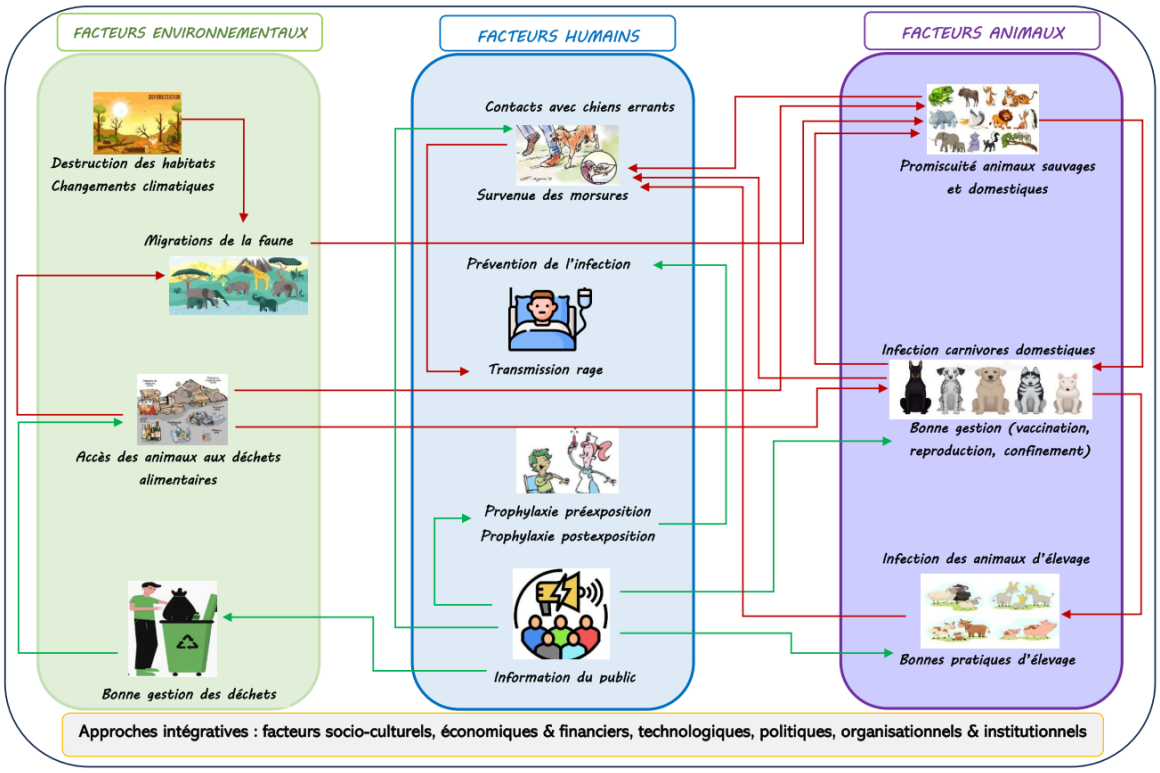

SYSTEMIC ANALYSIS OF THE TECHNICAL AND SOCIO-ECONOMIC FEASIBILITY OF DOMESTIC CARNIVORE-MEDIATED HUMAN RABIES CONTROL IN BURKINA FASO

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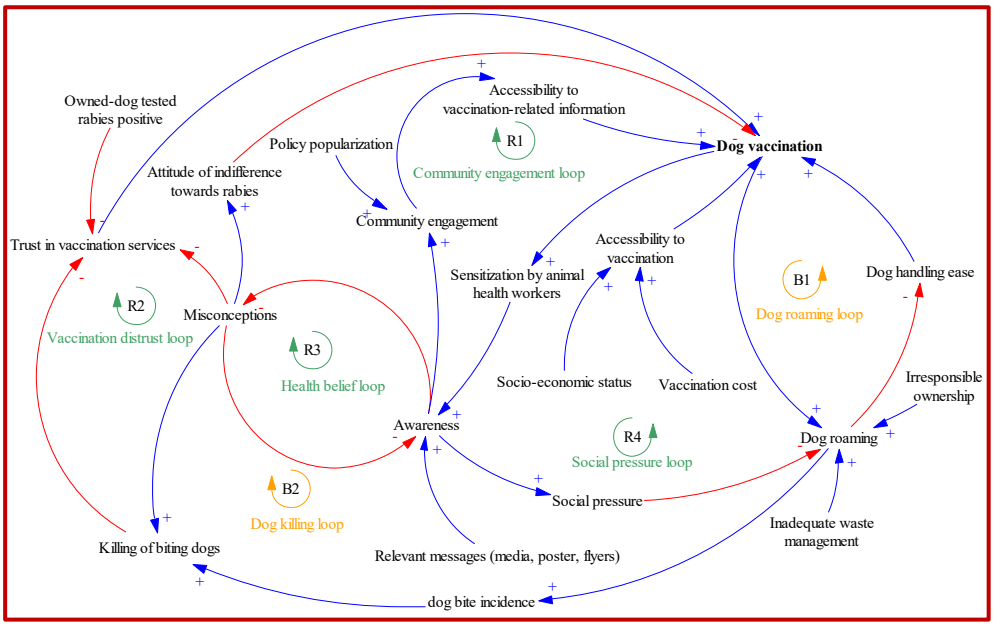

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Professeur Rianatou BADA ALAMBEDJI	*Ecole Inter-Etats des Sciences et Médecine Vétérinaires de Dakar, Sénégal*	*Co-promoteur*

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	Rianatou BADA ALAMBEDJI *Professeur titulaire de Microbiologie-Immunologie, Ecole Inter-Etats des Sciences et Médecine Vétérinaires de Dakar, Université Cheikh Anta Diop, Sénégal*
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	Bernadette ABELA-RIDDER *PhD en Epidémiologie, Department of the Control of Neglected Tropical Diseases, World Health Organization, Switzerland*

TABLE DES MATIERES

AVANT-PROPOS

La défense de cette thèse constitue une étape importante d'un parcours dont l'objectif est resté intact encore aujourd'hui : contribuer à la réduction de la transmission voire à l'élimination de la rage humaine transmise par les carnivores domestiques au Burkina Faso. En effet, l'origine de cette thèse remonte à 2012. Alors étudiant vétérinaire en deuxième année de formation à l'Ecole Inter-Etats des Sciences et Médecine Vétérinaires (EISMV) de Dakar au Sénégal, le doctorant venait ainsi de terminer une année académique au cours de laquelle il avait reçu les premiers enseignements sur les maladies zoonotiques d'intérêt en médecine vétérinaire. Rentré pendant les vacances pour effectuer un stage d'immersion dans les services techniques en charge de la santé et des productions animales au Burkina Faso, il est admis du 1er au 31 août 2012 à la Direction du Laboratoire National d'Elevage de la Direction Générale des Services Vétérinaires. Au cours du stage, le doctorant avait été marqué par la fréquence des cas de morsures et la proportion très élevée des animaux mordeurs détectés positifs à la recherche de l'antigène du virus rabique. Ainsi l'étudiant vétérinaire, dont le rêve de lycéen était celui de poursuivre des études universitaires en médecine, venait de découvrir la contribution que la profession vétérinaire pouvait apporter dans la protection de la santé publique. Cette attention portée à la question du contrôle de la rage, lui permet de remarquer très tôt que cette menace de santé publique n'était pas suffisamment prise en compte dans les politiques nationales en matière de santé animale, de santé humaine et de recherche en santé publique. Afin de contribuer à combler ce gap, il a d'abord préparé et défendu en 2015 une thèse de doctorat en médecine vétérinaire sur l'amélioration de la connaissance de l'épidémiologie de la rage au Burkina Faso. Plus tard, en 2017, il aura l'opportunité de poursuivre un programme de thèse de doctorat en Santé et Biotechnologies Animales. Les résultats de ces travaux de thèse, défendus devant un jury en décembre 2021 à l'Université Cheikh Anta Diop, avaient porté sur la caractérisation épidémiologique et socio-économique du contrôle de la rage au Burkina Faso. C'est au cours de ces travaux, qu'il sera admis au programme de bourses exceptionnelles financé par l'Académie de Recherche et d'Enseignement Supérieur (ARES) de Belgique. Il s'inscrit donc au doctorat en Sciences Vétérinaires à l'Université de Liège en septembre 2018. Cette deuxième thèse, s'appuyant sur les évidences déjà disponibles sur l'épidémiologie de la rage au Burkina Faso, visait à fournir des outils et approches innovantes permettant d'améliorer significativement les stratégies de lutte, en analysant de manière systémique la faisabilité technique et socio-économique du contrôle de la maladie à l'ère de l'approche One Health. Par ailleurs, dans le souci d'allier recherche scientifique et actions concrètes, le doctorant a activement participé depuis septembre 2020 à la création et à l'animation de Rabies Free Burkina Faso, une plateforme associative pluridisciplinaire dédiée à la lutte contre la rage animale et humaine au Burkina Faso, pour le renforcement de l'engagement multisectoriel One Health.

Si la science n'a pas de pays, le scientifique doit en avoir un,

et dédier à ce pays l'influence que ses travaux

pourraient avoir dans ce monde"

René Vallery-Radot, "La vie de Pasteur" (1923)

REMERCIEMENTS

La thèse constitue pour le doctorant une matrice fondamentale pour l'acquisition d'une expertise lui permettant de contribuer de manière significative au progrès de la science dans son domaine de recherche. Le programme de doctorat constitue un modèle de mentorship combinant efforts collaboratifs et partages de connaissances entre le doctorant et plusieurs experts de différentes disciplines. Plus que jamais convaincu que « *on ne ramasse pas la farine avec une seule main* », je voudrais, au terme de ce travail, remercier toutes les personnes dont les contributions aussi importantes que diverses m'ont permis d'y arriver.

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Je souhaite également remercier les membres de mon comité de thèse pour leur suivi régulier et bienveillant et pour leurs conseils éclairés et complémentaires qui ont grandement influencé le cours des travaux. Il s'agit du Professeur Justin Ayayi AKAKPO de l'Ecole Inter-Etats des Sciences et Médecine Vétérinaires de Dakar (Sénégal), du Professeur Jakob ZINSSTAG du Swiss Tropical and Public Health Institute (Suisse), du Professeur Claude SAEGERMAN de l'Université de Liège, du Professeur Bassirou BONFOH du Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, et du Dr Bernadette ABELA-RIDDER de l'Organisation Mondiale de la Santé à Genève (Suisse). Toute ma gratitude pour avoir consacré une partie de votre précieux à guider mon travail.

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J'exprime ma reconnaissance à l'Ecole Inter-Etats des Sciences et Médecine Vétérinaires de Dakar, à l'Université Cheikh Anta Diop, l'Université Libre de Bruxelles et l'Université de Liège pour les nombreuses enseignements et ressources pédagogiques auxquels que j'ai eu accès durant ma formation doctorale.

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Merci à toute l'équipe de Rabies Free Burkina Faso pour la passion et les rêves que nous partageons de voir notre cher pays libéré de la rage qui menace la santé animale et celle de nos communautés.

Les différentes activités de terrain et la collecte des données ont été possibles grâce à la franche collaboration des acteurs des niveaux national et déconcentrés, public et privé concernés par la gestion de la santé animale, de la santé humaine, de l'environnement, de l'assainissement et de collectivités territoriales au Burkina Faso. Recevez toutes mes gratitudes !

À ma famille, au repère et support réconfortant qu'elle a su représenter durant tout mon parcours.

Je remercie toutes les personnes qui ont contribué à la réalisation de ce travail.

A ma famille

A mon épouse

Aux enfants : Khayra, Rihana et Yazid

Pour la présence et la patience

SIGLES ET ABREVIATIONS

AES	: Confédération des Etats du Sahel
CDC	: Centre de Contrôle et de Prévention des Maladies
CLD	: Causal Loop Diagram
CNRST	: Centre National de la Recherche Scientifique et Technologique
CRSA	: Centre Régionale de Santé Animale
CTZ	: Commission Thématique n°6 Zoonoses
DGSV	: Direction Générale des Services Vétérinaires
EISMV	: Ecole Inter-Etats des Sciences et Médecine Vétérinaires
FAO	: Food and Agriculture Organization of the United Nations
GARC	: Global Alliance for Rabies Control
IRSS	: Institut de Recherche en Sciences de la Santé
MARAH	: Ministère de l'Agriculture, des Ressources Animales et Halieutiques
MATM	: Ministère de l'Administration Territoriale et de la Mobilité
MEEA	: Ministère de l'Environnement, de l'Eau et de l'Assainissement
MESRI	: Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation
MS	: Ministère de la Santé
MCDA	: Multi-Criteria Decision Analysis
NSP	: National Strategic Plan
ODD	: Objectifs de Développement Durable
OMS	: Organisation Mondiale de la Santé
OMSA	: Organisation Mondiale de la Santé Animale
OOAS	: Organisation Ouest-Africaine de la Santé
PEP	: Post-Exposition Prophylaxis
PNCOH	: Plateforme Nationale de Coordination One Health
PNUE	: Programme des Nations Unies pour l'Environnement
PPE	: Prophylaxie Post-Exposition
PPreE	: Prophylaxie Pré-Exposition
PreEP	: Pre-Exposition Prophylaxis
PSSAT	: Parsons' Social System Action Theory
PSSAT	: Parsons' Social System Action Theory
SARE	: Stepwise Approach for Rabies Elimination
STOH	: Secrétariat Technique One Health
UA-BIRA	: Bureau Interafricain des Ressources Animales de l'Union Africaine
UNEP	: United Nations Environment Programme
WHO	: World Health Organization
WOAH	: World Organisation for Animal Health

RESUME

La rage est connue comme étant l'une des maladies infectieuses les plus anciennes mais aussi pour lesquelles il existe des moyens de prévention efficace. Toutefois, elle continue de menacer sérieusement la santé publique ainsi que les moyens de subsistances des populations vulnérables dans au moins 150 pays dans le monde. Au niveau global, les estimations font état de 14000 à 59000 pertes en vies humaines enregistrées chaque année, dont près de 40% des décès concernent des enfants de moins de 15 ans. Depuis la découverte du vaccin antirabique en 1885, plusieurs pays en Amérique, en Asie et en Europe ont éliminé la maladie à travers de vastes programmes de vaccination des animaux réservoirs et vecteurs. Cependant, en Afrique et particulièrement au Burkina Faso où le principal vecteur de la maladie reste le chien, elle est endémique avec des conséquences graves sur la santé animale et la santé humaine. En effet, les efforts mis en place au fil des années n'ont pas permis de réduire significativement la menace. Face à la situation et en vue de favoriser la réalisation du troisième Objectif de Développement Durable (ODD3) intitulé « *Permettre à tous de vivre en bonne santé et promouvoir le bien-être à tout âge* », une stratégie mondiale a été lancée en 2015 avec pour ambition d'éliminer la rage humaine transmise par les carnivores domestiques à l'horizon 2030.

C'est dans ce contexte que plusieurs études ont été conduites afin de mieux documenter les contraintes ainsi que les facteurs de succès du contrôle de la rage en vue d'orienter l'élaboration des programmes d'élimination. Ces recherches ont permis à ce jour de générer un volume considérable de connaissances sur la biologie du virus et des principaux réservoirs, ainsi que sur l'épidémiologie de la rage. Ces résultats ont contribué à accroitre la prise de conscience sur l'ampleur du phénomène. Dans la foulée, la rage a été classée en 2017 parmi les cinq zoonoses prioritaires du pays et une Plateforme Nationale de Coordination One Health (PNCOH) a été créée en vue de porter la politique nationale d'engagement multisectoriel autour de ces maladies. Toutefois, en dépit des efforts considérables engagés avant et depuis l'adoption de l'approche One Health, la rage demeure endémique, et les approches de lutte ont peu évolué. Notre recherche s'insère dans la continuité des études précédentes en partant de l'hypothèse qu'en considérant la diversité des acteurs en interaction permanente au sein du système multisectoriel dédié à la lutte contre la rage, évoluant lui-même dans un contexte socio-économique et environnemental changeant, une perspective intégrative serait nécessaire pour une meilleure compréhension des défis et la mise en place d'approches nouvelles de lutte adaptées aux réalités.

S’inscrivant dans la pensée systémique, la recherche a utilisé des méthodes qualitatives et participatives pour analyser le système à travers trois études successives. La collecte des données, réalisée à travers des entretiens individuels et des focus groups, a ainsi concerné les différents secteurs et acteurs impliqués dans la lutte contre la rage au Burkina Faso. La première étude avait pour objectif d’analyser l’ensemble du système multisectoriel afin d’identifier les différents obstacles à sa performance globale. Ainsi, les données ont été analysées à l’aide de la théorie du système d’action social de Parsons (PSSAT). La seconde étude s’est focalisée sur un domaine d’action – la vaccination antirabique des carnivores domestiques – avec pour objectif de comprendre les dynamiques qui influent sur la réalisation de la couverture vaccinale. Une modélisation qualitative à travers les boucles causales (CLD) a été utilisée pour décrire les relations de causalité entre les différentes variables et l’effet des dynamiques engendrées sur l’efficacité opérationnelle de la vaccination de masse. Quant à la troisième étude, elle a mobilisé les acteurs autour d’ateliers participatifs pour prioriser les actions de lutte contre la rage. Pour cela, l’approche méthodologique utilisée était l’aide à la décision multicritère (MCDA).

L’analyse de l’ensemble du système multisectoriel a révélé une fragmentation persistante se traduisant par un faible alignement stratégique et opérationnel entre les secteurs et les acteurs. En outre, une insuffisance de capacités opérationnelles liée à une allocation financière et une logistique inadéquate, une insuffisance de la mobilisation sociale et communautaire, ainsi que des défis de gouvernance liés la diversité des acteurs et des domaines d’actions ont été également identifiés. Concernant l’étude sur la vaccination antirabique des carnivores domestiques, les résultats ont montré qu’il s’agit d’un domaine d’action fondamentalement multi-acteur et le succès de la mise en œuvre repose sur une bonne synergie d’action. Les boucles causales de renforcement et de stabilisation identifiées sont structurées autour d’interrelations dynamiques entre des facteurs socio-culturels, économiques, techniques, organisationnels et politiques affectant l’efficacité opérationnelle de la vaccination canine de masse dans le pays. La priorisation des interventions en sous-groupes sectoriels a révélé des écarts importants entre les préférences exprimées par les secteurs de la santé animale et de la santé humaine. Cependant, lorsque les acteurs ont été rassemblés dans un groupe multisectoriel, un accord relatif a pu être obtenu sur la priorisation des interventions. Un consensus a ainsi été porté par les acteurs sur un ensemble d'interventions intersectorielles, y compris l'harmonisation des procédures de surveillance, le partage des données ainsi que la prévention et le contrôle.

Les résultats de la recherche, allant de l'identification des contraintes systémiques à la priorisation multisectorielle des interventions de lutte contre la rage, ont confirmé la capacité des approches intégratives et participatives, non seulement à améliorer la compréhension du problème, mais surtout à faciliter la collaboration entre les différentes parties et le développement de stratégies adaptées à leurs attentes et aux réalités du terrain. En conclusion, nous pouvons affirmer que l'élimination de la rage est possible au Burkina Faso, mais elle ne pourra être réalisée ni par la seule volonté politique, ni par des actions institutionnelles ponctuelles, ni par des campagnes isolées de sensibilisation. L'élimination de la rage exige une synergie d'action cohérente et durable entre acteurs, et portée par une vision partagée et une stratégie intégrative.

Mots clés : Rage, Système multisectoriel, Approches intégratives, Contraintes, Elimination, Burkina Faso

ABSTRACT

Rabies is considered one of the oldest infectious diseases known and documented, but also one of the few for which effective means of prevention exist. However, it continues to pose a serious threat to animal and public health and to the livelihoods of vulnerable populations in at least 150 countries around the World. At the global level, estimates indicate that between 14,000 and 59,000 human lives are lost annually due to rabies, with nearly 40% of deaths occurring among children under 15 years of age. Since the discovery of the rabies vaccine in 1885, several countries in the Americas, Asia, and Europe have eliminated the disease through large-scale vaccination programs targeting animal reservoirs and vectors. However, in Africa - and particularly in Burkina Faso, where the main vector remains the dog - rabies is endemic, with serious consequences for both animal and human health. Despite the efforts undertaken over the years, the threat has not been significantly reduced. In response to the situation and to support the achievement of the third Sustainable Development Goal (SDG3) - "*Ensure healthy lives and promote well-being for all at all ages*" - a global strategy was launched in 2015 with the ambition of eliminating human rabies transmitted by domestic carnivores by 2030.

It is in this context that several studies have been conducted to better document the constraints and success factors associated with the rabies control in order to guide the development of effective elimination programs. These studies have generated a significant body of knowledge on the biology of the virus and its main reservoirs or vectors, as well as the disease epidemiology. The results have contributed to raising awareness about the extent of the problem. Subsequently, rabies was classified in 2017 among the country's top five priority zoonoses, and a National One Health Coordination Platform was established to support the national policy for multisectoral engagement around these diseases. However, despite substantial efforts made both before and after the adoption of the One Health approach, rabies remains endemic, and current control strategies have shown limited progress. Our research builds upon previous studies, starting from the hypothesis that, by considering the diversity of actors in continuous interaction within the multisectoral system dedicated to rabies control - operating in a changing socio-economic and environmental context - an integrative perspective is essential to better understand the challenges and implement more locally-tailored control approaches.

In line with systems thinking, the research employed qualitative and participatory methods to analyze the system through three successive studies. Data collection - carried out through individual interviews and focus groups - involved various sectors and stakeholders engaged in

rabies control in Burkina Faso. The first study aimed to analyze the whole multisectoral system to identify the key obstacles to its overall performance. The data were analyzed using Parsons' Social System Action Theory (PSSAT). The second study focused on a specific area of intervention: the rabies vaccination of domestic carnivores, with the goal of understanding the dynamics influencing vaccination coverage. Qualitative modelling through causal loop diagrams (CLDs) was used to describe the causal relationships between variables and how resulting dynamics affect the operational effectiveness of mass vaccination campaigns. As for the third study, it brought stakeholders together through participatory workshops to prioritize rabies control interventions. The method employed was multi-criteria decision analysis (MCDA).

The analysis of the multisectoral system revealed a persistent fragmentation, reflected by low strategic and operational alignment among sectors and stakeholders. In addition, the study identified a lack of operational capacity due to inadequate financial and logistical resources, insufficient community and social mobilization, and challenges in integrative governance related to the diversity of stakeholders and domains of actions have also been identified. given the need to coordinate diverse actors and domains of action within the system. Concerning the study on rabies vaccination of domestic carnivores, the results showed that this area of action is inherently multi-actor, and success depends on strong synergy. The reinforcing and balancing causal loops identified were structured around dynamic interrelations among socio-cultural, economic, technical, organizational, and political factors affecting the operational effectiveness of mass canine vaccination in the country. The prioritization of interventions within sector-specific subgroups revealed significant differences in preferences between the animal and human health sectors. However, when stakeholders were gathered in a multisectoral group, a relative consensus was reached regarding intervention priorities. A consensus was thus reached by the stakeholders on a set of intersectoral interventions, including harmonization of surveillance procedures, data sharing, and prevention and control measures.

The research findings, from identifying systemic constraints to multisectoral prioritization of rabies control interventions, have demonstrated the potential of integrative and participatory approaches not only to enhance understanding of the problem but also to facilitate collaboration between stakeholders and the development of strategies tailored to their expectations and to local context. In conclusion, we assert that rabies elimination is possible in Burkina Faso, but it cannot be achieved solely through political will, isolated institutional actions, or one-off

awareness campaigns. Rabies elimination requires coherent and sustainable synergies between stakeholders and interventions, driven by a shared vision and an integrative strategy.

Keywords: Rabies, Multisectoral system, Integrative approaches, Constraints, Elimination, Burkina Faso

CHAPITRE 1

INTRODUCTION GENERALE

CHAPITRE 1 : INTRODUCTION GENERALE

1.1. Contexte et problématique de la lutte contre la rage

1.1.1. Un siècle de progrès contre la rage dans le monde

La rage est une encéphalite inéluctablement mortelle une fois cliniquement déclarée. Elle est causée par le virus rabique (RABV), un *Lyssavirus* de la famille des Rhadoviridae qui présente un tropisme prononcé pour les tissus nerveux. En Afrique, on distingue trois clades du virus rabique. Par exemple, on retrouve le clade cosmopolitain (avec la lignée Afrique 1) endémique en Afrique du Nord, le clade Afrique 2 en Afrique de l'Ouest et en Afrique du Centre, et enfin le clade Afrique 3 des mangoustes dont la zone de répartition est limitée en Afrique Australe. Les clades Afrique 1 et Afrique 2, qui regroupent les virus des canidés principalement véhiculés par les carnivores domestiques, restent les plus répandus dans différentes zones géographiques du continent. Au Burkina Faso, des études phylogénétiques des virus de la rage isolés en 2007 avaient révélé que tous les virus testés appartenaient à la lignée Afrique 2. Une étroite parenté génétique avec les virus circulants dans pays de la région, notamment le Niger, la Mauritanie, le Bénin, le Cameroun, le Tchad et la Guinée, avait été également rapportée par la même étude (De Benedictis et al., 2010).

Maladie infectieuse connue et documentée depuis près de 2300 ans avant Jésus Christ (Tarantola, 2017), la rage compte de nos jours parmi les plus anciennes et les plus redoutables, menaçant gravement la santé des humains et des animaux, sauvages et domestiques. Le virus rabique sévit actuellement dans plus de 150 pays. Des évaluations entreprises au cours de la dernière décennie, estiment que les pertes globales en vies humaines causées par la maladie se situent entre 14000 et 59000 décès par an (Gan et al., 2023 ; Qin et al., 2025 ; Hampson et al., 2015). Il ressort également de ces études que les enfants de moins de 15 ans sont les plus concernés par l'infection, représentant au moins 40% des cas de rage humaine enregistrés dans les zones d'endémie. Aux graves conséquences sanitaires qu'engendre l'infection, s'ajoutent de nombreuses implications économiques et financières en termes de manque à gagner sur l'économie et les moyens de subsistance des communautés affectées (pertes en nombre d'années de travail dues aux décès prématurés dont des enfants de moins de 15 ans, pertes de productions dans les élevages, coût d'acquisition des vaccins, des immunoglobulines et autres intrants médicaux, frais de déplacement et séjour des patients dans les structures de soins, pertes en temps de travail pour les personnes exposées et les membres de leurs familles, pertes de revenus liées aux mortalités des animaux d'élevage) se chiffrent au plan global à environ 8,6 millions de dollars chaque année (Hampson et al., 2015).

La transmission du virus entre les animaux réservoirs, les vecteurs ou hôtes secondaires (par exemple les chats, les primates en captivité, ou les animaux d'élevage) et les humains intervient généralement de manière accidentelle, ou lors d'une agression (morsure ou griffure) ou d'un léchage sur une peau ou une muqueuse présentant une effraction. Dans la majeure partie des zones d'endémie (notamment en Afrique, en Amérique Latine et en Asie), la transmission de la maladie aux humains est causée dans au moins 98% des cas par le chien (Meslin et Briggs, 2013 ; Taylor et al., 2017 ; Savadogo et al., 2020). La rage est évitable par la vaccination aussi bien chez les humains que les animaux, rendant son élimination possible. En effet, Louis Pasteur, après avoir appliqué avec succès un vaccin antirabique vivant atténué expérimental pour traiter un enfant (Joseph Meister alors âgé de 9 ans) gravement mordu par un chien enragé en 1885, avait initié une série d'actions de recherche qui devaient conduire à la mise au point de méthodes plus sûres et plus efficaces pour réduire le nombre de décès dus à la rage humaine. De 1885 à 1895, Louis Pasteur utilisera ce nouveau vaccin pour prévenir la rage chez près de 20 000 personnes mordues par des animaux enragés, évitant ainsi la mort à 99,5% d'entre elles (Théodoridès, 1989). En 2012, l'on estimait que l'introduction de la prophylaxie postexposition (PEP) contre la rage a permis de sauver plus de 20 millions de vies depuis 1885 (Meslin, 2012). Les premiers succès dans le domaine de la lutte contre la maladie remontent ainsi à la fin du 19^{e} siècle (Rappuoli, 2014). L'expérience réussie de Louis Pasteur va ainsi constituer un point de départ du développement et de la promotion de la prophylaxie postexposition pour la prévention de la rage chez les personnes victimes de morsures. Toutefois, cette approche, largement mise en œuvre au cours des premières décennies suivant la mise au point du vaccin, n'avait pas permis de contenir efficacement la persistance et la multiplication des cas de transmission de la rage. Aujourd'hui encore, l'accès à la prophylaxie postexposition demeure limité dans des régions endémiques où le risque d'infection est réel. En outre, la mise en œuvre de la prophylaxie postexposition à large échelle nécessite des ressources financières considérables, les besoins globaux étant estimés à plus de 29 millions de doses de vaccin antirabique par an (Hampson et al., 2015 ; Wallace et al., 2017).

Très tôt au cours des premières décennies de l'utilisation de prophylaxie postexposition par Louis Pasteur et des collaborateurs, les limites d'une approche de contrôle basée principalement sur la vaccination des personnes mordues ont été constatées. C'est ainsi qu'à partir des années 1910, de nouvelles approches incluant la vaccination de masse des animaux réservoirs, notamment le chien, vont être introduites (Umeno et Doi, 1921). Les toutes premières campagnes de vaccination de masse des carnivores domestiques furent ainsi lancées dans l'empire du Japon, entrainant une réduction significative de l'incidence de la maladie dans

l'empire dès 1956 (Tenzin et Ward, 2012 ; Taylor et Nel, 2015). A partir de ces succès, les campagnes de vaccination de masse ciblant les animaux réservoirs vont par la suite être adoptées et largement utilisées dans plusieurs régions du monde. Ces campagnes ont ainsi permis de contrôler efficacement la maladie en Amérique du Nord, en Europe de l'Ouest, et plus récemment au Mexique (Hampson et al., 2007 ; Gutiérrez-Cedillo et al., 2021 ; Aréchiga Ceballos et al., 2022 ; Gutierrez-Cedillo et al., 2024).

Dans le cadre de ces politiques d'élimination de la rage, plusieurs pays d'Amérique Latine, à l'instar du Mexique, avaient rendu la vaccination antirabique des carnivores domestiques obligatoire dès la seconde moitié du 20^{e} siècle. Depuis lors, à travers l'efficacité prouvée des vastes programmes de vaccination de masse des chiens, l'élimination de la rage était désormais à portée de main dans la région (Rupprecht et al., 2022 ; Gutierrez-Cedillo et al., 2024). Plus tard, en 2019, le Mexique sera reconnu par l'Organisation Mondiale de la Santé (OMS) comme indemne de rage humaine transmise par les carnivores domestiques, les derniers cas humains rapportés dans le pays remontant à 2006.

Toutefois, la rage continue de causer de nombreuses pertes en vies humaines, essentiellement dans les communautés vulnérables d'Afrique et d'Asie (Sondo et al., 2015 ; Hampson et al., 2015 ; Gan et al., 2023 ; Qin et al., 2025). Ces régions concernées par les plus fortes incidences des cas regroupent des pays où les programmes de vaccination de masse des carnivores domestiques sont absents ou conduits de manière ponctuelle et inefficace.

1.1.2. Situation du contrôle de la rage au Burkina Faso

Situé en Afrique de l'Ouest, le Burkina Faso n'échappe pas à cette triste réalité. Le pays est entouré par six pays limitrophes à savoir le Bénin (Sud-Est), la Côte d'Ivoire, le Ghana et le Togo (Sud), le Mali (Nord-Ouest) et le Niger (Nord-Est). Sur le plan socio-démographique, la population burkinabè était estimée à près de 20,5 millions d'habitants en 2019 (Burkina Faso, 2019). Il s'agit d'une population relativement jeune, 45% de habitants étant âgés de moins de 15 ans. Concernant la répartition géographique, environ 74% des habitants vivent en milieu rural. Cette population est composée de plusieurs groupes communautaires vivant de manière sédentaire et organisés autour de la pratique de l'agriculture et de l'élevage comme principales activités socio-économiques. Il y a également de nombreuses communautés d'éleveurs qui, traditionnellement, pratiquent la transhumance. Ainsi, ces éleveurs se déplacent périodiquement avec leurs troupeaux à l'intérieur ou à l'extérieur du pays à la recherche des ressources pastorales telles que l'eau et les pâturages. Dans le pays, tous les types de communautés pratiquent souvent l'élevage de carnivores domestiques, principalement le chien

qui joue un rôle important dans la société burkinabè (Kouldiati, 1989 ; Sondo et al., 2018). En effet, près de 58% des ménages détiennent au moins un chien pour diverses raisons socio-économiques, y compris la garde des maisons ou des troupeaux, la chasse, les sacrifices lors de certains rites traditionnels, la compagnie (en particulier pour les enfants), la commercialisation et la consommation de la viande canine, et la consommation (par les chiens) des restes de repas familiaux qui, dans certaines cultures burkinabè, ne doivent pas être jetés à la poubelle (Nitcheman, 1983 ; Savadogo, 2015 ; Savadogo et al., 2020 ; Compaoré, 2022). Les pratiques d'élevage des communautés, généralement caractérisées par la divagation des animaux, facilitent les contacts entre différents types d'animaux sensibles à la rage et les populations humaines, augmentant le risque de transmission et de diffusion de la maladie (Akakpo, 1982 ; Kouldiati, 1989, Minoungou et al., 2021).

Les données épidémiologiques disponibles et suggérant la présence de la maladie dans le pays remontent au début des indépendances. En effet, plusieurs situations de rage animale et humaine ont été décrites par plusieurs auteurs (Izard et al., 1967 ; Nitcheman, 1983 ; Kouldiati, 1989 ; Coulibaly et Yaméogo, 2000 ; De Benedictis et al., 2010 ; Savadogo et al., 2020 ; Minoungou et al., 2021). Tout de même, les études conduites à partir de l'année 2000 ont apporté d'importantes informations sur l'épidémiologie de la maladie comparativement à celles remontant aux premières décennies des indépendances. La circulation du virus rabique a été décrite chez plusieurs espèces animales sauvages et domestiques, indiquant en particulier que plus de 70% des chiens mordeurs étaient confirmés enragés par le laboratoire vétérinaire. Pendant ce temps, la couverture vaccinale antirabique chez les carnivores domestiques (concernant essentiellement les chiens non errants détenus par des ménages urbains), variait de 8% à 36%, largement en deçà du seuil de 70% requis pour interrompre le cycle de transmission de la maladie (Davlin et VonVille, 2012 ; Zinsstag et al., 2017 ; Mindekem et al., 2017). Par ailleurs, les données enregistrées par les structures sanitaires du pays indiquent une tendance haussière de l'incidence annuelle des cas de morsures enregistrés de 2000 à 2022, passant de 3800 (Coulibaly et Yaméogo, 2000) à plus de 11500 (Burkina Faso ; 2022 ; Savadogo et al., 2023). L'augmentation du nombre de cas rapportés peut s'expliquer par plusieurs facteurs parmi lesquels on peut noter la prise de conscience progressive du risque dans les communautés, le renforcement des systèmes de surveillance de la santé animale et de la santé humaine, sans occulter que l'urbanisation croissante s'accompagne également d'une hausse du nombre de carnivores domestiques, en particulier dans les zones périurbaines des grandes villes à l'image de Ouagadougou et Bobo Dioulasso.

Face aux conséquences néfastes de la maladie, touchant divers domaines socio-économiques et sanitaires, plusieurs mesures de prévention et de contrôle ont été mises en place. Des textes règlementaires adoptés en 1989 ont conféré à la rage le statut de maladie légalement réputée transmissible et à déclaration obligatoire. Par ailleurs, les textes encadrant la police zoosanitaire ont consacré l'interdiction de la divagation des animaux domestiques y compris les carnivores, tout en rendant obligatoire la vaccination antirabique des carnivores domestiques (chiens et chats) et les primates en captivité sur l'ensemble du territoire national. Auparavant, le financement de la vaccination des carnivores domestiques était essentiellement supporté par les propriétaires. Il faut noter que les campagnes de vaccination de masse étaient rarement organisées et ce dans certaines localités du pays. Par exemple, celles organisées en 2007, 2011 et 2016 s'étaient limitées le plus souvent à la capitale (Savadogo et al., 2020). De 2011 à 2024, des campagnes organisées dans la ville de Bobo Dioulasso y ont permis de vacciner entre 5000 et 10000 carnivores domestiques par an. Toutefois, dans la plupart des localités du pays, de rares mini-campagnes étaient organisées à la suite de détection de foyer (Savadogo et al., 2023 ; Savadogo et al., 2024). Selon les informations disponibles, seulement deux campagnes de vaccination gratuite et d'envergure nationale ont été conduites au Burkina Faso, en 1999 et en 2024, ayant permis de vacciner près de 41900 et 80800 carnivores domestiques, respectivement, sur une population totale dont la taille n'est pas connue avec exactitude mais avait été estimée pour la seule ville de Ouagadougou, par ailleurs la capitale administrative du pays, à plus de 400 000 têtes (Savadogo, 2015). Les services de vaccination antirabique des carnivores domestiques sont assurés par les structures vétérinaires publiques et privées. Mais le maillage du territoire par les services vétérinaires demeure insuffisant, le niveau de déconcentration se limitant aux chefs-lieux des communes (Savadogo et al., 2020 ; Dahourou et al., 2021). Outre les campagnes de vaccination, des opérations sporadiques d'abattage des carnivores domestiques sont réalisées par les services municipaux, généralement à la suite de déclarations de foyer de rage.

Quant à la prévention de la rage humaine, le pays dispose actuellement de trois centres de traitement antirabique (couramment appelés services d'hygiène dont deux à Ouagadougou et un à Bobo Dioulasso situé à plus 350 km à l'ouest du pays). Ces centres sont généralement sous la tutelle du Ministère de l'Administration territoriale et bénéficie d'un appui technique du Ministère de la Santé. Ils sont ainsi spécialisés et mandatés pour assurer la dispensation de la prophylaxie préexposition et postexposition aux personnes à risque élevé d'infection, le plus souvent les personnes mordues et celles effectuant des voyages internationaux. Cependant, la prise en charge de la prophylaxie postexposition reste confrontée à de nombreux obstacles dont

la discontinuité dans la disponibilité et l'accès aux vaccins et aux immunoglobulines antirabiques. Une fois la prophylaxie postexposition initiée, les taux de complétude des protocoles utilisés dans le pays sont très faibles (notamment le protocole de Zagreb et celui d'Essen), se situant entre 31,7% et 46,6% en raison de la faible accessibilité géographique et financière aux services de prise en charge (Sondo et al., 2018 ; Savadogo et al., 2020).

La surveillance épidémiologique de la rage animale et humaine est distinctement assurée par les services vétérinaires et les services sanitaires, respectivement. Du côté de la santé animale, elle inclut la confirmation des cas par le laboratoire vétérinaire situé à Ouagadougou, et la mise en observation des animaux suspects assurée par les services vétérinaires publics et privés.

Dans le domaine de l'information du public sur la maladie et les moyens de prévention, les séances de sensibilisation, généralement conduites en marge de la célébration annuelle de la journée mondiale de lutte contre la rage, ont été renforcées ces dernières années suite à la naissance de plusieurs organisations de la société civile (Savadogo et al., 2022 ; Savadogo et al., 2023). Ces associations (dont les plus connues sont l'Association Stop la Rage, l'Association One Health Burkina Faso, l'Association pour la Protection et le Bien-être Animal, l'Association Nationale des Promoteurs de Cabinets de soins Vétérinaires, l'Association la Centrale Canine du Burkina Faso, Rabies Free Burkina Faso) jouent un rôle essentiel dans la mobilisation communautaire, dans la formation des professionnels de la communication, dans la sensibilisation des enfants ainsi que dans le plaidoyer auprès des acteurs institutionnels. Pour la mise en œuvre de leurs actions, ces associations collaborent avec les services publics et bénéficient de l'appui d'organisations professionnelles telles que le Conseil National de l'Ordre des Vétérinaires et le Conseil National de l'Ordre des Médecins.

En dépit de tous ces efforts impliquant plusieurs catégories d'acteurs du public, du privé, des associations et des communautés, force est de constater que plusieurs décès dus à la rage continuent d'être régulièrement rapportés par les services sanitaires, avec des chiffres allant de 26 à 57 cas chaque année (Sondo et al., 2018 ; Burkina Faso, 2022). Il s'agit notamment des services spécialisés dans la prise en charge des maladies infectieuses et rattachés aux centres hospitaliers universitaires et aux centre hospitaliers régionaux. Toutefois, les connaissances de la rage par les professionnels de la santé demeurent insuffisantes à différents niveaux de la pyramide sanitaire du Burkina Faso (Savadogo et al., 2020). D'une manière générale, les faibles capacités des systèmes de surveillance de la rage dans les secteurs de la santé animale et de la santé humaine sont à l'origine de sous-estimation, les données disponibles ne permettant pas de traduire l'ampleur réelle de la maladie. Cette situation constitue également un défi majeur pour le renforcement des politiques de prévention et de contrôle de la rage dans

de nombreux pays du continent, car la sous-surveillance contribue à l'émergence du « *cercle vicieux de la négligence de la rage* » (Dodet et al., 2009 ; Lembo et al., 2010 ; Mbilo et al., 2021 ; Haselbeck et al., 2021).

1.1.3. Lutte contre la rage à l'ère de l'approche One Health

L'évolution du monde s'accompagne de profondes mutations engendrant des modifications à l'interface entre les animaux, les humains et les écosystèmes dans lesquels ils vivent. Elle est accompagnée de l'émergence de nouveaux pathogènes dont certaines sont responsables de maladies zoonotiques, comptant pour environ 75% des maladies qui infectent les populations humaines (Taylor et al., 2001). Par ailleurs, les changements des écosystèmes entrainent des bouleversements dans les cycles épidémiologiques des maladies infectieuses. Au nombre de ces maladies zoonotiques, figure la rage. Les caractéristiques éco-épidémiologiques de la rage varient en fonction des spécificités sociologiques et écologiques des régions affectées. Le cycle épidémiologique de la maladie fait intervenir une diversité d'espèces animales sauvages ou domestiques, soit en tant que réservoirs, soit en tant que vecteurs ou hôtes secondaires, les humains constituant généralement un cul-de-sac épidémiologique. A titre illustratif, les principaux réservoirs de la rage sont le renard (*Vulpes vulpes*) en Europe occidentale (Laiskonis et al., 2006), la chauve-souris (*Desmodus rotundus*) et le raton laveur (*Procyon lotor*) en Amérique Latine et Centrale (Wallace et al., 2014 ; Ma et al., 2021, Rupprecht et al., 2022). En Afrique et en Asie, le chien est la principale espèce animale victime et vectrice de la maladie, mais la population canine est considérée comme réservoir à titre collectif (Akakpo, 1982 ; Zinsstag et al., 2017 ; Rupprecht et al., 2022). Toutefois, d'autres mammifères domestiques peuvent occasionnellement intervenir comme vecteurs de la maladie aux humains. Il s'agit par exemple du chat, des primates en captivité, des animaux d'élevage (ruminants, équidés, porcins, camélidés) (Minoungou et al., 2021 ; Savadogo et al., 2023 ; Savadogo et al., 2024). En d'autres termes, l'épidémiologie analytique de la rage révèle ainsi que sa distribution temporelle et spatiale est étroitement liée aux interactions multiples qui existent entre les animaux domestiques, les animaux sauvages et les humains. Malgré que la rage soit à 100% évitable par l'administration du vaccin antirabique mis au point et utilisé durant les 140 dernières années, la rage continue de tuer. Ce constat suggère qu'au-delà des connaissances techniques, l'existence des outils et des technologies, y compris un vaccin dont l'efficacité n'est plus à démontrer, l'élimination de la rage nécessite de repenser les approches utilisées jusque-là. Ces réflexions en faveur des innovations dans la lutte contre la rage ont joué un rôle central dans la conceptualisation et la promotion de la collaboration One Health dans le monde.

L'approche One Health est définie par le comité des experts de l'Alliance Quadripartite (composée de l'Organisation Mondiale de la Santé, de l'Organisation Mondiale de la Santé Animale, l'Organisation des Nations Unies pour l'Agriculture et l'Alimentation, et le Programme des Nations Unies pour l'Environnement) comme étant une approche intégrée et unificatrice qui vise à équilibrer et à optimiser durablement la santé des personnes, des animaux et des écosystèmes. Elle reconnaît que la santé des êtres humains, des animaux domestiques et sauvages, de l'environnement au sens large (y compris les écosystèmes) est étroitement liée et interdépendante (Mettenleiter et al., 2023 ; Mettenleiter et al., 2024). Selon le type de risque sanitaire, l'approche promeut la mobilisation de plusieurs secteurs et disciplines ainsi que les communautés à différents niveaux de la société afin qu'ils travaillent ensemble pour favoriser sa gestion adaptée, durable et efficace (Figure 1).

Dans ce contexte, la mise en place de l'Alliance Quadripartite représente une prise de conscience et la volonté des principales organisations internationales chargées de la santé publique mondiale d'harmoniser les politiques et de coordonner les initiatives pour une gestion optimale des risques sanitaires au niveau global. C'est dans cette optique d'opérationnalisation et de renforcement de la collaboration intersectorielle et interinstitutionnelle, que des outils d'évaluation conjointe des capacités des services vétérinaires (PVS de l'OMSA) et du règlement sanitaire international (RSI 2005 de l'OMS) ont développer pour accompagner les Etats membres (Belot et al., 2021 ; De la Rocque et al., 2023 ; Dar et al., 2025). A ce jour, plusieurs pays ont conduit des priorisations des maladies zoonotiques ainsi que des ateliers conjoints d'évaluation du PVS et du RSI 2005 pour soutenir l'engagement multisectoriel (Rist et al., 2014 ; Yasobant et al., 2019). Faisant suite aux différentes évaluations déjà conduites, un plan d'action conjoint (*The One Health Joint Plan of Action*) a été lancé en octobre 2022 pour promouvoir les actions collaboratives et coordonnées au niveau international, régional et national (World Health Organization, 2022 ; Milazzo et al., 2025).

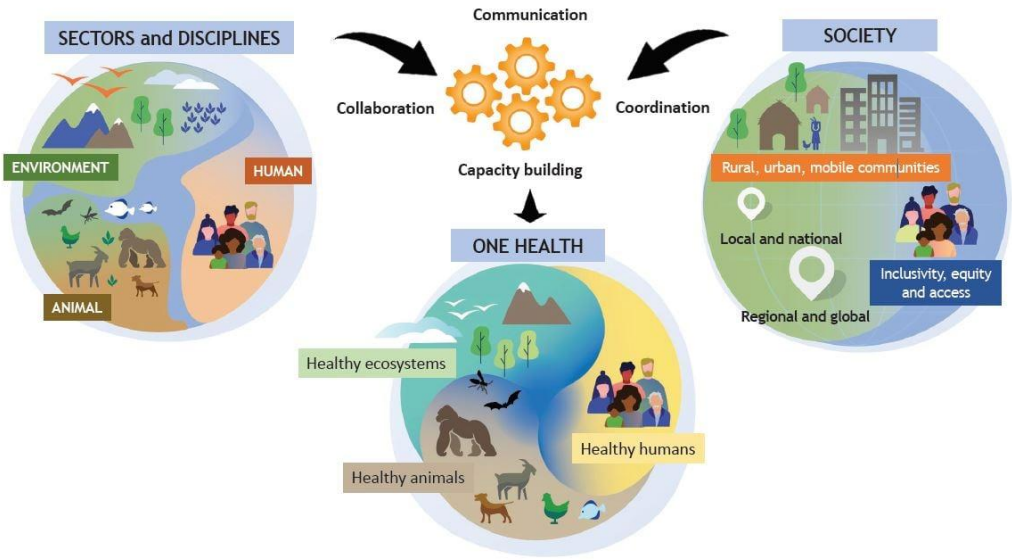

Figure 1 : Cadre conceptuel de la définition de l'approche One Health par le comité d'experts de l'Alliance Quadripartite (Mettenleiter et al., 2023)

En tant que défi sanitaire partagé par les différents secteurs et institutions, la rage est prise en charge dans le plan d'action conjoint One Health à travers le domaine d'intervention prioritaire intitulé « *Contrôle et élimination des zoonoses endémiques, des maladies tropicales négligées et des maladies à transmission vectorielle* » (Tidman et al., 2023). Au niveau global, la rage a été retenue parmi les 20 maladies zoonotiques prioritaires pour la santé animale et les huit maladies zoonotiques prioritaires pour la santé humaine (Qiu et al., 2023). Des démarches similaires ont abouti, dans plusieurs régions et pays, à l'établissement de listes conjointes de maladies zoonotiques prioritaires. Dans la majorité des cas, la rage était apparue parmi les cinq maladies prioritaires pour les secteurs et acteurs engagés dans les processus de priorisation (Mpouam et al., 2021).

C'est dans cette nouvelle dynamique structurée autour de la collaboration multisectorielle et transfrontalière, que l'OMS, l'OMSA, la FAO et l'Alliance Globale pour le Contrôle de la Rage (GARC) ont coordonné l'adoption en 2015 du « *Plan stratégique mondiale pour l'élimination de la rage humaine transmise par les carnivores domestiques à l'horizon 2030* ». Une étape importante vers l'opérationnalisation de ladite stratégie a été le lancement en septembre 2020 de l'initiative United Against Rabies (Tous Unis contre la Rage) (Tidman et al., 2022) dont le mandat est d'accélérer la mise en place de moyens innovants et plus inclusifs pour fédérer les parties prenantes à travers le monde, en leur fournissant une plateforme pour œuvrer collectivement pour la réalisation de l'objectif d'élimination de la rage humaine transmise par les animaux. La vision donnée à cette stratégie accorde une place de choix aux

actions qui ciblent le réservoir animal de la maladie (les carnivores domestiques), tout en intégrant les stratégies de lutte dans les efforts plus élargis visant à renforcer les capacités des systèmes de santé (Minghui et al., 2018). Sa mise en œuvre vise à apporter l'appui nécessaire aux pays dans l'opérationnalisation de l'approche One Health pour la détection précoce, la prévention efficace et la riposte rapide contre la rage. Au nombre de réalisations dans le cadre de cet appui, une méthode d'évaluation (l'approche raisonnée vers l'élimination de la rage) et une feuille de route ont été conçues pour guider l'élaboration des stratégies nationales (Tidman et al., 2023).

C'est dans ce contexte qu'en 2017, dans une volonté du Burkina Faso de promouvoir un engagement multisectoriel et d'améliorer l'efficacité de la lutte contre les zoonoses, une priorisation conjointe a été conduite, impliquant principalement les secteurs de la santé animale, de la santé humaine et de l'environnement. Au terme du processus, la rage avait été identifiée comme la deuxième maladie zoonotique prioritaire pour le pays et placée sur une liste de cinq maladies dont le charbon bactéridien ou anthrax, la brucellose, l'influenza aviaire hautement pathogène et la dengue (Mpouam et al., 2021). La poursuite de ces efforts a abouti en 2019 à l'institutionnalisation de l'approche One Health dans le pays, à travers la création de la Plateforme Nationale de Coordination One Health. Pour la réalisation de ses missions, cette plateforme est composée de plusieurs instances de décision et d'organes d'exécution (Figure 2). Les instances de décision comprennent le Conseil National présidé par le premier ministre et le Comité Technique de Pilotage présidé de manière alternée tous les deux ans par les ministres en charge de la santé humaine, de la santé animale et de l'environnement, respectivement. Enfin, le Secrétariat Technique One Health en tant qu'organe d'exécution est dirigé par un secrétaire exécutif, appuyé par des experts représentant les secteurs ministériels (santé humaine, sécurité sanitaire des aliments, santé animale, santé environnementale et faune, recherche et innovation). Le Secrétariat Technique est composé de cinq (05) Points focaux ministériels, de Comités déconcentrés et de sept Commissions thématiques spécialisées, dont la commission thématique en charge de la lutte contre les maladies zoonotiques (CTZ). Dans le cadre de l'animation des organes de la plateforme, une stratégie nationale d'opérationnalisation de l'approche One Health a été adoptée en mars 2022, suivie de l'adoption de la stratégie nationale intégrée d'élimination de la rage humaine transmise par les carnivores domestiques 2022-2030 en novembre 2022. Toutefois, en dépit des efforts considérables enregistrés dans le pays avant et depuis l'adoption du One Health dans le pays, la persistance de la maladie suscite des interrogations quant à l'efficacité des actions de lutte mises en place.

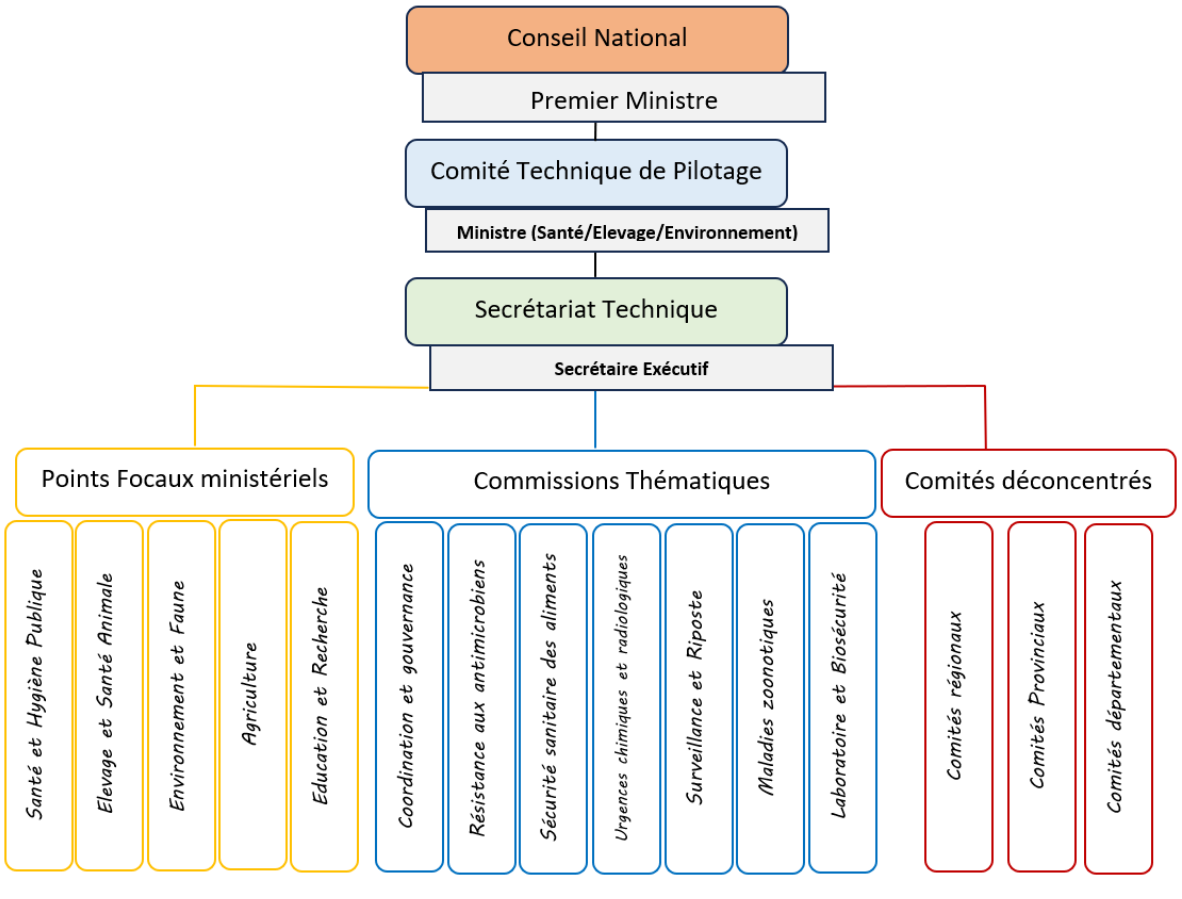

Figure 2 : Organigramme de la Plateforme Nationale de Coordination One Health du Burkina Faso

1.2. Cadre théorique de la recherche

La recherche explore l'apport de la pensée systémique dans la compréhension de l'épidémiologie et des stratégies de lutte contre les zoonoses et autres menaces sanitaires à l'interface entre les animaux, les humains et l'environnement. En effet, la pensée systémique reconnait les interdépendances dynamiques entre les organismes, l'environnement et les systèmes sociaux (Wilcox and Gubler, 2005). Cette vision de la pensée systémique justifie une conceptualisation des systèmes socio-écologiques qui organisent les déterminants de la santé sur une échelle hiérarchique. Dans la lutte contre les zoonoses, cette conceptualisation permet de dépasser les approches sectorielles fragmentées en intégrant les dimensions biologiques, environnementales, sociales et économiques. Parmi ces dimensions, il y a par exemple le phénomène de la croissance de la population humaine qui entraine avec elle une demande sans cesse accrue en ressources pour la satisfaction des besoins. Plusieurs travaux (Zinsstag et al., 2011 ; Gebreyes et al., 2014) soulignent que la dynamique des maladies émergentes est façonnée par les dimensions des systèmes socio-écologiques relatives aux comportements humains, aux dynamiques institutionnelles et sociales. Dans ce contexte, les risques sanitaires

sont influencés par des déterminants systémiques tels que la mondialisation, l'urbanisation, l'intensification des pratiques de productions agricoles, la destruction des forêts, les changements d'usage des sols, le commerce des animaux vivants, l'évolution des politiques et systèmes de santé. Par ailleurs, les changements chez les agents pathogènes, les hôtes et au sein des biodiversités affectent les relations hôte-pathogène, modifiant les mécanismes de transmission ou de persistance des maladies (Wilcox and Steele, 2020).

L'application de la pensée système facilite l'identification des points de levier stratégiques pour agir sur les facteurs structurels de risque (Meadows, 1999). Par exemple, la modélisation systémique a permis d'anticiper la propagation de la grippe aviaire ou du virus Nipah en tenant compte des flux de populations, des pratiques agricoles et des interactions avifaune, animaux d'élevage et humains (Leach et al., 2010). Les outils de la pensée système ont été mobilisés pour concevoir des interventions et renforcer la résilience des systèmes de santé, notamment dans le cadre de la surveillance intégrée (Destoumieux-Garzón et al., 2018). Des études de cas en Afrique et en Asie montrent que les outils systémiques, tels que les cartes cognitives et les diagrammes de boucles causales, facilitent la compréhension partagée des problèmes et solutions impliquant plusieurs catégories d'acteurs (Rüegg et al., 2018). La pensée système contribue aussi à explorer les compromis et synergies entre objectifs sanitaires, économiques et environnementaux. En contexte de ressources limitées, elle aide à prioriser les actions sur les déterminants majeurs de transmission (Xia et al., 2017 ; Vujcich et al., 2023). Toutefois, la mise en œuvre opérationnelle reste confrontée à des défis méthodologiques et organisationnels, notamment la disponibilité des données et la capacité à fédérer les acteurs autour d'une vision commune. Ainsi, la pensée système est reconnue comme un atout stratégique pour aborder les menaces sanitaires à l'interface homme-animal-environnement, mais son intégration effective nécessite un investissement soutenu en renforcement des capacités et en gouvernance collaborative.

A l'instar de différents risques sanitaires à l'interface homme-animal-environnement, les succès ou les échecs de plusieurs programmes de lutte contre la rage sont liés à des déterminants sociaux, institutionnels, environnementaux et écologiques pouvant influer sur les dynamiques d'entretien, de transmission et de propagation des virus (Thompson et al., 2024).

Sur le plan social, plusieurs études ont montré que les connaissances, les attitudes, les perceptions ou les comportements des individus ou des communautés déterminent par exemple leur adhésion aux mesures de prévention en cas d'exposition (Sondo et al., 2018 ; N'Guessan et al., 2022), l'adoption de bonnes pratiques d'élevage y compris la gestion responsable des carnivores domestiques (Taylor et al., 2017), la décision de vacciner les animaux (Savadogo et

al., 2021), l'adoption des bonnes pratiques en matière de gestion des déchets, d'hygiène et d'assainissement (Wright et al., 2021 ; Dickin et al., 2025) (Figure 3). Les faibles capacités de gestion des déchets d'origine alimentaire issus des ménages, des restaurations collectives, des unités de transformation des produits alimentaires favorisent les sources d'alimentation des chiens errants et leur survie. La prolifération non contrôlée et la divagation des carnivores domestiques, augmentent les possibilités de contacts entre animaux domestiques et sauvages, impactant significativement sur l'écologie de la population canine et ainsi sur la circulation du virus. En effet, selon Akakpo (1982) mais aussi Atuman et collaborateurs (2014), la distribution de la rage et les mesures de lutte sont fortement impactées par la structure de la population canine. Dans de nombreux pays africains, l'analyse de la population canine révèle qu'elle est généralement composée de chiens dits domestiques, de chiens errants occasionnels et de chiens errants permanents (Akakpo et Alambedji, 2001). Ce sont principalement les chiens errants qui, au contact avec d'autres animaux domestiques ou sauvages, peuvent s'infecter et transmettre le virus, contribuant ainsi à sa propagation. C'est ainsi que le chien joue un rôle central à l'interface entre la rage sylvatique et la rage citadine, cette dernière étant la principale source de transmission aux humains.

Concernant l'environnement, l'accroissement des effets néfastes des changements anthropiques (pratiques agricoles extensives, urbanisation galopante, chasse, feux de brousse, déforestation) se traduit progressivement par une dégradation de la biodiversité, des déséquilibres écologiques, un accroissement de la population canine en particulier dans les grandes agglomérations urbaines, une destruction des habitats naturels des animaux sauvages (Figure 1). Ces bouleversements au sein des écosystèmes associés aux effets des changements climatiques, entrainent des migrations d'animaux sauvages et une modification de l'interface entre les animaux domestiques, les animaux sauvages et les humains, augmentant les risques d'échange d'agents pathogènes entre différentes espèces (Cassidy, 2012 ; Pecl et al., 2017). Ces changements environnementaux peuvent également s'accompagner de mutations génétiques qui modifient les capacités d'adaptation des agents pathogènes à de nouveaux hôtes. Dans ce contexte, un changement de paradigme, en rapport avec les approches de lutte contre les maladies utilisées jusque-là, est nécessaire. Une prise en considération de la complexité de la gestion des maladies zoonotiques est nécessaire pour soutenir le développement des politiques publiques capables de mobiliser des ressources, des outils et des expertises et de conduire des interventions efficaces et adaptées aux réalités (Rock et al., 2017 ; Haselbeck et al., 2021). Eu égard à la multiplicité des facteurs qui influent sur l'épidémiologie de la rage, des interventions structurées autour d'approches systémiques devraient être envisagées. Ces

approches visent à intégrer un ensemble des domaines d'actions pertinents, dont la vaccination de masse des animaux réservoirs et des vecteurs, la prophylaxie postexposition pour les personnes à risque d'infection, la surveillance épidémiologique pour la collecte de données probantes, la détection rapide en laboratoire pour la confirmation des cas suspects, la gestion de la population canine, le renforcement des compétences techniques des professionnels, l'information des communautés, le plaidoyer pour l'engagement de toutes les parties. Face à l'efficacité limitée des stratégies fragmentées et sectorielles, des approches intégratives apparaissent comme une voie pour favoriser des synergies d'action. En effet, tirant leçon de l'intégration des sciences biomédicales et des sciences sociales qui a amélioré la compréhension de la place des facteurs sociaux, comportementaux, psychologiques et biologiques dans la santé publique, les approches intégratives se proposent de prendre en charge la question sanitaire dans toutes ses dimensions sociale, émotionnelle, économique, psychologique et physique (Organisation Mondiale de la Santé, 1946). Présentant des implications pour la santé humaine, la santé animale, la protection de l'environnement et l'économie, le contrôle de la rage représente ainsi un cas classique d'application de l'approche One Health (Figure 1).

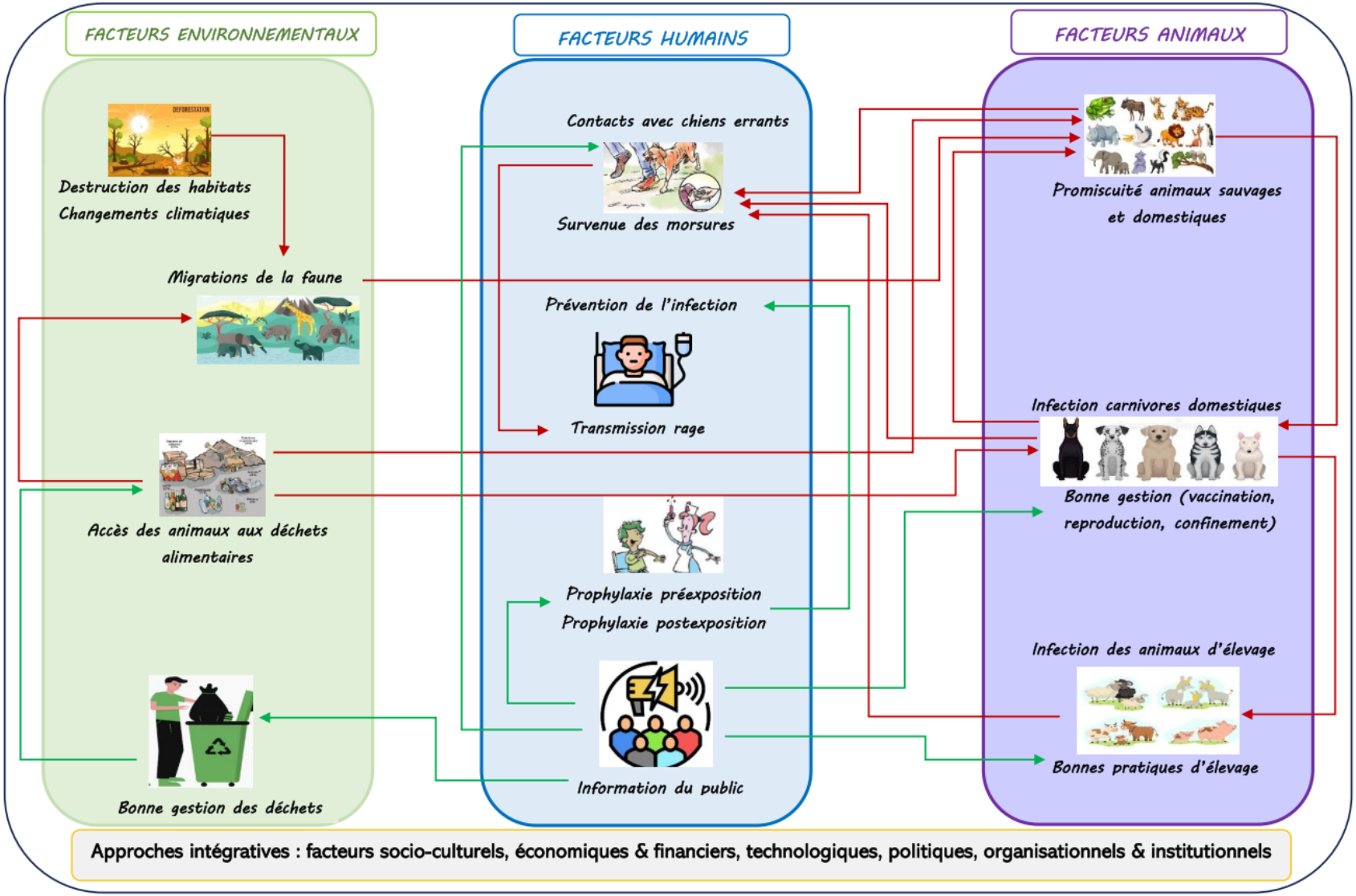

Figure 3 : Cadre conceptuel des approches intégratives dans la lutte contre la rage humaine transmise par les carnivores domestiques

1.3. Objectifs et cadrage méthodologique

1.3.1. Question de recherche

Au regard de ce qui précède, la principale question de recherche qui se dégage est la suivante : Dans quelle mesure l'application des approches intégrées d'évaluation de la stratégie de lutte contre la rage pourrait-elle améliorer la compréhension des incertitudes liées à la collaboration One Health et favoriser la mise en place de programmes adaptés pour l'élimination de la maladie au Burkina Faso ?

1.3.2. Hypothèse de recherche

Pour répondre à la question de recherche, la réflexion part de l'hypothèse que compte tenu de la diversité des acteurs en interaction permanente au sein d'un système multisectoriel évoluant lui-même dans un contexte socio-économique et technologique changeant, des évaluations de la stratégie de lutte basées sur des approches systémiques facilitent la compréhension des dynamiques qui influent sur la mise en œuvre de l'approche One Health dans le domaine de la lutte contre la rage. Ainsi, la compréhension de ces dynamiques par les différentes parties concernées et leur prise en considération sont nécessaires pour l'élaboration de stratégies adaptées pour l'élimination de la rage humaine transmise par les carnivores domestiques.

1.3.3. Objectifs de recherche

En vue de contribuer à l'amélioration de l'efficacité opérationnelle du système de lutte contre la rage au Burkina Faso, la présente recherche vise à analyser celui-ci de manière intégrée en vue de cerner les principaux défis et incertitudes dont la prise en considération pourrait améliorer l'application effective de l'approche One Health.

Afin de répondre à cet objectif de la recherche, la problématique posée a été abordée sous quatre perspectives différentes et complémentaires. Ainsi, de manière spécifique l'étude avait pour objectif de :

1. Analyser les principales contraintes à l'application de l'approche One Health dans le système multisectoriel de lutte contre la rage humaine transmise par les carnivores domestiques ;
2. Explorer les déterminants qui influencent l'efficacité opérationnelle de la vaccination antirabique des carnivores domestiques ;
3. Prioriser de manière participative les actions à fort impact sur l'élimination de la rage en vue de soutenir la conception de stratégies efficaces et adaptées aux réalités du terrain.
4. Évaluer, à partir d'une expérience de terrain menée via une plateforme de la société civile, comment une démarche d'action réflexive peut générer des apprentissages collectifs et orienter l'amélioration des pratiques de lutte contre la rage dans une perspective One Health.

1.3.4. Méthodologie et structuration de la recherche

La recherche a été réalisée en trois étapes successives synthétisées dans le cadre méthodologique ci-dessous (Figure 4) : i) la première étape a porté sur une analyse transversale du système multisectoriel de lutte contre la rage pour une évaluation des contraintes à la collaboration entre les différentes parties, en utilisant le cadre d'analyse de la performance issu de la théorie de l'action du système social de Parsons [en anglais *Parsons' Social System Action Theory (PSSAT)*] (Sicotte et al., 1998 ; Contandriopoulos et al., 2012) ; ii) la seconde est relative à une analyse verticale ayant porté sur l'un des multiples domaines d'action, en l'occurrence la vaccination antirabique des carnivores domestiques, en vue d'explorer les facteurs qui influent sur son efficacité opérationnelle dans un contexte local, en se basant sur la méthode dite des diagrammes en boucles causales [en anglais *Causal Loop Diagramming (CLD)*] (Sterman, 2002 ; Renmans, 2018) ; iii) la troisième étape vise à proposer une approche participative dont la mise en œuvre pourrait améliorer l'adéquation des stratégies de lutte compte tenu des contraintes et des réalités locales, justifiant la mobilisation de la méthode de priorisation multicritère d'aide à la décision [en anglais *Multi-criteria Decision Analysis (MCDA)*] ; et iv) la dernière étape s'est focalisée sur le potentiel contributif d'une organisation de la société civile, inscrite dans une dynamique One Health, pour la mise en œuvre d'interventions réflexives de contrôle de la rage. La démarche ainsi adoptée a permis de mobiliser trois méthodes d'analyse complémentaires afin d'aborder la problématique de manière globale pour premièrement diagnostiquer de manière transversale les incertitudes liées à l'organisation institutionnelle et fonctionnelle du système dans son ensemble, puis analyser les déterminants de l'efficacité opérationnelle des interventions initiées pour le contrôle de la rage (notamment le cas de la vaccination antirabique de masse des carnivores domestiques), ensuite engager les parties concernées à travers une approche participative de priorisation et des interventions avec pour objectif d'améliorer la synergie d'action dans le système. La démarche a mobilisé également une approche interventionnelle réflexive par la mise en œuvre d'activités concrètes sur le terrain à travers une organisation de la société civile dédiée à la lutte contre la rage au Burkina Faso.

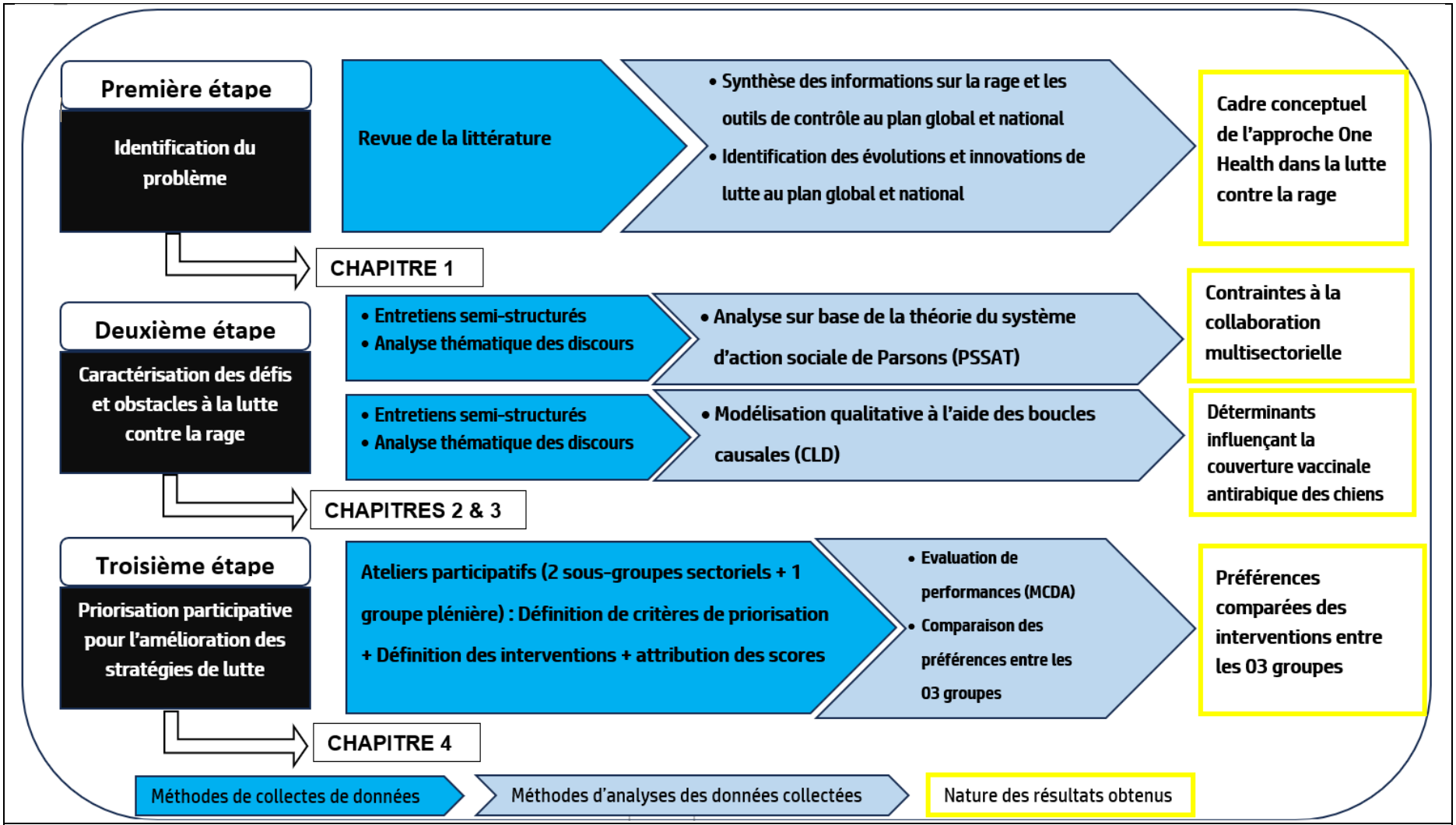

Figure 4 : Synthèse du cadre méthodologique utilisé pour la mise en place de la recherche

Ainsi, cette thèse est présentée sous la forme d'une série de quatre études insérées dans le format d'articles de recherche. Etant donné que chaque chapitre correspond à une étude, et que chacune des études comprenait déjà une introduction et une discussion, nous avons ajouté une introduction générale (**chapitre 1**) et une discussion générale (**chapitre 6**) pour compléter le manuscrit de thèse.

Par conséquent, le **chapitre 2** de la thèse correspond à la première étude. Il s'agit d'une étude qualitative basée sur des entretiens semi-structurés conduits de février 2019 à février 2021 auprès des acteurs de la lutte contre la rage au Burkina Faso. Les discours des acteurs ont fait l'objet d'une analyse thématique, puis les informations obtenues ont été catégorisées sur la base des dimensions définies dans le cadre d'analyse de la performance issu de la théorie de l'action du système social de Parsons [en anglais *Parsons' Social System Action Theory (PSSAT)*] (Sicotte et al., 1998 ; Contandriopoulos et al., 2012). Cette étude avait pour objectif de dégager les principales contraintes auxquelles le système multisectoriel était confronté relativement à la mise en œuvre de l'approche One Health pour l'élimination de la rage humaine transmise par les carnivores domestiques. La Théorie de l'Action du Système Social de Parsons (PSSAT) constitue un cadre d'analyse systémique de ce type. Elle a été développée afin de fournir une compréhension globale du fonctionnement des organisations complexes (Sicotte et al., 1998). Selon la perspective de Parsons, au-delà des techniques et des outils utilisés, toute forme d'organisation - qu'elle soit sociale, économique, industrielle ou sanitaire - peut être modélisée comme une interaction dynamique entre quatre fonctions fondamentales à savoir : i) l'adaptation à l'environnement dans lequel elle opère ; ii) la réalisation des objectifs fondamentaux ; iii) l'intégration des processus internes pour produire les résultats attendus ; et iv) le maintien des conditions internes favorables, fondées sur des valeurs et des normes partagées. Les interconnexions réciproques entre ces quatre fonctions définissent ainsi six liens dynamiques, dont la modification influence la dynamique globale, et donc la performance du système. Ces liens, appelés « alignements » ou « équilibres », comprennent : l'alignement stratégique, l'alignement allocatif, l'alignement tactique, l'alignement opérationnel, l'alignement de légitimation, et l'alignement contextuel. Ces alignements assurent les régulations internes nécessaires entre les fonctions, traduisant les atouts du concept intégrateur de Parsons et le rendant opérationnel dans une approche systémique. Initialement, la PSSAT a été appliquée dans les pays du Nord, notamment dans le secteur industriel, pour évaluer les facteurs de l'action collective et l'efficacité organisationnelle. Elle a ensuite été introduite dans le domaine de la santé afin de mieux comprendre les dynamiques internes et externes des

systèmes de santé (Sicotte et al., 1998 ; Contandriopoulos et al., 2012). Même en l'absence de données quantitatives, la PSSAT offre la possibilité d'une évaluation qualitative, fondée sur le recueil d'opinions d'experts ou de parties prenantes impliqués dans l'initiative évaluée. En ce sens, elle peut s'avérer particulièrement utile pour l'analyse des interventions sanitaires multisectorielles, notamment dans les contextes à ressources limitées, où les données sont rares et où le fonctionnement comme les enjeux demeurent mal définis et en évolution constante. En tant que cadre conceptuel, la PSSAT permettrait d'analyser le système de lutte contre la rage de manière systémique, en tenant compte de sa complexité, de ses interactions avec l'environnement, ainsi que des tensions ou équilibres établis entre ses quatre composantes fonctionnelles. Le **chapitre 3** correspond à la deuxième étude qui a permis d'analyser la mise en œuvre opérationnelle de la vaccination antirabique des carnivores domestiques dans le contexte local. Des entretiens semi-structurés réalisés de février 2019 à février 2021 ont permis de collecter des données auprès des acteurs intervenant dans la mise en œuvre de la vaccination antirabique des carnivores domestiques au Burkina Faso. Ensuite, des analyses thématiques des discours ont été menées, suivies de modélisation qualitative des variables identifiées à l'aide de diagrammes en boucles causales [en anglais *Causal Loop Diagramming (CLD)*] (Sterman, 2002 ; Renmans, 2018). Le diagramme des boucles causales est l'un des outils issus de la dynamique des systèmes qualitative, utilisé pour explorer les interactions et les boucles de rétroaction qui sous-tendent la dynamique d'un système et la production de ses résultats spécifiques. Un CLD est constitué de variables (facteurs) et de relations (influences) (Bowen, 1992). Une influence est représentée par une flèche et une polarité : le signe « + » indique que les deux variables A et B évoluent dans la même direction, tandis que le signe « – » indique qu'elles évoluent en sens opposé. Selon la polarité des flèches qui composent une boucle de rétroaction, celle-ci est qualifiée de boucle renforçante ou de boucle d'équilibrage : un nombre nul ou pair de relations négatives le long de la boucle indique une dynamique de renforcement, notée par la lettre « R » ; un nombre impair de relations négatives indique une boucle de stabilisation, notée par la lettre « B ». La direction de la boucle de rétroaction est indiquée par une flèche dans le sens horaire ou antihoraire autour des lettres de polarité (R ou B) (Sterman, 2000). Cette étude a permis de décrire différents cercles vertueux et de cercles vicieux au sein desquels plusieurs variables socio-culturelles, techniques et organisationnelles interagissent, influençant l'efficacité opérationnelle de la vaccination.

Les résultats consignés dans le **chapitre 4** et obtenus grâce à la troisième étude avaient pour but de proposer une approche participative permettant de combler les lacunes révélées par

l'étude 1 et l'étude 2 et d'améliorer l'adéquation des stratégies de lutte. Ainsi des ateliers participatifs ont réunis de mai à juin 2024, différentes parties prenantes du système pour conduire une priorisation multicritère [en anglais *Multi-criteria Decision Analysis (MCDA)*] des interventions définies dans le cadre de la stratégie nationale intégrée d'élimination de la rage humaine transmise par les carnivores domestiques (Marttunen et al., 2015 ; Aenishaenslin et al., 2019). La priorisation multicritère d'aide à la décision (MCDA) est une approche structurée qui permet de comparer et de hiérarchiser plusieurs options (actions, stratégies, interventions, politiques, etc.) en tenant compte de plusieurs critères de décision pouvant être de nature différente (technique, économique, sociale, environnementale, sanitaire). L'objectif de la MCDA est d'aider les acteurs à formuler un choix éclairé, fondé sur une évaluation transparente et participative des préférences et des valeurs des parties prenantes. Elle favorise la transparence et la participation dans la prise de décision, tout en permettant de rendre visibles les compromis entre critères parfois contradictoires. La MCDA peut être particulièrement utile dans les situations multi-acteurs et multisectoriels, comme celle de la lutte contre la rage ou celui de l'engagement multisectoriel One Health, où les décisions impliquent des enjeux sanitaires, économiques et sociaux et des acteurs aux attentes différentes, parfois divergentes. En résumé, c'est une approche participative qui permet aux acteurs de dégager des interventions ou alternatives consensuelles, s'accorder sur des critères pertinents d'évaluation, d'évaluer les performances des interventions consensuelles, en vue de les classer par ordre de priorité ou de préférence (Aenishaenslin et al., 2019).

Le **chapitre 5** rapporte les résultats de l'étude 4 portant sur la contribution d'une plateforme multidisciplinaire de la société civile dans la lutte contre la rage au Burkina Faso. Il s'agit d'une approche interventionnelle réflexive, l'objectif étant d'éclairer la recherche par la pratique dans la réalité du milieu de l'étude (Ford et al., 2004). Elle a consisté à la mise en place de la structure, inspirée des principes de l'approche One Health, en incluant principalement les acteurs de la santé animale, de la santé humaine, de l'environnement, de la faune, de la socio-économie, de l'anthropologie, de la communauté. Les actions portées par l'initiative couvrent l'éducation et le renforcement des capacités des acteurs, l'amélioration de l'accès à la prophylaxie postexposition, les investigations des foyers et la gestion des cas de morsure, la collecte des évidences par la recherche-action. L'étude synthétise les étapes clés de la création ainsi que les principaux domaines d'interventions pertinentes autour desquels la société civile s'avérer une alternative de changement, de traduction concrète des résultats de la recherche en

actions de terrain et de dialogue entre les acteurs institutionnels et communautaires conformément aux principes de l'approche One Health.

Dans l'ensemble, cette thèse contient des informations utiles pouvant être directement intégrées dans les politiques publiques et dans les pratiques des acteurs en vue d'améliorer durablement la gestion de la rage et des autres maladies zoonotiques qui sévissent dans le pays.

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SECTION ETUDES

CHAPITRE 2

Etude 1

Multi-sectoral health system analysis for zoonotic diseases management: An application of Parsons' Social System Action Theory to improve One Health practice for rabies control in Burkina Faso

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Madi Savadogo[a,b,c,d,&], Victor Ndadi Nkuembe[a,e], Rianatou Bada Alambedji[f], Zékiba Tarnagda[b], Nicolas Antoine-Moussiaux[a,g]

a. Fundamental and Applied Research for Animals and Health, Faculty of Veterinary Medicine, University of Liege, Liege, Belgium
b. Laboratoire National de Référence-Grippes, Unité des Maladies à potentiel Epidémique, Maladies Emergentes et Zoonoses, Département de Biologie Médicale et Santé Publique, Institut de Recherche en Sciences de la Santé (IRSS/CNRST), Ouagadougou, Burkina Faso,
c. Direction de la Santé Animale, Direction Générale des Services Vétérinaires, Ministère de l'Agriculture, des Ressources Animales et Halieutiques, Ouagadougou, Burkina Faso,
d. Rabies Free Burkina Faso, Ouagadougou, Burkina Faso,
e. Department of Zootechnics, Faculty of Veterinary Medicine, Universite de Kinshasa, Kinshasa, Democratic Republic of Congo,
f. Service de Microbiologie-Immunologie et Pathologies Infectieuses, Département de Santé Publique et Environnement, Ecole Inter-Etats des Sciences et Médecine Vétérinaires, Dakar, Sénégal,
g. Department of Public Health Sciences, Faculty of Medicine, University of Liege, Liege, Belgium

[&]Corresponding author: Madi SAVADOGO (savadogo.madi@yahoo.fr)

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CHAPITRE 2: MULTI-SECTORAL HEALTH SYSTEM ANALYSIS FOR ZOONOTIC DISEASES MANAGEMENT: AN APPLICATION OF PARSONS' SOCIAL SYSTEM ACTION THEORY TO IMPROVE ONE HEALTH PRACTICE FOR RABIES CONTROL IN BURKINA FASO

2.1. Abstract

Background: Rabies is a deadly infectious disease that affects humans and animals. Human cases are preventable through vaccination and rabies can be eliminated by applying the One Health approach to build integrated, operational and innovative health systems. However, in the context of Burkina Faso, animal and human rabies systems are not properly inter-connected. Despite several initiatives conducted in Burkina Faso for decades by animal health and human health stakeholders (including vaccination of domestic carnivores, post-exposure prophylaxis, awareness raising), the country is still facing human cases of dog-transmitted rabies.

Method: To unravel the factors that hinder the control of rabies and to support locally-tailored strategic planning, this qualitative study applies the framework of Parsons' Social System Action Theory (PSSAT) to assess the functioning of multi-sectoral efforts for rabies prevention and control. The qualitative data obtained from semi-structured interviews were analyzed using a thematic approach. The identified themes were then grouped in light of the functional dimensions of PSSAT, in order to structure the understanding of the system under study.

Results: The stakeholders mapping showed the diversity of entities and actors involved in the rabies control system. In addition, the constraints on the system's capacities were analyzed considering factors related to adaptation, fundamental goal achievement, operational processes for expected services delivery as well as organizational culture. In total, 39 function-related challenges and 22 alignment-related challenges were described.

Conclusion: The framework proved useful in the analysis of this complex multi-sectoral health system, hence constituting a potential tool for the implementation of One Health in different contexts. Indeed, if the identified challenges are comprehensively converted into forward-looking actions, this can enable the development of locally-tailored strategies for effective domestic carnivore-transmitted human rabies control.

Keywords: Rabies control, Health systems, Qualitative analysis, Challenges, Enabling factors, Public health, Systems thinking

2.2. Introduction

During the last few decades, the World has been confronted with the emergence and re-emergence of zoonoses, with the flagship examples of Ebola virus disease or COVID-19. At the same time, many endemic diseases affecting daily both animal and human health as well as community livelihoods are often ignored or not much considered in public health initiatives. Moreover, it is estimated that over 75% of pathogens responsible of human infectious diseases (either endemic or with epidemic potential) are zoonotic [1]. As with many African countries, Burkina Faso does not escape this endemic infectious burden that affects both animals and humans. Therefore, it is important to establish collaborative animal and human health systems, able to effectively manage zoonoses, and then being best prepared to jointly and promptly address any epidemic emergency. From this perspective, in accordance with the global health security requirements, national health security stakeholders established a list of the top five priority zoonoses. Namely, anthrax, dengue, highly pathogenic avian influenza, brucellosis and rabies were prioritized by a national One Health stakeholders' group, composed of members from the Ministry of Livestock, the Ministry of Health, the Ministry of Environment and partnering entities [2]. Subsequently, the country has created a National One Health Coordination Platform (which includes mainly the Ministry of Health, the Ministry of Agriculture and Livestock, the Ministry of Environment and Wildlife, the Ministry of Research and Higher Education) aiming to operationalize a multi-sectoral coordination towards the control of priority zoonoses and other public health threats.

Rabies is an infectious disease that affects humans as well as domestic and wild animals. It is an endemic health threat in Burkina Faso [3,4,5]. Indeed, several animal and human cases are annually recorded in Burkina Faso. According to previous studies, an average of 11500 bite cases and 40 human deaths are reported annually, while post-exposure prophylaxis completion among bitten people remains challenging [5,6]. Indeed, only two centers (located in the two main cities of the country, Ouagadougou and Bobo Dioulasso) are able to provide post-exposure prophylaxis. In addition, the national rabies surveillance system lacks sensitivity and responsiveness in both animal and human health. The two surveillance systems remain un-connected, thus not enabling the integrated management of rabies. Therefore, although rabies has been a notifiable disease in Burkina Faso for decades, it remains highly under-reported [7,8]. The only laboratory with rabies diagnostic capacities belongs to the animal health sector and is located in Ouagadougou. In addition, significant rabies control measures such as dog vaccination, human pre- and post-exposure prophylaxis, public awareness raising, responsible dog ownership are still not or incompletely implemented. For example, dog vaccination remains

very low (ranging from 8% in rural areas to 36% in urban area), while post-exposure prophylaxis delivery is characterized by a frequent shortage of inputs and lack of knowledge among health workers [8,9,10]. Due to the epidemiological features of the disease, the adoption and the implementation of measures to control rabies require the participation of different sectors, professionals and administrations, which is encouraged under the aegis of the One Health concept [11]. Indeed, rabies epidemiology is tied to the multiple interactions between domestic animals, wild animals, humans and their shared environment. Therefore, beyond biological knowledge and tools (including effective vaccine known since 1885), rabies control requires integrative approaches, considering the social-cultural, institutional, environmental and ecological determinants that can influence the dynamics of the virus transmission and propagation (Figure 1). By prioritizing rabies and creating a One Health platform, the health security authorities have shown in these recent years an increasing political will to operationalize integrated approaches for effective prevention, surveillance and response to zoonoses [2,11]. Therefore, rabies provides a valuable case study to experiment and explore the functioning and outcomes of such a multi-sectoral health system in the context of the persistence and emergence of zoonoses, as well as of other public health threats at the animal-human-environment interface.

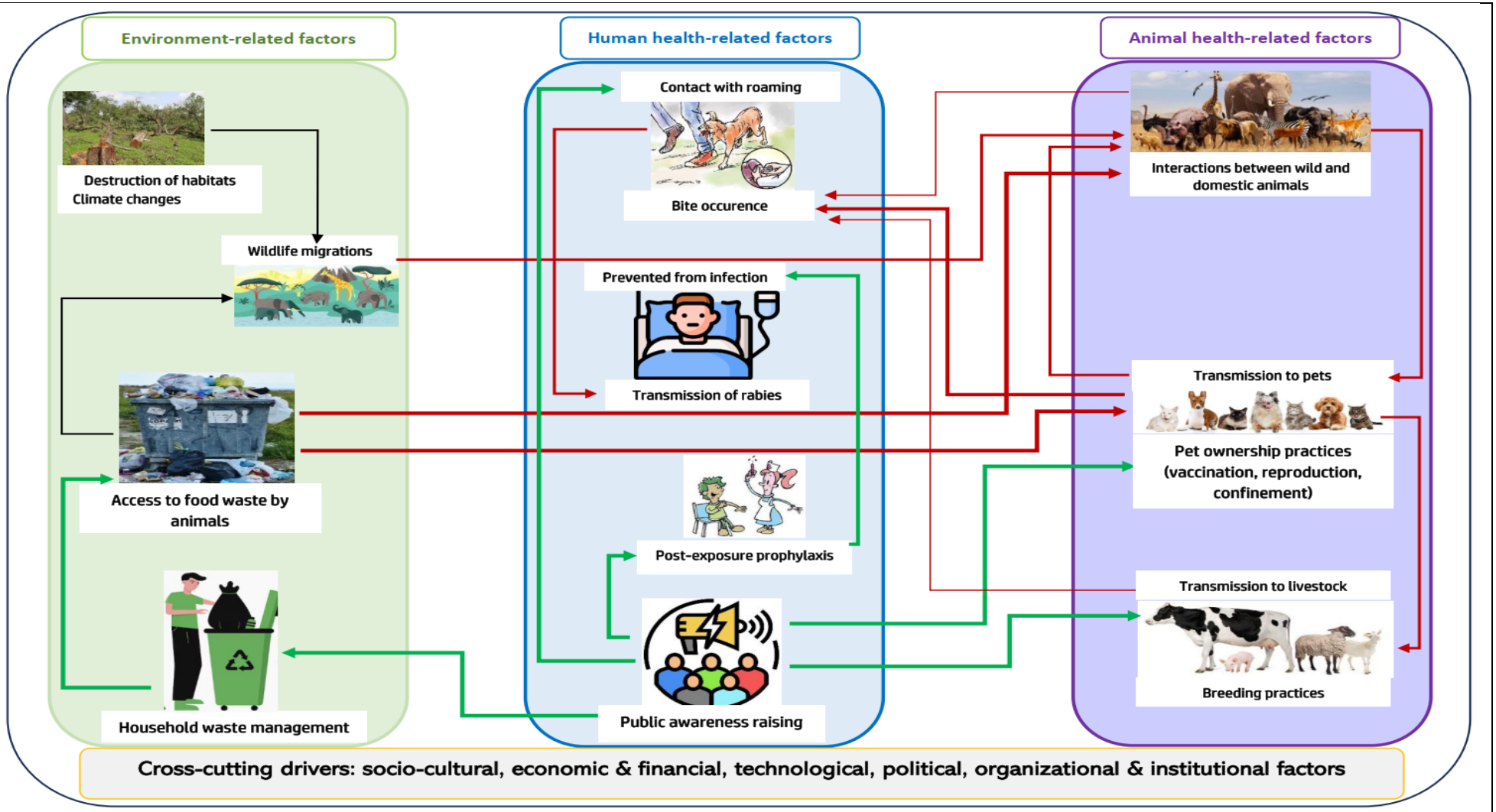

Figure 1: Conceptual framework describing the complex interactions that influence rabies control and prevention (*red arrows represent transmission paths and green arrows represent control paths*)

Finally, understanding how rabies control performs and identifying effectiveness gaps would guide the relevant decisions to improve resilience, preparedness and response capacities towards the global objective of rabies elimination by 2030. As described by previous studies, such a zoonotic disease management entails the need to act on complex systems, characterized by a multiplicity of stakeholders, diversity of their goals, beliefs and values, this involvement, as well as the incompleteness of knowledge [12]. Indeed, as highlighted and developed by Rüegg et al. [13], the assessment of such a multi-sectoral system for rabies management requires a systemic approach.

The Parsons' Social System Action Theory (PSSAT) represents such a systemic analysis framework. It was developed to provide a comprehensive overview of how complex organizations function [14]. According to Parsons' perspective, beyond techniques and tools used, every form of organization (social, economic, industrial, health) may be modelled as a dynamic interplay between four fundamental functions: i) the adaptation to the environment in which it operates, ii) the achievement of fundamental goals, iii) the aggregation of internal processes to deliver expected outcomes, and iv) the maintenance of internal enabling conditions based on shared values and norms (Figure 2, description of dimensions provided in Table 1). The reciprocal interconnections among the four functions define six dynamic links whose modification affects the overall system performance. These links are termed as "alignments" and include the strategic alignment, the allocation alignment, the tactical alignment, the operational alignment, the legitimization alignment and the contextual alignment (Figure 2). These alignments ensure the required internal regulations between functions, expressing the assets of the Parsons' integrative concept and making it operational for systems thinking. Previously, the PSSAT was applied in high-income countries in the industry sector to assess drivers of collective action and organization effectiveness. Later, it was introduced into health environment to better understand the dynamics in and around healthcare systems [14,15]. Even without quantitative information, the PSSAT provides opportunity of qualitative assessment, based on opinion elicitation of experts or stakeholders involved in the assessed initiative. As such, it may be useful for the analysis of multi-sectoral health interventions, especially in a resource-limited context, for which data are lacking and the functioning as well as issues at stake are inadequately defined and evolving continuously. Furthermore, the PSSAT constitutes a cross-section of previous segmented methods developed, including the rational goal model [16], the human relations model [17], the open system model [18,19], and the internal process model [20]. As a conceptual framework, the PSSAT would allow to analyze the rabies control

system in a systemic way, taking into account its complexity, interactions with the environment and the tensions or balances established between its four functional components.

Having in mind the aforementioned complexity of zoonotic diseases control, we performed a qualitative case study of the multi-sectoral system in charge of rabies prevention and control in Burkina Faso. To this goal, the paper applies the framework of PSSAT to assess hindrances to optimal rabies intervention in Burkina Faso. To the best of our knowledge, this is the first time that this conceptual framework is applied to explore improvement pathways for zoonoses control in a One Health perspective.

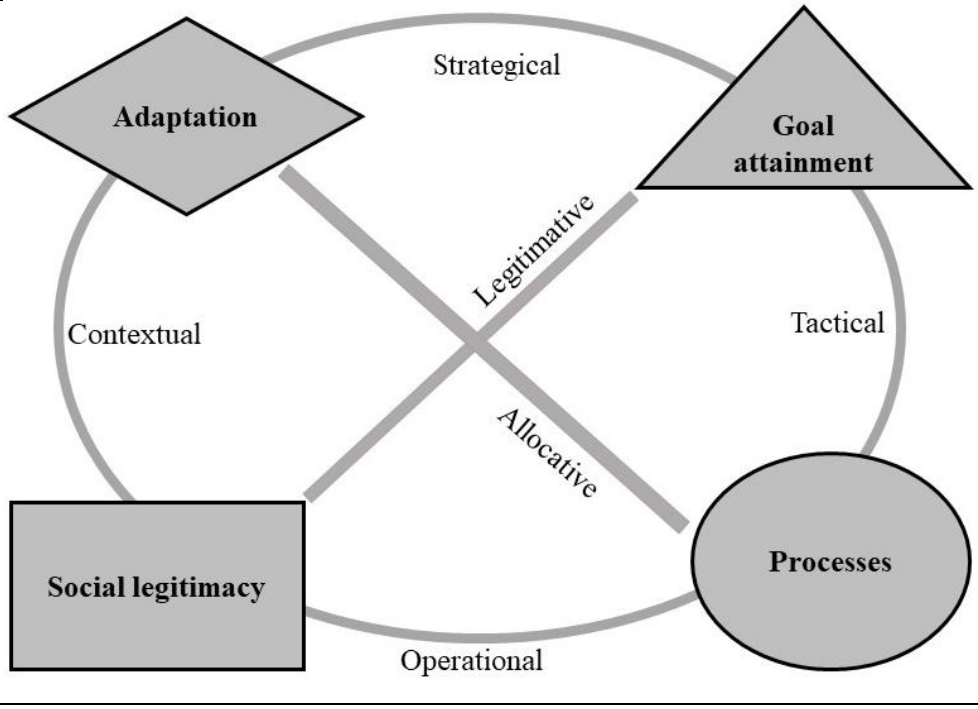

Figure 2: Schematic representation of the Parsons' Social System Action Theory developed for organization performance analysis [14]

2.3. Material and methods

2.3.1. Overall multi-staged methodology

The study was performed from February 2019 to March 2021. The overall approach of the study was composed of five steps which are described below and represented in Figure 3: problem structuring, stakeholder mapping, stakeholder interviews, system analysis and challenges identification.

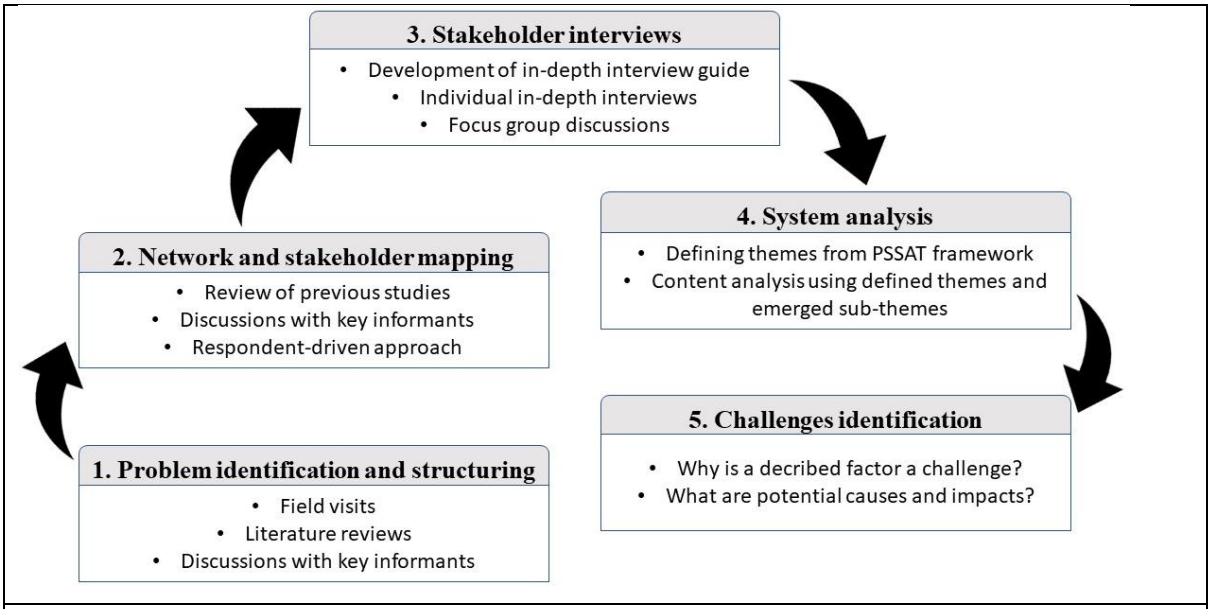

Figure 3: Stepwise methodology used for the assessment of the multisectoral rabies control system; *PSSAT: Parsons' Social System Action Theory*

2.3.2. Problem structuring

This phase assessed the overall situation of rabies control in Burkina Faso through document review (peer-reviewed literature, technical reports, policy documents) and key-informant interviews (composed of four national experts and two international experts). Relevant preliminary data were gathered about rabies status in the country and actors involved. Collected data included confirmed rabies cases in dogs, humans and other animals, post-exposure prophylaxis provision, dog vaccination, government and non-government structures involved, their responsibilities or expected roles as foreseen in legislation and other regulatory texts.

2.3.3. Stakeholder mapping

Based on previous studies and discussions with the key informants, the National Veterinary Office, the National Livestock Laboratory, the Rabies Treatment Centre of Ouagadougou, the referral hospital center, the Public Health Protection Office and private veterinary clinics were visited (July to August 2019). During the first visit, a primary list of stakeholders was developed that included public and private entities playing direct or indirect roles in the rabies control system. This includes the Ministry of Health, the Ministry of Livestock, the Ministry of Environment and Wildlife, the Ministry of Territorial Administration, the Ministry of Research and Higher Education, as well as private stakeholders and community members. Thus, these initial stakeholders (heads of visited entities) were interviewed regarding the roles of their entities as well as the interactions and relationships they have with other stakeholders

as part of rabies control activities. These interviews contributed in completing the list of stakeholders.

2.3.4. Semi-structured interviews with stakeholders

For the first steps, a national expert with deep understanding of the issue of human dog-mediated rabies assisted to prioritize stakeholders from the list according to their perceived centrality in the issue (established in Step 2). Subsequently, a respondent-driven sampling allowed the participants to suggest other individuals or entities that could be included in the study [21]. Therefore, the sampling method allowed for the integration of under-represented and non-familiar or unexpected stakeholders. Finally, 82 stakeholders were engaged through face-to-face individual and group semi-structured interviews (Tableau 1).

A semi-structured interview guide was developed, based on international standards and policy in the matter of rabies control. This includes mainly the global human dog-mediated rabies elimination strategy and the stepwise approach towards rabies elimination roadmap, which were developed jointly by World Health Organization, World Organization for Animal Health, Food and Agriculture Organization, and Global Alliance for Rabies Control, aiming at rabies elimination at national, regional and global levels by 2030 [22,23]. Hence, the interview guide was composed of the seven rabies control components [24]: dog population management, rabies data collection and analysis, rabies prevention and control (this includes dog vaccination, human pre-exposure and post-exposure prophylaxis), laboratory diagnosis capacity, rabies-related legislation, public awareness (meaning information, education and communication), and finally cross-cutting issues (with a focus on the need for transdisciplinary approaches).

Invited participants were provided with the study background and objectives. In addition, an invitation reminder was sent monthly to participants, and in case of non-response or refusal to participate, a replacement was chosen from the stakeholders' list. Those who agreed to participate were met in a convenient location that could ensure confidentiality (e.g. interviewee office, place of residence). With agreement of the participants, all interviews were audio-recorded and completed by field observations. All obtained information were transcribed in Microsoft Word files. A particular attention was paid to ensure the validity of collected data. Interviewees' narratives were crosschecked using local experts' comments, field observations during interviews, and available documented data. Finally, narratives provided by stakeholders who were separately interviewed were crosschecked.

Table 1: List of stakeholders interviewed during the study

Sectors	Categories	Sub-categories	Rationals for inclusion	Number of interviewed stakeholders
Animal health entities	Public animal health and livestock workers (veterinarians)	Heads of institutions	Responsible for animal national animal health policy development and implementation	03
		Veterinary epidemiologists and animal health specialists	Coordinating rabies surveillance and dog vaccination	07
		Laboratory specialists	Responsible for animal rabies diagnostic in the reference laboratory	03
	Public animal health and livestock workers (veterinary para-professionals)	Heads of regional veterinary laboratories	Responsible for animal sampling, sample shipment to the reference laboratory	03
		Laboratory officers	Responsible for animal sampling, sample shipment to the reference laboratory	02
		Livestock and animal health officers	Involved in rabies activities (dog vaccination, sampling, data collection, biting dog observation)	11
	Private animal health and livestock workers (veterinarians)	Veterinary clinicians and pharmacists	Involved in vaccine distribution, dog vaccination, biting dog observation and data collection	03
		Veterinary drug suppliers	Vaccines and supplies importation	01
	Private animal health and livestock workers (veterinary para-professionals)	Animal health caregivers	Dog vaccination, biting dog observation and data collection	04
Human health entities	Public human health workers	Heads of institutions	Responsible for animal human health policy	02

	(medical doctors)		development and implementation	
		Healthcare personnel	In charge of care to rabid (and suspected) patients	03
		Epidemiologists and public health specialists	Involved in rabies surveillance	03
		Medical professionals	Involved in rabies pre- and pre-exposure prophylaxis provision	01
	Public human health workers (medical para-professionals)	Nurses	Involved in rabies pre- and pre-exposure prophylaxis provision	05
		Medical biologists	Responsible for human sampling, sample shipment to the reference laboratory	02
	Private human health workers	Pharmacists	Supplying of rabies vaccines	03
	Private human health workers (medical para-professionals)	Nurses	Providing medical care and advice to bitten patients	02
Environment and Wildlife management entities	Wildlife officers	Heads of institutions	Responsible for wildlife management policy development and implementation	01
	Wildlife officers	Wildlife officers	Event monitoring in wildlife	03
	Environment officers	Environment officers	Environmental protection, sanitation and waste management	02
Communities	Bite victims	Bite victims	Affected by the quality of PEP provision	03
	Dog owners	Dog owners	Decision for owned-dog vaccination	5
	Traditonal care givers	Traditonal care givers	Providing traditional medicines to bitten patients	01
Territorial administration entities (Rabies Treatment centers)	Public Hygiene officers	Public Hygiene officers	Advancing public hygiene, sanitation and household waste management	04

Education and research entities	Research scientists	Research scientists	Generating evidence on rabies epidemiology and control measures	02
	Lecturers	Animal health and livestocks lecturers	Teaching animal disease and zoonosis control	02
	Lecturers	Human health and nurse science lecturers	Teaching public health pre-service professionals	01
Total				**82**

2.3.5. System analysis and challenges identification

All transcripts were first crosschecked with the audio-recordings and observation notes to ensure their accuracy and completeness. Then, considering the description of the PSSAT used, a thematic analysis was performed to identify corresponding themes emerging from the participant narratives. As developed by Halcomb and Davidson [25], a qualitative reflexive and iterative approach was used by the research team to analyze the content of narratives. Qualitative content analysis is well-known and widely used in qualitative studies to describe patterns of meanings among different interview reports [26,27]. According to our structured approach, applying here a pre-defined analytical framework, the transcribed narratives were coded following dimensions, i.e. functions and their alignments composing the PSSAT (Table 2). Within each dimension, findings were structured in pre-defined themes. To achieve this, the framework (functions and their alignments) was displayed on a table and each challenge was reported on an adhesive notepaper. Thus, the classification of the challenges according to the different dimensions of the framework was conducted by co-researchers. The content of each adhesive notepaper was read and the researchers agreed on a common dimension to which it had to be ascribed. In case of disagreement, the case was discussed until consensus was obtained. Finally, relevant quotations were selected to illustrate and deepen findings.

Table 2: Operational description of dimensions used for data analysis [14,15]

Dimensions used	**Description**
1. Four functions of the assessed organization	
Adaptation	Ability to acquire the resources needed to maintain and develop core activities, and to adapt to changes in the external environment

Goal attainment	Ability to achieve the fundamental objectives assigned to the organization. In public health perspective, these may include improving the health of targeted population, effectiveness, equity, and the satisfaction of various stakeholder groups (*should be understood as outcomes or impact*).
Service production	Ability to implement internal processes for effective service production and delivery (*should be understood as outputs*)
Culture and values	Ability to generate and maintain cohesion among stakeholders, by fostering consensus as a fundamental value of organizational culture
2. Six dynamic alignments between functions	
Strategic alignment	Compatibility between resources and objectives assigned, and relevance of objectives with regard to available or mobilizable resources
Resource allocation alignment	Appropriateness of resource allocation in the face of service production imperatives, and compatibility between needs for service delivery and available resources
Tactical alignment	Ability of control mechanisms to regulate the service delivery procedures, as well as relevance of goals versus production requirements
Operational alignment	Ability of internal cohesion factors to mobilize the service production processes, and impact of service production requirements on cohesion factors
Legitimative alignment	Contribution of internal cohesion factors to goal attainment, and impact of choice of goals on organizational culture
Contextual alignment	Capacity of internal cohesion factors to mobilize the adaptation mechanisms, and influence of adaptation needs on the cohesion and consensus factors within the organization

2.3.6. Ethical considerations

Ethical approval was obtained from the Research Ethical Committee of Université Cheikh Anta Diop (Protocole-0322/2018/CER/UCAD). In addition, prior to each interview, participants were informed about the background and purpose of the study, highlighting that their participation was voluntary, and information would be kept anonymous. Therefore, only participants who verbally agreed were interviewed.

2.4. Results

2.4.1. Mapping of stakeholders

The stakeholders involved in national rabies control effort were mapped to provide an overview of the disease management in the country (Figure 4), categorizing them into directly and indirectly involved entities.

The direct stakeholders were working in three key technical sectors, i.e. animal health, human health, and environment and wildlife. In the human health sector, stakeholders were reported as being responsible for the provision of pre-exposure prophylaxis, post-exposure prophylaxis (in cooperation with Rabies Vaccination Centers managed by the territorial administration sector), and human rabies diagnosis and surveillance. Regarding the animal health stakeholders, their reported roles included dog mass vaccination, biting dog observation, dog population management, animal rabies diagnosis and surveillance. According to the interviewees, wildlife and environment stakeholders' roles include rabies surveillance in wild animals, sanitation of housing areas, and monitoring of contacts occurrence between wildlife and humans or domestic animals.

The indirect stakeholders provided supporting efforts that enhance roles of the first category of stakeholders. Indeed, government departments in charge of territorial administration, finance, research and education were considered as providing, respectively, regulations, budget, evidence, and awareness and capacity building. Some entities were described by participants as "partner organizations": civil society associations (Rabies Free Burkina Faso, Association Stop la Rage, One Health Burkina Faso and Centrale Canine du Burkina Faso), non-government organizations and international institutions (Food and Agriculture Organization of United Nations, World Organization for Animal Health, World Health Organization, West African Health Organization, Regional Animal Health Center). Such entities roles included advocacy and mobilization of human, financial and knowledge resources to support the efforts of national key stakeholders. In addition, media communication and information were indicated

as important for the success of any rabies control strategy. Finally, community stakeholders' roles included responsible dog keeping (vaccination, confinement in households), medical care seeking for bitten individuals, household waste collection.

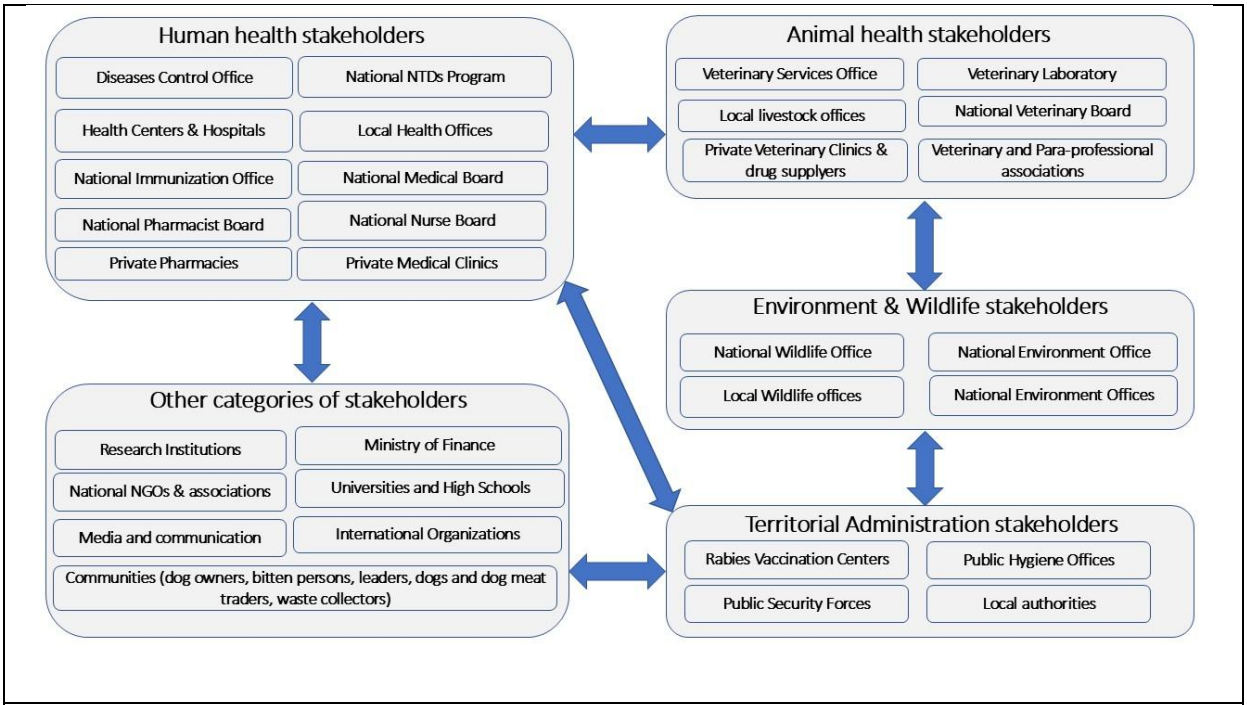

Figure 4: Overall mapping of the stakeholders involved in rabies control in Burkina Faso

2.4.2. Assessment of challenges to rabies control identified

Themes identified through content analysis covered issues related to strategic planning, workforce adequacy, collaboration between entities and stakeholders, governance, animal health and human health services delivery as well as logistics provision. In what follows, findings are described based on the four functions and their six dynamic interactions according to the PSSAT.

2.4.2.1. Challenges described at the function levels

In total, the results showed 11 themes related to the PSSAT and covering 39 challenges reported by the participants, as follows:

Adaptation. Six challenges were reported and classified into three themes (Table 3): the availability of resources (workforce, budget, equipment), innovation (continuous adaptation to the context), and the mobilization of stakeholders (wider societal resources). Interviewed veterinarians and public health specialists discussed the budget mobilization issues as important barriers to rabies control. Participants reported the fact that rabies was not properly

included in government annual budget plans. They added that this situation worsened with the context of occurrence of epidemics such as highly pathogenic avian influenza, dengue and COVID-19. According to interviewed stakeholders, finance difficulties were also associated to inadequate support from NGOs and international institutions with respect to a lack of well-integrated planning of rabies control in the country. In the area of innovation and learning, the participants mentioned that, despite the large use of mobile communication technologies in the country, those remain very little used to improve rabies data collection, dissemination of awareness messages, and service delivery to various users. Findings also revealed inadequate capacities for data collection and monitoring, resulting in a lack of evidence for decision making. Regarding the mobilization of stakeholders involved in rabies interventions, interviewed actors from both animal and human health sectors pinpointed the absence of a formal consultation partnership platform as a barrier to collaboration, notably in data and information sharing between private and public entities.

Table 3: Summary of challenges that affect the capacity of the rabies multi-sectoral control system to adapt with regard to the environment

Themes defined in PSSAT	**Challenges identified**	**Supporting quotes**
Availability of resources	Low budget allocation by the government as for rabies control	Q1: *«Rabies is a neglected disease. The truth is that the authorities are only interested in and engaged for controlling a disease, when partners provide funding»* (veterinarian, public veterinary office)
	Inadequate funding of local rabies activities by NGOs and international public health agencies	
Innovation	Low use of mobile technologies for rabies surveillance and education	Q2: *«We would have used the opportunity given by mobile technologies and social media to develop a better communication between veterinarians, doctors, nurses, the laboratory and exposed persons »* Human health
	No initiative towards dog population size estimation	
	Lack of animal and human rabies case definition for sensitive surveillance	

		worker, Rabies Treatment Center) Q3: « *We need to know the size of the dog population* » (Animal health worker, Ouagadougou)
Mobilization of stakeholders	Lack of consultation platform between private and public stakeholders in the AH sector	Q4: *« We have no other channel of communication with the private veterinary clinicians* » (animal health officer, public veterinary office)

Goal attainment. Five challenges were reported and classified into two themes (Table 4): effectiveness and health equity, and capacity of the system to meet user expectations. Regarding the low post-exposure prophylaxis coverage for bitten people and the persisting low vaccination coverage in dogs, almost all participants recognized that implemented rabies control initiatives had remained ineffective. Discussing the equity considerations in rabies prevention services, participants indicated that while infection risk was higher in rural and vulnerable communities, most of interventions (post-exposure prophylaxis, dog vaccination as well as awareness efforts) were always located in urban areas. In addition, considering the reported low data collection capacities (e.g. lack of procedures and tools for the follow-up of bite cases and post-exposure prophylaxis), decreasing the availability of evidence-based data, participants believed that it was difficult to monitor interventions and assess stakeholder needs.

Table 4: Summary of challenges that affect the capacity of the rabies multi-sectoral control system to achieve assigned objectives

Themes defined in PSSAT	**Challenges identified**	**Supporting quotes**
Effectiveness and equity	Rabies treatment centers located in urban areas while rabies affects mostly rural and vulnerable communities	Q5: « *To enhance services accessibility, it is necessary to take into account the financial capacities of the populations* » (Human health worker, Ouagadougou)

	Expensive cost of dog vaccination charged to owners out of short campaign periods	Q6: *« Dog vaccination and postexposure must be truly available and accessible to the entire population »* (Public health specialist, Ouagadougou)
	Expensive cost of post-exposure prophylaxis (PEP) charged to patients	Q7: *« The health worker must be able to follow up the bitten person, contact the rabies treatment center to obtain the rabies vaccine, and take care of the patient on site. Unfortunately, this is not currently the practice. »* (Public health specialist, Rabies treatment center, Bobo Dioulasso)
	Significant part of bitten people not receiving adequate PEP	
Satisfaction of users	No procedure developed for the follow-up of bite cases and PEP provision	

Service production. Twelve challenges were reported and classified into three themes (Table 5): the capacity of the system to deliver services, the continuity and accessibility of services, and the harmonization and coordination of procedures. Indeed, the participants pointed to the lack of infrastructures and equipment (for biting dog observation, vaccine storage, roaming dog capture). In addition, the legal procedures in place have not been effective in tackling the fraudulent interventions (e.g. dog vaccination, biting dog observation). The interviews also revealed that the system's limitations are linked to the unavailability of rabies immunoglobulins for adequate PEP prophylaxis. Regarding the quality of services, several challenges including the lack of an appropriate mechanism for shipping laboratory samples, the cold chain shortages in rural areas, the inaccessibility of rabies diagnostics and post-exposure prophylaxis in most areas of the country. Animal health workers explained that the recurrent issues along the cooling chain in their sector may comprise spoiling of stored vaccines. In terms of samples management, stakeholders complained about the fact that laboratory samples were shipped through public transports, which includes several disadvantages (risks of damage and contamination of persons). Explaining the inadequacy of services, participants stated that dog vaccination coverage remained poor across the country, dog population size has never been estimated, and most bitten people registered in health facilities were not receiving adequate post-exposure prophylaxis. Discussing the importance of coordination and collaboration

between sectors, participants mentioned that their sectors lacked policies and standard operational procedures for integrated surveillance and control (e.g. post-exposure prophylaxis, dog vaccination, Integrated Bite Case Management, biting dog observation, case definition).

Table 5: Summary of challenges that affect the capacity of the rabies multi-sectoral control internal processes to produce services and address assigned objectives

Themes defined in PSSAT	**Challenges identified**	**Supporting quotes**
Service delivery capacities	Lack of adequate infrastructure for biting dog observation	Q8: *«The municipality has a department [municipal police] in charge of capturing roaming animals in the city. However, there is no equipment for of biting dog observation»* (officer, municipal agency) Q9: *« The supply capacities of our grocers are very low »* (Animal health worker, Ouagadougou) Q10: *« The absence of technical services in the field encourages the development of fraudulent vaccine networks* » (Private animal health worker, Ouagadougou)
	Unavailability of distinguishing marks for vaccinated dogs (e.g. collars)	
	Frequent vaccine shortages and unavailability of rabies immunoglobulins for adequate PEP provision	
	Low capacity to detect and monitor fraudulent interventions (e.g. dog vaccination, biting dog observation)	
	Inadequate availability of cooling equipment for vaccines storage in animal health facilities	
Quality of service (continuity and accessibility)	Shipping of laboratory samples using the public inter-city transports (inadequate storage, risk of contamination)	Q11: *« They transported the sample by passenger buses without any respect for the conditions of packaging and handling of infectious biological samples »* (Animal health worker, Laboratory, Ouagadougou)
	Low capacity for biological products storage in rural and	

	local services (human vaccines, animal vaccines)	Q12: « *I believe that the way dogs are vaccinated is not effective due to poor storage of vaccine along the supply chain »* (Private veterinarian, Bobo Dioulasso) Q13: *« We have checked coolers used in some veterinary clinics to store vaccines and they were at 19°C »* (Animal health worker, Koudougou) Q14: *« I am not aware of any dog vaccination or bite management procedures »* (Public health worker, Rabies treatment center, Ouagadougou)
	Low number of PEP centers (only two for population of over 22 million inhabitants) and rabies diagnostic laboratory (only one) in the country	
	Lack of mass dog vaccination campaigns covering ≥70% of dog population	
Harmonization of procedures	Lack of standard operational procedures for rabies surveillance and control (e.g. PEP, dog vaccination, IBCM, biting dog observation, case definitions)	
	Lack of well-coordinated and harmonized interventions across sector and disciplines (e.g. IBCM)	
	Lack of standard operational procedures for secured PEP delivery	

Culture and values. Sixteen challenges were reported and classified into three themes (Table 6): issues that hinder the collaboration and values sharing between stakeholders, the establishment of consensus for common values, and the compliance and motivation of workforce regarding national rabies control efforts. Participants explained that a lack of One Health leadership impedes the development of strong synergies between entities, disciplines, and individual actors. Lack of workforce compliance was raised by stakeholders as a factor that decreases cohesion within rabies multisectoral system. This was commonly due to the absence of incentives for the personnel engaged in field interventions (financial reward,

individual protection equipment, pre-exposure vaccination). Some participants reported that the One Health collaboration was threatened by low task-sharing and networking competencies. They explained that the poor governance and legislation resulted in a lack of coordinated and harmonized interventions across sectors, which was enhanced by a sectoral financing approach practiced by international partners. Finally, discussions highlighted that integrating local socio-cultural norms is key in enabling the collaboration with community members, improving their compliance to rabies prevention and control interventions. Indeed, some dog owners were aware about the usefulness of dog vaccination. However, the reported weak affectionate relationship between owners and their pets, combined with the absence of significant economic objectives in owning these animals, results in poor health care. Concerning the place of workforce motivation (perceived quality of life at work and satisfaction of workforce), lack of incentives and appropriate materials for secured containment of roaming dogs during vaccination, as well as lack of continued trainings were reported.

Table 6: Summary of challenges that affect the capacity of the rabies multi-sectoral control system to generate and maintain internal enabling conditions

Themes defined in PSSAT	**Challenges identified**	**Supporting quotes**
Collaboration between stakeholders and values sharing	Lack of integration of waste and public hygiene issues in rabies control	Q15: *«Rabies has always served as a model for collaboration between animal health and human health workers, but increased involvement of the environment and wildlife sector is needed to achieve One Health»* (public health specialist, human health office) Q16*: « Nurses received training course on rabies in health schools. However, the content is limited and there is no capacity strengthening for human*
	No rabies course integrated into curricula for the training of pre-service in wildlife sector	
	Inadequate knowledge of rabies in human health sector	
	Low knowledge about the risk rabies infection in the community	

	Perceived low valuation of animal health professional in health promotion	*health workers practicing on the field »* (nurse, rabies vaccination center) Q17: *« There are many actors, but we need them to come together to think about intersectoral coordination »* (Animal health worker, Ouagadougou) Q18: « *My product is made to treat dog bites and certain venomous insects* », (Traditional care givers, Ouagadougou) Q19: « *Because of the cost and lack of awareness of post-exposure prophylaxis, some take traditional treatments* », (Human health worker, Bobo Dioulasso) Q20: *« I visited a pharmacy in Dédougou, I saw traditional products labelled "anti-rabies"* », (Animal health worker, Bobo Dioulasso)
	Low integration of rabies issue by civil society associations in their intervention domains	
	Lack of One Health leadership for the establishment of strong synergy between relevant sectors and disciplines	
	Persisting use of traditional medicines for the prevention of animal and human rabies	
Consensus with core values and culture	Attitude of indifference towards rabies at some levels	Q21: « *The truth is that rabies is not a priority public health problem for the authorities* » (Human health worker, Bobo Dioulasso) Q22: *« Collaboration is especially difficult with biting dog owners during the observation process »* (Private animal health worker, Ouagadougou) Q23: «*The main challenge that remains is the lack of awareness about rabies infection in the communities*» (Nurse, Rabies vaccination center) Q24: *«There is inadequacy because multisectoral initiatives only bring together directors, and most of time*
	Presence of hesitancy in community to vaccinate owned-dogs or to receive PEP after dog bite	
	Lack of knowledge of legislation about dog ownership	
	Poor communication and public education on rabies (no education/advocacy plan)	
	Inadequate political will for an integrated control program	

		there is no feedback to technical officers » (Human health worker, Ouagadougou)
Quality of life at work and satisfaction of workers	Lack of incentives for the personnel engaged in short vaccination campaigns	Q25: « *Work conditions are not adequate during vaccination campaigns, no individual protection equipment, which exposes the agents to dog bites* » (Animal health worker, Bobo Dioulasso)
	Lack of equipment for the capture of free-roaming owned dogs during short vaccination campaigns	Q26: « *Work conditions are not adequate during vaccination campaigns, no individual protection equipment, which exposes the agents to dog bites »* (Animal health worker, Bobo Dioulasso)
	Lack of continued training on rabies for workforce involved in human, animal and wildlife health sectors	Q27: «*I believe that the way dogs are vaccinated is not effective due to lack of good practices by vaccinators»* (veterinarian, public veterinary office)

2.4.2.2. Challenges related to alignments between the system functions

In this section, 22 challenges were reported and categorized into eight themes related to the framework, as presented in Table 7.

Concerning the strategic alignment (between the adaptation and the goal attainment functions), the first weakness that emerged from the finding was the lack of integrated strategic planning of rabies control in the country. In addition, the country lacked capacities to design interventions appropriately informed by evidence. According to participants, the lack of national strategic plan was a major barrier to both adequate resource mobilization and to improving disease control indicators.

The allocative alignment (between the adaptation and service production functions) included challenges about the adequacy of financial, supplies and workforce allocation, participants raising the low involvement of professionals from the wildlife and environment sector in

national rabies control initiatives. In addition, they deplored the lack of prioritization of professionals for pre-exposure rabies vaccination, despite their higher risk of infection. It also emerged from interviews that resource allocation was strongly influenced by crisis communication that may be built around a health threat, resulting in prioritization of resources to tackle more epidemic outbreaks.

The tactical alignment (between the goal attainment and service production functions) was characterized by a large number of observations that suggest a critical inadequacy between rabies control processes in place and goals to be achieved. Indeed, tactical-related challenges included geographical inaccessibility of remote areas during rainy season, low financial and technical capacities of dog-owners to seek rabies vaccination, use of expensive postexposure prophylaxis protocols, chronic vaccine shortages in animal health and human health sectors, as well as inadequate availability of animal health workforce.

Operational alignment issues (between the service production function and the function related to organizational culture and values) were related to society's perception of the human-domestic animal relationship, inadequate involvement of private stakeholders and communities in decision-making processes. Indeed, participants raised local perceptions (negative perception of affectionate relationships with dogs, lack of dog welfare and care habits in most owning communities) that impede dog vaccination, top-down approaches used for decision-making, and obstacles to rabies data sharing between private and public stakeholders involved in the disease control.

When it comes to the legitimative alignment (between goal attainment and values functions), a lack of congruence as well as of capacities for integrating of social norms emerged from interviews. Participants raised the fact that dog meat consumption was still not included in veterinary food safety policies. Therefore, in the absence of veterinary inspection, handling, trading and consumption dog meat may expose communities to rabies infection. Overall, participants considered that ineffective rabies legislation, a poor implementation of regulations in place, as well as low public awareness of rabies and responsible dog ownership hinders the adoption of effective control measures. In addition, it was reported an inadequate capacity of reshaping shared values with regard to rabies elimination goal, resulting from the fact that rabies remains not considered as relevant topic in the sector of research.

With regard to the contextual alignment (between the adaptation and values functions), only one challenge emerged from the discussions. According to interviewees, the sectoral

approaches used by international partners in supporting rabies interventions is related to a lack of cohesion and effective coordination between stakeholders and sectors involved in the multi-sectoral rabies control system.

Table 7: Summary of challenges related to the dynamic interactions between the four functions of the rabies multi-sectoral control system

Themes defined in PSSAT	**Challenges identified**	**Supporting quotes**
Strategic alignment		
Adequacy between system adaption needs and choice of objectives towards rabies elimination	Lack of national and integrated strategy Lack of integrated human and animal rabies surveillance for evidence-based decision making	Q28: ''*We [in Burkina Faso] have the required institutional environment for rabies elimination by 2030, provided that a national program that engages all relevant entities be developed.*'' (Animal health officer, Ouagadougou) Q29: « *There is no rabies surveillance program that brings together public health and livestock sectors* » (Human health worker, Ouagadougou)
Allocative alignment		
Appropriate allocation of resources (financial, workforce) with regard to multisectoral nature of processes	Low involvement of wildlife and environment professionals in rabies control efforts Lack of provision of pre-exposition prophylaxis to professional at risk of rabies infection (both in animal and human health sectors)	Q30: *« Since the outbreak of the security crisis and the coronavirus disease (COVID-19) in the country, no political leader listens when we talk about other diseases like rabies »* (director, public veterinary office)
Congruence between expected services	Prioritization of resources for response to epidemic	Q31: *« I have the feeling that the government is not doing enough to*

and needs of stakeholders	outbreaks (COVID-19, HPAI, Meningitis)	*combat this deadly zoonosis »* (Animal health specialist, Ouagadougou)
Tactical alignment		
Adequacy between internal processes and choice of objectives	Poor practicability of rural roads in the rainy season	Q32: *« In rural areas, vaccine may be available, but if the office is not provided with adequate mean of transportation, vaccination cannot be delivered to villagers »* (Animal health worker, Koudougou)
	Lack of adequate means for owners to transport dogs to vaccination sites	
	Low financial capacities of community to pay for rabies-related services (e.g. PEP, dog vaccination, biting dog observation)	
	Use of expensive PEP protocols (e.g. Zagreb, Essen)	
	Chronic PEP shortage in rabies treatment centers	
	Chronic dog vaccines shortage in the country	
	Remoteness of animal and human health facilities (PEP centers, dog vaccination sites, laboratory)	
	Chronic understaffing in animal health sector	
Operational alignment		
Adequacy between internal processes and shared values	Perceived functional relationship between owners and dogs, being owned mainly for house guarding	Q33 « *Some of local social values and traditions are obstacles to the fight against rabies in the country* » (Private animal health worker, Ouagadougou)

	Use of top-down approach for decision making	
	Negative perception of affectionate relationships with dogs	Q34 *« We have no other channel of communication with the private veterinary clinicians* » (animal health officer, public veterinary office)
	Lack of dog welfare and care culture in most owning communities (e.g. provision of healthcare, food, chennel)	
	Difficulty in rabies-related data sharing from private stakeholders	
Legitimative alignment		
Adequacy between system's objectives and shared values	No veterinary inspection designed for securing dog meat processing and consumption	Q35: *« I have not seen any text concerning, for example, dog vaccination, integrated management of bite cases, ownership of pets* » (Animal health worker, Koudougou)
	Poor legislation of human and animal rabies surveillance and control	Q36: « *Researchers should try studying the products used by communities, their modes of action, the required proportions* » (Human health worker, Ouagadougou)
Capacity of reshaping values with regard to objectives	Rabies not considered as relevant topic in national research efforts	
Contextual alignment		
Integration of social and environmental changes in view of the values	Sectoral support approaches adopted by international institutions	Q37: « *In terms of collaboration, we need to coordinate financial supports from financial partners, because pooling resources is necessary to establish One Health* » (Civil society organization leader, Ouagadougou)

2.5. Discussion

2.5.1. Constraints to integrated rabies control

Despite being considered since 2017 as the second most priority zoonotic disease by the government [2], and the multiple interventions conducted by veterinary and medical entities through the National One Health Coordination Platform, rabies remains a serious public health threat in Burkina Faso. Previous initiatives, including the evaluation of the Performance of Veterinary Services [28] and the Joint External Evaluation of the International Health Regulation [29] were conducted in the country. However, the recommendations and conclusions from these assessments, which are based on sector-specific tools, have not led to the implementation of effective measures to control animal-transmitted human rabies. Therefore, the PSSAT was mobilized as a systemic analysis framework in order to better organize our understanding of the multiple challenges affecting rabies control. This was thought as an integrative approach, aimed to overcome more conventional and segmented approaches to performance evaluation, which are based on the measurement of achievement rates in relation to set objectives and allocated resources. In addition to results criteria, the PSSAT framework enables the investigation of socio-cultural and organizational factors, which are often neglected in evaluations [17,30]. Developed in the mid-20th century to support the performance of industrial companies, the PSSAT and its potential were progressively conceptualized by several authors to provide a holistic understanding of the effectiveness of public health interventions [14,15]. Indeed, all these papers have highlighted the potential usefulness of the conceptual framework for understanding patterns of public health organizations' effectiveness. However, previous studies, that had looked into the framework, were limited to the conceptual stage, with no practical application to the actual evaluation of public health interventions. Therefore, to the best of our knowledge, our study is the very first practical application of PSSAT to a public health system assessment based on stakeholder interviews. The method highlighted functional and dynamic interactions between and within challenge groups, providing an integrative view of results, helping to make sense of the overwhelming number of challenges faced throughout implementation. This method and its outputs align with the vision of health systems as subject to complex internal and external dynamics and calling for appropriate systemic assessment methods, as stressed by Adam and de Savigny [31].

Throughout the exercise, the researchers have felt, however, the possibility for alternative categorizations to the one they had proposed. Therefore, it must be recognized that

categorization choices are dependent on the analysts' understanding and choices, not excluding the possible perception biases associated with qualitative methods [32, 33, 34]. The PSSAT may be particularly subject to such subjectivity, due to the part of indetermination in the definition of the links between its components and the identified themes. Also, the dynamic alignments, bringing conceptual richness to the framework, inevitably entails a cognitive difficulty in their mobilization. Eventually, while this analyst-dependency must be taken into account, it is not invalidating the usefulness of the tool. Rather it points to the interest of it as a discussion tool, to facilitate workshops that will help dissecting complex situations by confronting views, rather than as a standardized assessment and reporting tool.

With this caveat in mind, one may notice and question the unbalanced distribution of challenges identified across the functions and alignments that form the basis of PSSAT. The method followed by the research team have let emerge the challenges as per interviewees' testimonies through semi-structured interviews. The imbalance of challenges distribution between PSSAT analytical categories may thus point to aspects of the system functioning that remain blind spots for its actors. This indicates a potential interest of the PSSAT to identify such blind spots and direct efforts towards their active search and analysis. This use would also gain from a participatory approach with surveyed stakeholders and local experts being involved in all stages of the process (definition of framework, identification of stakeholders, review and classification of challenges into the framework components). Such situation-based workshops would also foster an increased awareness of the complexity and interdependencies, improving the understanding of the issues at stake and uptake of knowledge produced, as highlighted by group model building approaches [35,36].

By adopting a cross-cutting perspective, the evaluation captured challenges found through various conventional methods (Joint External Evaluation of IHR 2005, National PVS and IHR Bridging workshop, Stepwise Approach towards Rabies Elimination), including scarcity of resources, low capacity for producing high quality services, lack of synergy between actors and initiatives, workforce motivation [28, 29,30]. In addition, it highlighted challenges that are neglected by these conventional approaches, as the important role played by innovative learning [37], equity in health [38], and the culture of organization (integration of social norms, coordination, development of procedures, stakeholder commitment and loyalty) [39,40].

The systemic approach used in the study provided a cross-sectional look at the barriers to the system's effectiveness through its stakeholders' viewpoints. Indeed, in line with the principles

of management of One Health challenges (including antimicrobial resistance, food safety, environmental pollutions, as well as zoonotic diseases like rabies [41,42]), the study included a diverse panel of stakeholders (S1). Such an assessment tool, that is able to consider, organize and help visualize the discourse of stakeholders, could be helpful in generating practical and shared understandings. This is one of the qualities required for learning healthcare systems (culture of innovation, evidence based-intervention, learning for improvement). Hence, as an evaluative approach, the study findings illustrate the very first step – the problem identification - from the six phases of the health systems learning cycle described by Greene et al. [43].

2.5.2. Prospects for progress towards effective rabies control

The challenges met by the rabies multi-sectoral system may appear obvious, given the direct need to enhance control efforts in line with the zero by 2030 global objective [44,45]. However, this diagnosis aims to exceed such a foregone conclusion. Indeed, the conversion of each of the identified challenges into actionable solution can fuel a locally-tailored strategic planning. The systemic nature of the approach then helps to understand what actions are to undertake jointly or can be phased along distinct stages, and what response or function elsewhere in the system has to be monitored while acting on a given challenge. Designing such a strategy falls beyond the sole scope of science and must be tackled with policy-makers and citizens. This analysis, however, may already suggest five key areas of actions that we propose here to be considered by policy-makers.

1. **Improve coordination between sectors and stakeholders**: Poor collaborative interventions and data sharing between relevant stakeholders is a major barrier to effective control of rabies [46]. The creation of a legal supportive National One Health Coordination Platform reflects a stronger political will towards integrative approach in rabies management. Moving forwards, it is critical to develop practical tools and procedures clarifying roles and responsibilities of sectors and stakeholders, whenever collaborative interventions are required (bite case management, surveillance, training and capacity building, public awareness raising, resource mobilization). In addition, a national integrated strategic plan endorsed by the government and by the Quadripartite member institutions, such as World Organisation for Animal Health, is crucial for enhancing commitment, collaboration and financing to eliminate human deaths from dog-mediated rabies by 2030 [47].

2. **Enhance mass domestic carnivore vaccination**: Achieving and maintaining at least 70% rabies vaccination coverage among reservoirs remains the most cost-effective way of eliminating rabies [48,49]. In the local context, while dogs are the main source of human rabies [4,8], the dog vaccination coverage remains poor (ranging from 8% to 36%, [8,9,50]). To cope with the limited resources allocated to rabies control efforts, the government should consider integrating rabies into the current national mass vaccination programs against animal diseases (including peste des petits ruminants, contagious bovine pleuropneumonia, Newcastle disease) as a more sustainable strategy. In addition, such vaccination campaigns, annually conducted by the Ministry of Livestock, if also targeting cross-sectoral priority zoonosis like rabies, could receive financial support from other beneficiary ministries, in particular the Ministry of Health and the Ministry of Territorial Administration. Such an effort pooling approach was successfully implemented in other countries in Latin America and North Africa, and can significantly reduce dependence on partner funding for rabies interventions [49,51]. Locally-tailored strategies combined with adequate local resource allocation are key for more sustained focus on Global South endemic diseases (like rabies). Otherwise, diseases with higher burden on local populations may be overlooked in the event of an international public health emergency. This situation was well illustrated by COVID-19 pandemic, which led to the interruption of rabies prevention activities in the country, including post-exposure prophylaxis [10,52,53].
3. **Strengthen dog bite case management**: After a bite caused by a rabies animal, the transmission of the virus to human is 100% preventable by ensuring timely access to and effective delivery of post-exposure prophylaxis [54]. However, as reported by previous studies [8,55,56], our results highlighted inadequate access to postexposure prophylaxis, due to frequent vaccine shortages in the country [52,53], remoteness of PEP facilities [8,57], lack of knowledge among health professionals [58], as well as poor coordination between medical and veterinary services [3,11]. Despite under-reporting related weak surveillance capacities [7,59], an average of 11,500 bite cases and 40 human deaths are recorded per year [55,56,60]. To effectively address this situation, it is urgent to improve the availability of WHO pre-qualified vaccines, create PEP centers in each administrative regions, and operationalize an integrated bite case management (IBCM). An advanced form of rabies surveillance is needed, combining efforts from animal and human health sectors and communities, to control rabies utilizing the One Health approach [46,61]. The situation calls on prompt data collection, rapid response and coordinated action across sectors to prevent rabies transmission. As the surveillance capacity affects PEP decision-making, IBCM can

therefore be used to follow a risk-based approach to deliver PEP, where PEP onset may be delayed or discontinued based on the outcome of the biting animal assessment (veterinary observation or laboratory sample testing). In the meantime, public health authorities should consider introducing recently developed intradermic PEP regimens that are recognized to be more cost-effective than Zagreb and Essen regimens currently used in the country [8,54,62,63].

4. **Strengthen rabies diagnostic capacities and surveillance**: Well-equipped laboratories which can ensure rapid detection are pivotal in any rabies prevention and control strategy [64]. As revealed by the study, only one laboratory has rabies sample testing capacities. Moreover, the laboratory is located in Ouagadougou, the capital city, while most rabies cases occur in remoted and rural locations [8]. Laboratory data contribute not only to better management of bite case, but also to measuring the effectiveness of strategies such as dog vaccination. Moving towards the zero by 2030 global objective, it is important to establish more diagnostic facilities across the country.
5. **Additional forward-looking actions**: To effectively address these challenges within an integrative public health perspective of rabies control, beyond above actions, strategic planning needs to consider communication and education means (advocacy and public awareness raising, household waste management, dog population management), including One Health trainings for involved in-service and pre-service professionals [64,65,66]. Introducing mobile and new technologies should help in these efforts. Furthermore, the increased digitalisation of services like dog vaccination, post-exposure prophylaxis, surveillance is important for improved anti-corruption, transparency and accountability rabies control [67,68]. Therefore, foresight workshops may help identify levers and ways forward beyond the sole take up of the lacks and gaps one by one.

2.6. Conclusion

The study provided a practical application of the Parsons Social System Action Theory for a comprehensive understanding of diversity and nature of challenges in rabies control interventions as well as the close interactions between them. The findings highlighted the need of integrative approaches for evaluation of zoonotic disease control interventions, by suggesting that all internal and external factors are interlinked and influence together the whole system performance. However, if the identified challenges are comprehensively converted into forward-looking actions, this can make possible the development of locally-tailored strategies for most effective domestic carnivore-transmitted human rabies management, reducing rabies burden in public health and community livelihoods. Facing the fast global changes and

increasingly complex health threats, it is critical to have state-of-the-art but more importantly learning health systems, with its actors being empowered to handle these systemic aspects. Therefore, the Parsons Social System Action Theory, if properly defined and communicated, can contribute to the development of a participatory evaluation method that enables systems thinking among stakeholders.

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CHAPITRE 3

Etude 2 :

Using causal loop analysis to explore pathways for zoonosis control in low-income setting: The case of dog rabies vaccination in Burkina Faso

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Madi Savadogo[a,c,d,*], Dimitri Renmans[b], Rianatou Bada Alambedji[c], Zékiba Tarnagda[d], Nicolas Antoine-Moussiaux[a]

a.Fondamental and Applied Research for Animals and Health (FARAH), Faculty of Veterinary Medicine, University of Liege, Belgium; **b.** Institut of Development Policy, University of Antwerp, Belgium; **c.** Service de Microbiologie-Immunologie et Pathologie Infectieuse, Département de Santé publique et Environnement, Ecole Inter-Etats des Sciences et Médecine Vétérinaires, Université Cheikh Anta Diop, Dakar, Sénégal; **d.** Laboratoire National de Référence-Grippes (LNR-G), Unité des Maladies à potentiel Epidémique-Maladies Emergentes et Zoonoses, Département de Biologie Médicale et Santé Publique, Institut de Recherche en Sciences de la Santé, Ouagadougou, Burkina Faso

[*]**Corresponding author**: Madi SAVADOGO (savadogo.madi@yahoo.fr)

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CHAPITRE 3: USING CAUSAL LOOP ANALYSIS TO EXPLORE PATHWAYS FOR ZOONOSIS CONTROL IN LOW-INCOME SETTING: THE CASE OF DOG RABIES VACCINATION IN BURKINA FASO

4.1. Abstract

Dog vaccination is an effective pathway to control rabies if a minimum of 70% dog vaccination coverage is achieved. For more than six decades, dog vaccination has been adopted as part of the rabies control measures in Burkina Faso. However, the required vaccination coverage in canine population remains challenging and rabies endemic. This study describes the use of systems thinking to explore the dynamics arising from dog vaccination complexity and explain the possibles causes of low vaccination coverage in the dog population. In-depth interviews were conducted in three administrative regions and included various stakeholders. A thematic analysis was performed to analyze the obtained narratives. Subsequently, causal loop diagrams (CLDs) were developed, depicting the causes of low dog vaccination coverage. The CLDs were composed of reinforcing loops and balancing loops, visualizing how different variables including social, economic, technical, political and organizational factors that affect the implementation of rabies vaccination in the country are causally interrelated. Overall, the results revealed the importance of community awareness raising, strengthening the vaccination workforce, enhanced governance and leadership in the dynamics of dog vaccination. The study calls for wide consideration of all drivers and factors that may affect dog vaccination coverage, for the development of any rabies control strategy or vaccination program. Beyond the dog vaccination problem, the methods and findings from this study could be applied to other critical rabies-related questions such as postexposure prophylaxis, epidemiological surveillance, dog population management, laboratory diagnosis, and the One Health collaboration issues, to understand and improve rabies control.

Key words: Burkina Faso, zoonosis, rabies control, dog vaccination, facilitators, barriers, system dynamics, causal loop diagramming.

4.2. Introduction

Rabies is a serious global public health threat, with higher impact in low- and middle-income countries in Africa, Asia and Latin America. This preventable but always fatal disease mostly affects poor and rural communities. It is a zoonosis that affects wildlife and domestic animals, and is transmissible to humans, through bite, scratch or licking by a rabid animal. Dogs were reported to be the main cause of human cases in Africa (99%) (Sondo et al., 2015; Minghui et

al., 2018). Although rabies remains under-reported, more than 59,000 human cases are estimated to occur in African and Asian countries annually, representing approximatively one human death every nine minutes (Hampon et al., 2015). Every year rabies causes almost 2,000 deaths in North Africa, 6,000 in Southern Africa, 6,000 in West Africa and 7,000 in Central Africa (Hampson et al., 2015).

Located in West Africa, Burkina Faso has been endemic to rabies for decades (Dodet et al., 2008; Savadogo et al., 2020; Minoungou et al., 2021). Indeed, on average 19 human cases and more than 4000 exposures to suspected rabid animals are regularly recorded across the country (Burkina Faso, 2016; Sondo et al., 2015; Ouermi et al., 2018). Routine laboratory surveillance detected many positive cases in pets, including cats and dogs, but also in wildlife, cattle, and equids (Nitcheman, 1983; Savadogo et al., 2020; Minoungou et al., 2021). From 2001 to 2013, approximatively 90% of rabies positive samples were from canine species and at least 70% of suspected rabid dog samples were rabies positive (Savadogo et al., 2020; Minoungou et al., 2021). However, rabies is known to be 100% preventable if dogs are appropriately vaccinated and post-exposure prophylaxis is adequately provided to exposed persons (World Health Organization, Food and Agriculture Organization of the United Nations and World Organisation for Animal Health., 2016). It is estimated that rabies can be eliminated if almost 70% of canine population is regularly vaccinated (Coleman and Dye, 1996; Zinsstag et al., 2017).

Several measures have been initiated in the country to mitigate rabies risk: veterinary public health policies have made rabies a notifiable zoonosis, dog free roaming is prohibited, and rabies vaccination is compulsory for all pets above 3 months of age (Koudiati, 1989; Burkina Faso, 1989; Burkina Faso, 2018). Current rabies control actions include awareness campaigns, surveillance, pre- and post-exposure prophylaxis, dog population management, and dog vaccination. The latter has been adopted as a method for rabies control since the 1960s (Nitcheman, 1983). It is provided by private and public veterinary services, the latter being often the sole available in rural areas. In addition, on the yearly World Rabies Day, short vaccination campaigns are often organized, particularly in the main cities, i.e. Ouagadougou, Bobo Dioulasso and Koudougou. Dog vaccination cost ranges between 1.5 euros (during campaings) and 3.8 euros (in veterinary clinics) and is charged to owners (Savadogo et al., 2020; Savadogo et al., 2021). Despite these measures, owned-dog vaccination coverages in the country remain low: 8.2% in Dédougou (Dahourou et al., 2021), 25.9% in Bobo Dioulasso (Savadogo et al., 2021) and 36.5% in Ouagadougou (Sondo et al., 2015; Savadogo et al., 2020;

Savadogo et al., 2021). Studies investigated the reasons for this poor vaccination coverage using quantitative methods, such as cross tabulation, logistic regression models and principal component analysis (Savadogo et al., 2021). Such methods focus on the main expected drivers through structured questionnaires, leaving aside the in-depth complex dynamics of the issue. However, like any public health intervention, dog vaccination entails a complex setting, the understanding of which requires systemic approaches (Narrod et al., 2012; Peters, 2014; Castillo-Neyra et al., 2017). This study uses causal loop diagramming to analyse the system underlying dog vaccination in Burkina Faso. It aimed to (1) identify barriers and facilitators to dog rabies vaccination as well as the interplay between different stakeholder levels in Burkina Faso, and (2) understand how they causally interact affecting the dog vaccination coverage.

4.3. Material and Methods

3.3.1. Description of study areas

The study was conducted from February 2019 to February 2021 in three administrative regions of Burkina Faso (**Figure 1**): Centre (Ouagadougou, the administrative capital), Hauts Bassins (Bobo Dioulasso, the second biggest city) and Centre-Ouest (Koudougou). These three areas are the most important urban agglomerations of the country. The local population owns dogs for various purposes, including house or herd guarding, hunting, for sacrifices during traditional meetings, companionship especially for children and for consumption as source of protein (Kouldiati, 1989; Jibat et al., 2015; Savadogo et al., 2020). Ministries, central veterinary and medical offices are located in Ouagadougou. Nevertheless, in each of surveyed locations there are public and private technical services that provide veterinary care and animal rabies vaccination (veterinary clinics, short vaccination campaigns). However, as the interviews were conducted in only three administrative regions, the study did not include rural area. Therefore, factors associated with the vaccination coverage described in this study may not be fully representative for the situation across the whole country.

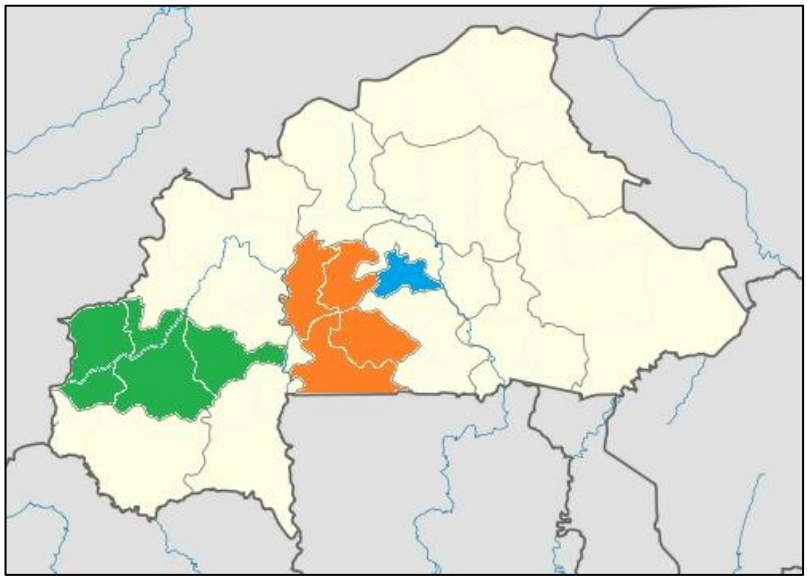


Figure 1: Geographical location of the three administrative regions where interviews were conducted, Burkina Faso (*Blue: Centre region; Green: Hauts Bassins region; and Orange: Centre-Ouest region).*

3.3.2. Stakeholders identification

The participants were recruited following the process described by Figure 2. The study started with reviewing existing information (grey literature, theses, publications) to capture the organization of the rabies control system in Burkina Faso. In February 2019, interviews with key informants from public and private animal health entities were held during a first field visit in Ouagadougou. These interviews informed a first list of rabies control stakeholders, including entities and actors intervening or affected by the rabies control activities. From this first list, a second list was established including entities and actors playing a direct or indirect role in dog rabies vaccination. Subsequently, a local expert with good knowledge of the issue of dog vaccination helped refine and prioritize a short list of relevant stakeholders to be interviewed. In addition, during the field investigations, interviews also allowed completing the stakeholder short list.

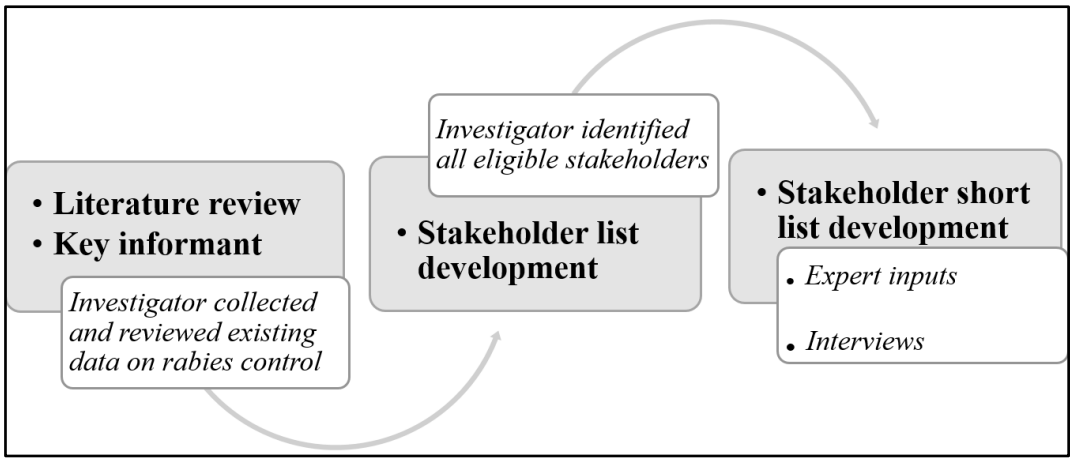


Figure 2: Mixed methods used for stakeholder recruitment (Literature review, Key informant interviews, inputs from field animal health experts)

3.3.3. Sampling methods

Study participants were recruited using a dual sampling approach including purposive and respondent-driven sampling. First, all short-listed stakeholders were invited to participate in interviews (purposive sampling). Then, these first respondents introduced the researchers to other stakeholders involved in dog rabies vaccination in the study area (respondent-driven sampling). Dog owners were selected from a list of participants established during a short vaccination campaign organized in 2019 by the veterinary services. Victims of dog bite were recruited during field sensitization in the community. Therefore, all included stakeholders were selected on the basis of their involvement or interest in rabies control and, in particular, the dog vaccination issue. The employed sampling method was effective and appropriate for the data collection due to logistic and resource convenience (Taha, 2020). Interviews were conducted until the point of data saturation was reached (Glaser and Strauss, 1967). Thus, inclusion of participants was stopped when, despite the search for various situations, data collected provided enough information, and the capacity to obtain new additional information was reached (Guest et al., 2006; Fusch and Ness, 2015). In total, 62 in-depth interviews were conducted including animal health workers (n=28), human health workers (n=16), wildlife workers (n=4), municipality officers (n=4), dog owners (n=8), and victims of dog bite (n=2) (**Table 1**). Interview guides were tailored to each category of participants to cover the relevant range of aspects to be discussed.

Table 1: Categories of stakeholders interviewed in the three study locations, Burkina Faso.

Sector	Category	Number of participants

		Bobo Dioulasso	Koudougou	Ouagadougou
Animal health	Public veterinarians	-	-	6
	Public paraveterinarians	6	5	4
	Private veterinarians	-	-	3
	Private paraveterinarinas	2	-	3
Human health	Physicians	1	-	4
	Nurses	2	-	9
Wildlife and environment	Wildlife and environment technicians	-	-	4
Municipality	Hygiene Officers	1	-	3
Community	Dog owners	3		4
	Victims of dog bite	-	-	2
Total		**15**	**5**	**42**

3.3.4. Data collection

Data collection included individual and focus group semi-structured interviews, conducted both in local language and French by the principal researcher. Participants were invited by email or phone providing them the study background and objectives. Each participant was reminded once every month. In case a participant did not respond or declined the invitation to participate, a replacement was operated from the stakeholder list. An interview guide was used to collect narratives on rabies control, with a focus on the issue of dog vaccination against rabies: known involved stakeholders, roles of each category of stakeholders, challenges, enabling factors, strategies and leverages that may be successful for improving dog rabies vaccination compliance. For each discussion, participants were met in a location convenient to them that ensured confidentiality (e.g. participant office, place of residence). All interviews were conducted by the researcher, audio-recorded and transcribed in a Microsoft Word document. Throughout the data collection process, validity of data was ensured. This started with the used respondent-driven sampling which helped avoiding major selection biases from researchers in participant recruitment, by involving local stakeholders in the process. In interviews, participant's own information was crosschecked with opinions of local experts,

direct observations of the researcher and with documented information when available. Stated information about context of dog rabies vaccination was crosschecked using independent interviews.

3.3.5. Qualitative data analysis

Before analysis, transcripts were reviewed and cross-checked with audio-recordings to ensure their quality and completeness. Thematic analysis is a widely used method in qualitative studies to identify patterns of meanings across various interviewees narratives (Olivier de Sardan, 2004; Guest et al., 2006, Xie et al., 2017). Data were obtained using the qualitative reflexive and iterative process developed by Halcomb et al. (2006). For the qualitative analysis purposes, themes and sub-themes were defined on the basis of the themes structuring the Stepwise Approach towards Rabies Elimination (SARE) and the Global Framework to eliminate rabies deaths by 2030 (STOP-R framework) (GARC, 2016; Chen et al., 2019). All transcripts were progressively read to explore available data, identify excerpts relevant to the pre-established (sub-)themes and define additionnal sub-themes emerging from the text.

Finally, based on the SARE and the STOP-R framework, five themes and nineteen sub-themes were defined as follow: i) socio-economic and cultural context (awareness, dog ownership, accessibility to vaccine and vaccination services, and community engagement), ii) technical factors (logistics, vaccine availability, vaccine effectiveness, training and technical support), iii) organizational factors (governance, synergy, monitoring and evaluation, performance measurement, communication), iv) political factors (political will, policy and framework, partnerships, impact of rabies and vaccination), and v) resources (workforce, budget). Within each sub-theme, the described barriers or facilitators were translated in the form of variables, termed in a concise manner. The stakeholders and their roles, the potential variables potentially associated with dog rabies vaccination were then listed using a Microsoft Excel spreadsheet.

3.3.6. Causal loop diagramming

Causal loop diagramming (CLD) is one of the tools from qualitative system dynamics, used to explore interactions and feedback loops underlying the dynamics at play and specific outputs of a system. As presented in **Figure 3**, a CLD is composed of variables (factors) and relationships (influences) (Bowen, 1992). An influence is characterized by an arrow and a polarity: « + » indicates that the two variables A and B change in the same direction and « - » indicates that the two variables A and B change in the opposite direction. According to polarities of arrows that compose a feedback loop, the loop is named reinforcing or balancing

loop. A null or even number of negative relationships along the loop indicates a reinforcing dynamic, noted with the letter « R ». An uneven number of negative relationships indicates a balancing loop, noted with the letter « B ». The direction of a feedback loop is shown by a clockwise or counter-clockwise arrow around the loop-polarity-letters (R or B) (Sterman, 2000).

The Vensim software (*Vensim® PLE for Windows Version 8.2.1 Double Precision x64, 2019 Ventana Systems, Inc, see* https://vensim.com/free-download/) was used to build and generate the CLDs. For each defined sub-theme, all listed variables were displayed in Vensim and linked to each other using arrows. This stage allowed the creation of the first draft of a general CLD. Subsequently, transcripts were read again to ensure that this CLD took into account all topics and ideas collected from participants. The purpose of this process was also to have a revised and better representation of the relationships in the CLD. From the revised general CLD, the most relevant feedback loops were selected according to the following criteria: a selected causal loop should i) best reflect the ideas captured from the participants' narratives, ii) involve as few variables as possible to facilitate interpretation and understanding, and iii) describe a specific dynamic of the dog vaccination. This resulted in 17 feedback loops which were grouped into three distinct diagrams according to the SARE-derived themes.

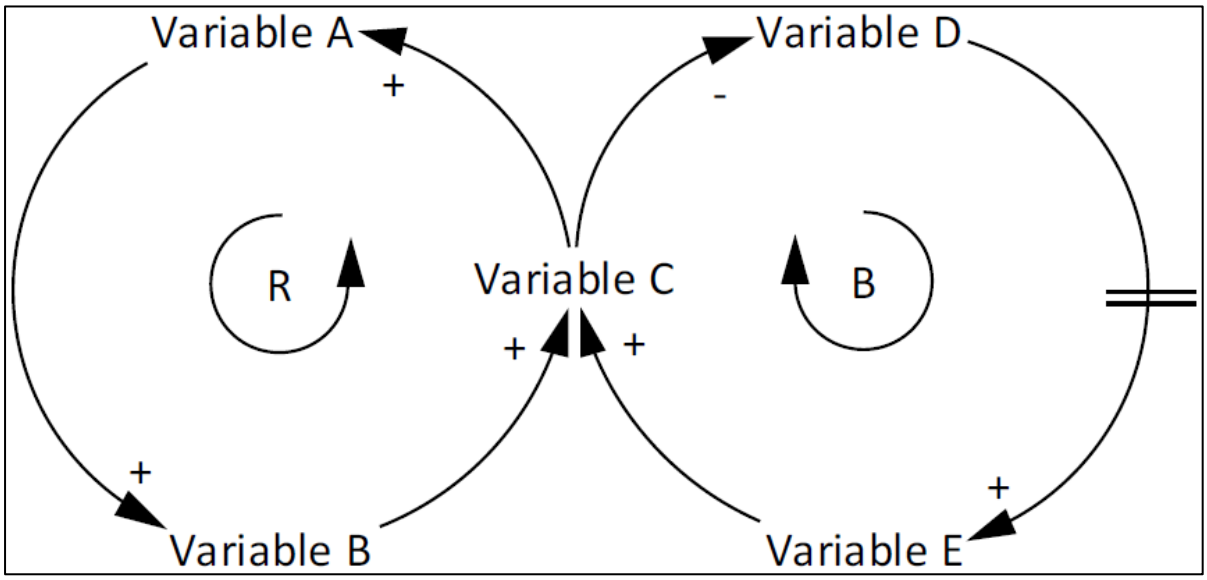


Figure 3: Example of a causal loop diagram with a balancing loop and a reinforcing loop (Renmans, 2018)

3.4. Results

3.4.1. Stakeholders involved in dog rabies vaccination

Stakeholders were categorized in direct and indirect stakeholders according to their roles in dog vaccination (**Table 2**). Stakeholders who were directly involved included dog owners, community animal health workers, private veterinarians, public animal health officers, vaccine suppliers, animal health authorities, and illegal field vaccinators. Indirect stakeholders included local authorities, hygiene officers, human health workers, educational actors, media, civil society organisations, NGOs, and international health institutions (FAO, Food and Agriculture Organization; WHO, World Health Organization; OIE, World Animal Health Organization; WAHO, West African Health Organization; and RAHC, Regional Animal Health Center).

Table 2: Cited stakeholders and their roles associated with dog rabies vaccination

Category	**Stakeholder**	**Entity**	**Category of roles**
Direct	Dog owners	Local community	Seeking of vaccination, transportation of dogs to vaccination sites, payment for vaccination
	Community Animal Health Workers	Local community	Dog vaccination, community sensitization
	Vaccine suppliers	Veterinary drugs import company	Vaccine supply
	Private technicians and veterinarians	Veterinary clinics	Dog vaccination, data collection and reporting
	Animal health officers	Local and regional animal health offices	Supervising, dog vaccination, data collection and reporting
	Animal health authorities	Ministry of Livestock, National Veterinary Office,	Subsidized vaccine, vaccination planning (resources, logistics), supervising of interventions
	Illegal vaccinators	Local community	Dog vaccination
Indirect	Town criers	Local community	House-to-house information spreading

	Opinion leaders (Traditional chiefs)	Local community	Supporting officers for awareness raising and building of trust
	One Health and rabies associations	Civil society organisations	Education and public awareness raising
	Livestock development projects actors	Ministry of Livestock	Financial and logistic support (cooling equipments)
	Local authorities, Local representatives, Municipal hygiene officers, Public security officers	Ministry of Administration	Awareness raising, control of dog population (roaming), policy popularization, repression against law-breakers, waste management
	Human Health Workers	Ministry of Health	Sensitizing of biting dog owners and victims of bite
	Teachers, Researchers, Students	Ministry of Education and Research	Training, awareness raising, research and evaluation: canine population, vaccination issues, knowledge-attitude-practice assesment, assessment of intervention effectiveness
	Journalists and media actors	Ministry of Communication	Information and communication, community awareness
	Health intervening NGOs	NGOs	Financial support, training of community animal health workers
	FAO, WHO, OIE, WAHO, RAHC	International health institutions	Knowledge and financial resources

3.4.2. Dynamics involved in dog rabies vaccination: causal loop description

The refined list of 17 causal loops was structured into three categories of dynamics. The socio-economic and cultural dynamics (composed of four reinforcing loops and two balancing loops) describe the factors associated with the community's perceptions of rabies and dog vaccination, the dog husbandry practices, and the social networking in the general public (Figure 4). The technical and resources dynamics (composed of five reinforcing loops and two balancing loops) capture factors associated with the funding and the effectiveness of the involved animal and public health systems (Figure 5). The political and organizational dynamics (composed of four reinforcing loops) capture factors associated with the political context of rabies control and the interactions between key stakeholders (Figure 6). In the description here below, each loop is named by an interpretative term between quotation marks and all variables are highlighted with italic font.

3.4.2.1. Socio-economic and cultural dynamics for dog vaccination

The « community engagement » reinforcing loop (Fig. 4, R1) is expected to produce a virtuous cycle by which the *accessibility to useful vaccination-related information* by dog owners, their participation in *dog vaccination*, and the *sensitization* of these owners by animal health workers during vaccination, increase the level of the *awareness* of rabies and dog rabies vaccination. An improved level of *awareness* combined with *policy popularization* (regarding dog ownership and vaccination) leads to a higher *engagement of community* members for dog vaccination. However, the virtuous cycle is presently impaired and the level of awareness about rabies and dog vaccination was reportedly unsatisfactory. The field investigations revealed that the community's knowledge is improved by useful messages provided by animal health workers or shared from a diversity of sources (radio, TV, booklets, banners, flyers, social media, town criers, breeders' networks).

The « vaccination distrust » reinforcing loop (Fig. 4, R2) acts as a vicious cycle mediated by misconceptions and the communities' habits of *killing biting dogs* regardless of their vaccination status. Indeed, in the local practices, in case of bite, the hair of the biting dog should be collected and applied on the wound of the bitten victim. Yet, owners make a confusion, thinking that the vaccine should protect their dogs from biting people. Hence, they ascribe the fact that their dog has bitten and was killed to an inefficacy of the vaccine. This loop lowers the *trust of dog owners in the vaccination services*. As participation in *dog vaccination* decreases, level of *awareness* decreases, increasing *misconceptions* and habits of *killing biting dogs*. In addition, trust in dog vaccination is negatively influenced by the occurrence of

laboratory results that may declare positive for rabies a dog that has been vaccinated. Owners then preferentially ascribe the discrepancy to a default of the vaccine.

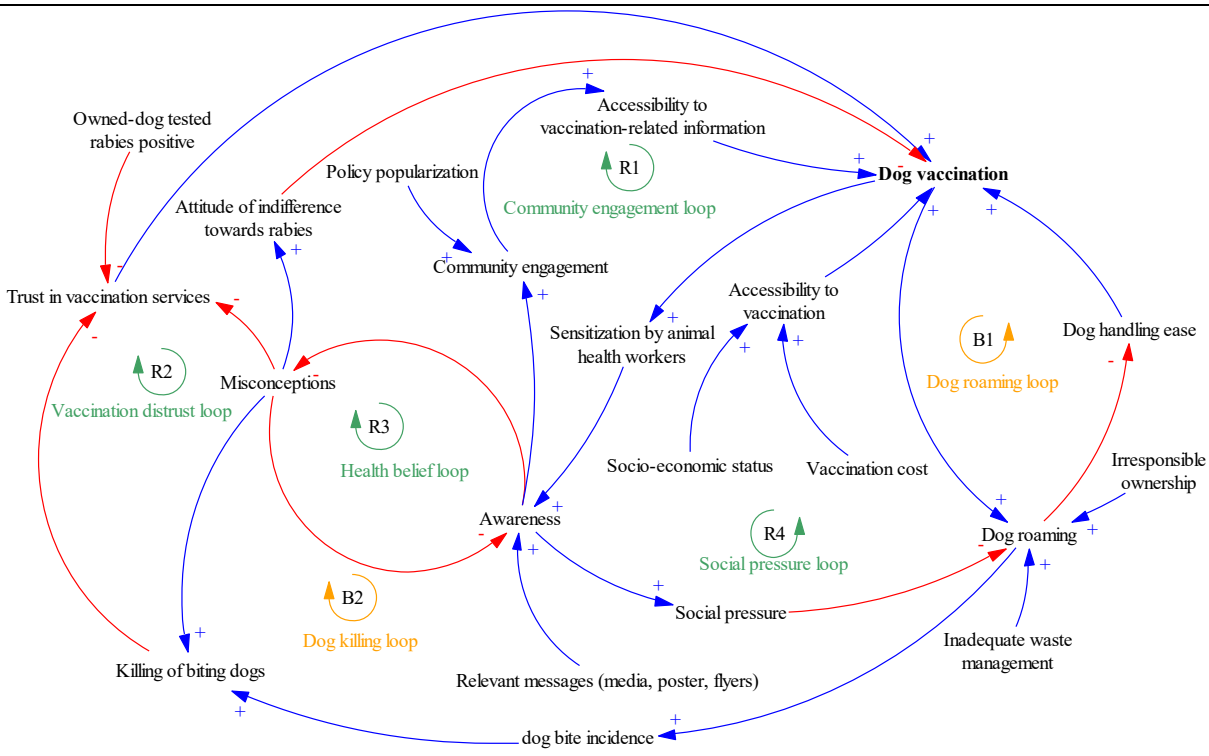
The « health belief » reinforcing loop (Fig. 4, R3) is a vicious cycle whereby the increasing circulation of *misconceptions* is directly defeating the *awareness*-raising actions, which leads to a further increase of popularity of *misconceptions* in the community. Participants reported the low health literacy in the community as a cause of misconceptions (fear of dog vaccination, seeking of traditional treatment such as applying the biting dog hair on the wound). For example, there were socio-cultural barriers to transporting dogs, some owners not wishing to publicly show their affection to a dog. Misconceptions also increase the habits of *killing biting dogs* and the *attitude of indifference* towards rabies in local communities, dimishing *dog vaccination*.

The « social pressure » reinforcing loop (Fig. 4, R4) actually produces a virtuous cycle that improves *dog vaccination.* Indeed, with the rise of *awareness* about rabies*,* a *social pressure* appears within the community. Dog owners fear being discredited and charged for post-exposure and veterinary observation in case their dog bites a person. Therefore, those owners keep their dog at home, diminishing *dog roaming* in the community. As a result, *dog handling ease* increases, facilitating the owners' participation in *dog vaccination*. Through the *sensitization by animal health workers*, this will further contribute to raising the level of *awareness* and generating higher *social pressure* in the community. Indeed, having vaccinated their dogs (checkable through a vaccination certificate or collar) helps owners reassure neighbors that they care about community health, raising the role of social network in the dynamics.

The « dog roaming » balancing loop (Fig. 4, B1) describes a distinct owner logic that counters the previous loop by reintroducing *dog roaming* in the dynamics. Indeed, with a generally low *awareness* and enforcement of dog management policies, some owners tend to release their vaccinated dogs for free-roaming, believing that the rabies vaccination exempts them from keeping dogs confined. *Dog vaccination* then increases the *dog roaming*, which decreases *dog handling ease* (by owners or vaccinators), then lowering *dog vaccination*.

The « dog killing » balancing loop (Fig. 4, B2) puts a strain on vaccination, being related to the « vaccination distrust » and « dog roaming » loops. This loop points to the increase of *dog roaming* as a result of *dog vaccination*, as described here above (see B1). As the free-roaming

dogs increase dog bites and the *killing of biting dogs* by the community members, this decreases the *trust in the vaccination services,* thus *dog vaccination.*



***R1** : awareness, community engagement, accessibility to vaccination-related information, **dog vaccination**, and sensitization by animal health workers ; **R2** : awareness, misconceptions, killing of biting dogs, trust in vaccination services, dog vaccination, and sensitization by animal health workers ; **R3** : awareness, and misconceptions ; **R4** : awareness, social pressure, dog roaming, dog handling ease, dog vaccination, and sensitization by animal health workers ; **B1** : dog vaccination, dog roaming, and dog handling ease ; **B2** : dog vaccination, dog roaming, dog bite incidence, killing of biting dogs, and trust in vaccination services*

Figure 4: Socio-economic and cultural causal loop diagram

3.4.2.2. Technical and resources dynamics for dog vaccination

The « workforce allocation » reinforcing loop (Fig. 5, R5) actually produces a vicious cycle whereby the poor *data collection and reporting* about rabies situation (including the incidence and the socio-economic impact) in Burkina Faso weakens the potential for *advocacy*, causing a lack of *budget allocation* and a lack of *staff* and of *staff motivation* that would be needed to produce that knowledge. Indeed, the interviews revealed insufficient staffing, mostly in peri-urban and rural locations, and veterinary officers reported a lack of competencies in frontline animal health officers. As pointed out by interviewees, staff motivation may be raised through continued trainings, incentives and regular free rabies vaccination for the personnel.

The latter dynamic is stressed in a distinct loop, called « staff motivation » reinforcing loop (Fig. 5, R6), which nevertheless acts as a vicious cycle in the present conditions. Indeed, as the *staff motivation* decreases, the *dog vaccination* delivery decreases, and vice versa. The loop indicates that a satisfactory vaccination delivery requires that the motivation of the workforce be gained and maintained. As highlighted here above (Fig. 5, R5), reported causes of low motivation of the personnel included the insufficient staffing, the lack of continued trainings, and unsatisfactory remuneration, for both public and private vaccinators involved during short vaccination campaigns. Moreover, vaccinators do not themselves benefit of any rabies vaccination, dropping their commitment to dog vaccination.

The « vaccination workload » balancing loop (Fig. 5, B3) limits the ability to benefit from a momentarily improved *vaccine availability* and *staff motivation*. Indeed, the increase in *dog vaccination seeking* from dog owners and subsequently in dog vaccination is reported to rapidly exceed the *workload* limits of staff, in particular during the short vaccination campaigns. It is therefore important that technical staff be regularly upgraded to meet higher demand during vaccination campaigns.

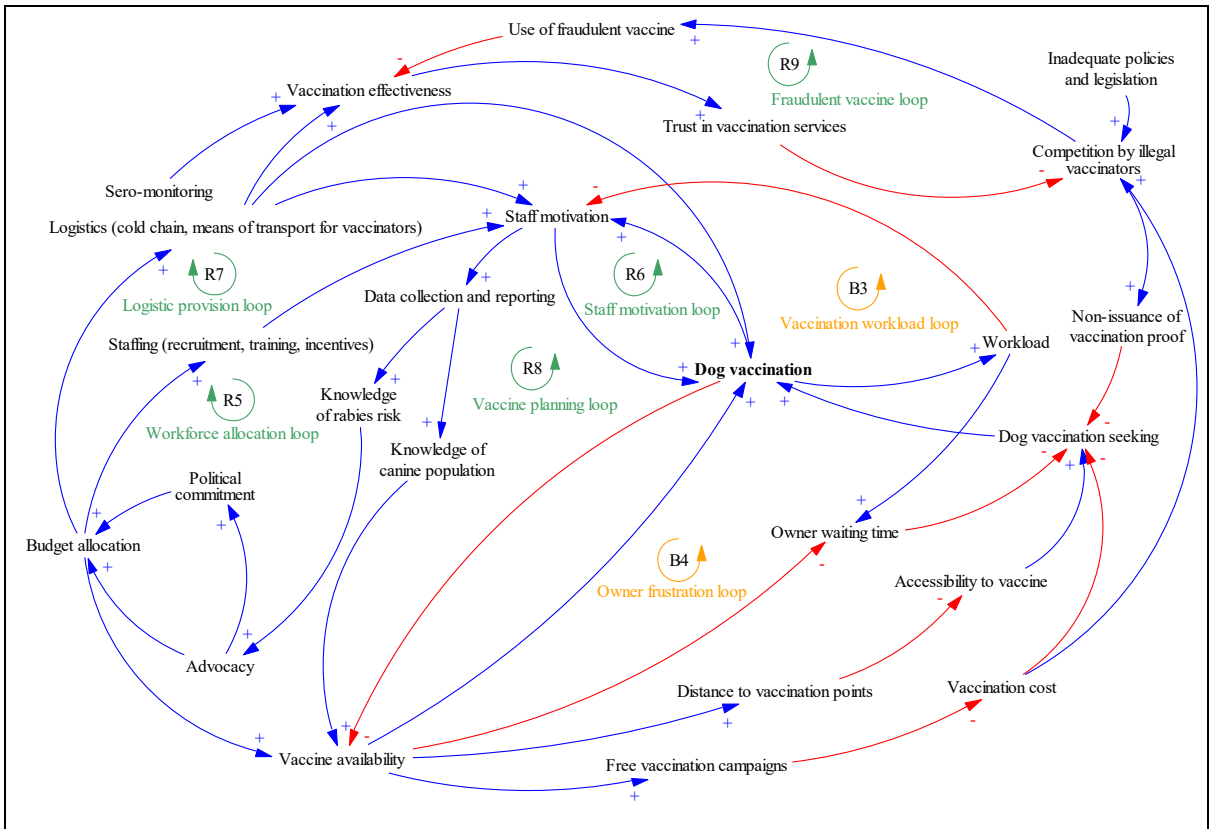
The two previous loops combine in a « logistic provision » reinforcing loop (Fig. 5, R7), that shows a vicious cycle whereby low *budget allocation* for rabies control hinders the supply of vaccination *logistics* (cooling material, transportation facilities, infrastructures for dog impounding, dog handling equipments for vaccination purpose, and vaccination personal protective equipments decrease) both in public and private sectors. The lack of logistics hinders vaccination itself then further lowering *staff motivation*, *data collection and reporting*, *knowledge of rabies risk*, and consequently the *political commitment*. The lack of safe handling equipments is a particularly discouraging factor, many dogs being aggressive at vaccination points. In remote rural areas, the lack of transportation facilities constitues a key barrier to the provision of accessible dog vaccination to communities.

The « vaccine planning » reinforcing loop (Fig. 5, R8) also refers to a same lack of means and *staff motivation* but points to the lack of *data collection* and *knowledge of dog population (size, structure and ecology)*. This gap actually results in inappropriate *vaccine availability*, decreasing the *dog vaccination* delivery, the *staff motivation*, and thus the *data collection and reporting* that would be required for adequate vaccine need assessment. However, inappropriate *vaccine availability* hinders the organization of regular *free vaccination campaigns*. Besides, the vaccination cost was unanimously reported by participants as a

significant bottleneck to dog vaccination accessibility. The reported *vaccination cost* (ranging from 1.5 euros to 11.5 euros) was found to be very expensive by interviewed dog owners. Therefore, *vaccination cost* and recurrent vaccine stock-outs impede the *accessibility to vaccine* and the appropriate vaccination of dogs.

The « fraudulent vaccine » reinforcing loop (Fig. 5, R9) represents a vicious cycle that exhibits how the gradual destruction of owners' *trust in the vaccination services* benefits to a *competition by illegal vaccinators*. The *use of fraudulent vaccines* then further destroys the trust in vaccination, affecting indiscriminately fraudulent and official services. The fraudulent practices also produce additionnal side effects resulting from the fact that illegal vaccinators do not issue dog vaccination proofs (vaccination certificate, collar) to owners. This practice makes that more owners do not expect receiving a proof of vaccination, which lowers their motivation to vaccinate their dogs.

The « owner frustration » balancing loop (Fig. 5, B4) emphasizes the importance of having timely vaccination of owners' dogs. A decrease in *vaccine availability* increases the *waiting time*, sometimes running out of the period of dog vaccination validity. This causes frustration and decreases the *dog vaccination seeking*, and *dog vaccination.*



***R5** : budget allocation, staffing, staff motivation, data collection and reporting, knowledge of rabies risk, and advocacy; **R6** : staff motivation, and dog vaccination; **R7** : budget allocation, logistics, dog vaccination, staff motivation, data*

collection and reporting, knowledge of rabies risk, and advocacy; ***R8*** *: staff motivation, data collection and reporting, knowledge of canine population ; vaccine availability, and dog vaccination ;* ***R9*** *: trust in vaccination services, competition by illegal vaccinators, use of fraudulent vaccine, and vaccination effectiveness ;* ***B3*** *: dog vaccination, workload, and staff motivation ;* ***B4*** *:Dog vaccination, vaccine availability, owner waiting time, and dog vaccination seeking.*

Figure 5: Technical and resources causal loop diagram

3.4.2.3. Political and organizational dynamics for rabies vaccination

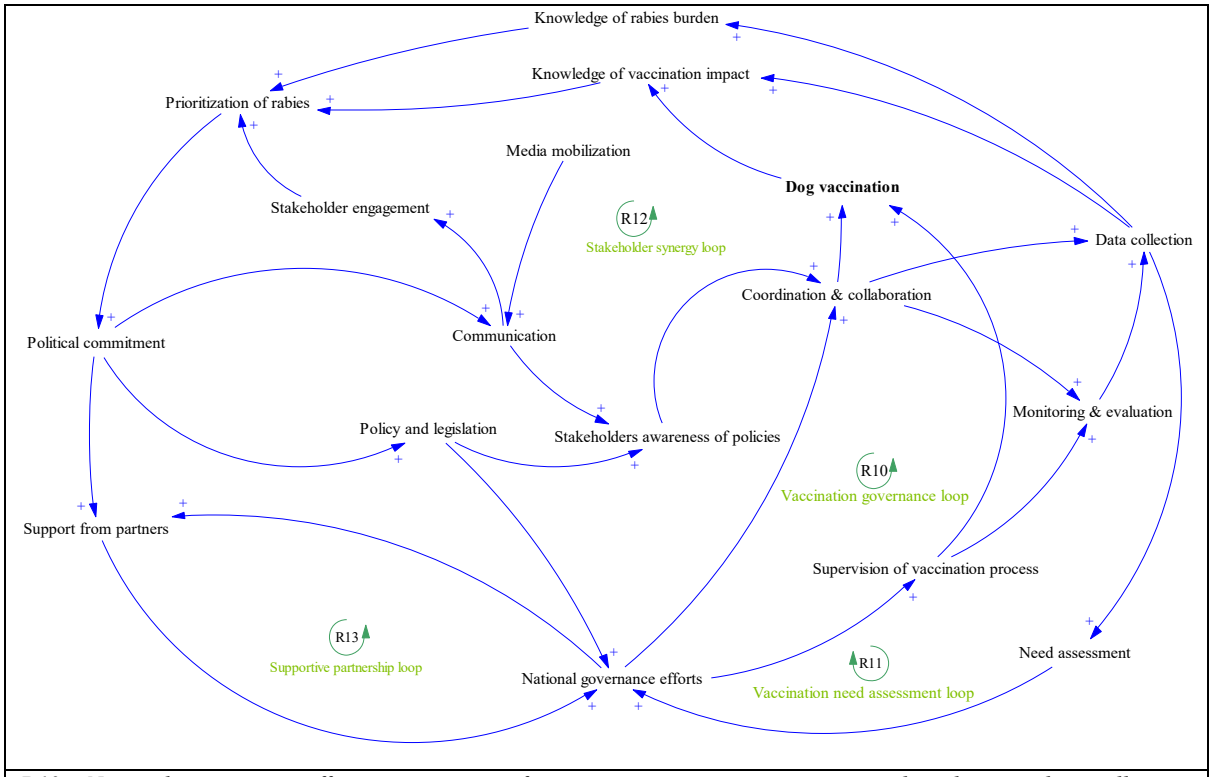
The « vaccination governance » reinforcing loop (Fig. 6, R10) acts as a vicious cycle whereby the lack of *supervision* decreases the efforts of *monitoring and evaluation*, the *data collection*, the *knowledge of both rabies burden and vaccination impact*, and therefore the *prioritization of the disease* and the *political commitment*. A lower *political commitment* hinders the *legislation* and *national governance efforts* for rabies control (national rabies control program, proper governance). Reported governance weaknesses included a lack of transparency in the management of vaccines funded by the government, and a lack of regular consultation of stakeholders regarding the roles they could play in dog rabies vaccination.

The « vaccination need assessment » reinforcing loop (Fig. 6, R11) acts presently as a vicious cycle starting from the same problem whereby the low *governance efforts* finally decrease *data collection*. In this case, the poor *data collection* impairs the *need assessment* practices, hence the *governance efforts*. This loop is associated with the level of collaboration between stakeholders and puts a strain on national governance efforts towards dog vaccination improvement, in particular regarding vaccine management.

The « stakeholder synergy » reinforcing loop (Fig. 6 R12) actually produces a vicious cycle. It results in a lower interaction and collaboration between actors along preparation, implementation and evaluation of field interventions, especially municipality, medical and veterinary services. By this loop, the weakness of *policy and legislation* associated with a lack of wide media communication impede the dog vaccination *stakeholders' awareness of policies*. The lack of awareness about legislation by the key stakeholders decreases the *collaboration and coordination*, the *vaccination delivery*, the *knowledge of vaccination impact*, thereby lowering the *prioritization of rabies* and the *political commitment.*

The « supportive partnership » reinforcing loop (Fig. 6, R13) also acts as a vicious cycle whereby the weak *national governance efforts* discourage a diversity of partners from investing in rabies control in the country (in terms of knowledge sharing and financial support). This neglect from diverse partners further weakens *national governance efforts*. Despite the actual

key role of public actors (animal health, human health, municipalities), participants mentioned the need of developing stonger partnerships with various stakeholders, including communities, NGOs and international institutions, especially involved in community engagement.



***R10** : National governance efforts, supervision of vaccination process, monitoring and evaluation, data collection, knowledge of both rabies burden and vaccination impact, prioritization of rabies, political commitment, and policy and legislation ; **R11**: National governance efforts, supervision of vaccination process, monitoring and evaluation, data collection, and need assessment ; **R12** : communication, stakeholders awareness of policies, collaboration and coordination, dog vaccination, knowledge of vaccination impact, prioritization of rabies, and political commitment; **R13** : National governance effort, and support from partners.*

Figure 6: Political and organizational causal loop diagram

3.5. Discussion

Dog rabies vaccination involves various factors, sectors and actors, interacting with each other and having an impact on the final vaccination coverage. According to de Savigny and Adam (2009), health systems have to be considered as complex adaptative systems, subject to continuous change and feedbacks. These systems are thus constantly adapting to internal or external actions or changes, showing a degree of self-organization beside or replacing its planned and expected functioning. Within the approach of systems thinking, several methods have been developed that allow taking into account both the complexity of a vaccination initiative and the whole system within which it operates (Shiell et al., 2008; Peters, 2014; Rüegg et al., 2018). Firstly, developed in engineering and management realms (Senge, 1990;

Adam and de Savigny, 2012; Peters et al., 2012), systems thinking and its tools/methods are increasingly employed to understand health issues and health systems behaviour (de Savigny & Adam, 2009; Xie et al., 2017; Hitziger et al., 2021). From our analysis using the causal loop diagram, we were able to describe the stakeholders involved in rabies vaccination and how multiple categories of factors were interrelated.

3.5.1. Stakeholders involved in dog vaccination

Stakeholder identification revealed a complex social network in which community members, and several public and private sector stakeholders interact. The established relationships between the multiple stakeholders explain the whole dynamic and the outcomes of the system (Crozier and Friedberg, 1977; Ridde, 2011; Saadi et al., 2021). Unfortunately, all previous reflections on the issue of collaboration for rabies control in Burkina Faso have focused on animal health and human health sectors (Coulibaly and Yameogo, 2000; Sondo et al., 2018; Zangré, 2018; Savadogo et al., 2020). The findings showed that beyond animal and human health actors, a successful dog rabies vaccination strategy requires the involvement of multiple direct and indirect stakeholders. By highlighting the diversity of stakeholders involved in dog vaccination, the study exhibited its complexity and the need to consider stakeholders from other involved sectors such as politics, education, environment management and sanitation, security and community, as pointed out for other zoonoses (Saadi et al., 2021).

3.5.2. Socio-economic and cultural dynamics

Concerning the socio-economic and cultural dynamics, the study revealed the positive impact of social networks and social pressure, improving both dog husbandry practices and dog vaccination seeking in the community. As decribed by the theories of diffusion of innovations (Balas and Chapman, 2018), of social learning (Parcel and Baranowski, 2013) and of planned behaviour (Madden et al, 1992), social norms contribute to involve communities in issues related to their well-being. The use of transectorial approaches that promote community participation along the processes of preparation, implementation and evaluation of interventions can enhance health education and the dog vaccination compliance in owners (Charron, 2012; Buregyeya et al., 2021; Hitziger et al., 2021). However, that social pressure has to be guided by adequate education on rabies prevention measures (dog responsible ownership, vaccination, management of biting dogs and the roles of community members in rabies control). Indeed, if guided by misconceptions, the social pressure can play against vaccination programs. An example from the present case study is that owners vaccinating their

dogs may be accused to show undue care for a dog, similarly to what has been reported by Saadi et al. (2021) regarding the anthelmintic treatment of dogs against echinococcosis in Morocco. Therefore, in order to take advantage of community interpersonal networks to improve dog vaccination coverage, enhanced communication and education should focus on changing cultural, traditional and social conceptions regarding dog and dog ownership (Akakpo et al., 1990; Mindekem et al., 2005). As reported in previous studies (Castillo-Neyra et al., 2017; Oyo-Ita et al, 2021), effective community participation and behavioral change requires useful messages provided from trusted sources, like traditional leaders, opinions and religious leaders, or primary school teachers. In addition, networked and influential individuals can be selected in the communities to champion and promote good practices for responsible dog ownership and dog rabies vaccination. The findings showed that local dog husbandry practices characterized by free-roaming were unfavorable to dog vaccination. This is not suprising as no action has ever been taken to educate people on responsible dog ownership in Burkina Faso. In some Latin American countries where dog vaccination coverage has been significantly improved during the last decade, national vaccination strategies included dog social and responsible ownership education programs (Vigilato et al., 2013; Rodriguez Medonza, 2014; González-Roldán et al., 2021). Moreover, the positive feedbacks of community awareness and engagement in the vaccination coverage in children were reported in Burkina Faso (Kagoné et al., 2019), indicating that similar approaches could be employed in the animal health sector to leverage success for zoonosis control (Buregyeya et al., 2021).

3.5.3. Technical and resources dynamics

Rabies control requires rigorous and integrated planning, with timelines, budgets and mostly accurate performance indicators as recommended by the SARE tool (Coetzer et al, 2016; Chen et al, 2021). Besides these technical requirements, the present analysis of technical and resources dynamics points to the central need for workforce motivation and commitment. If this motivation is present, their efforts to sensitize, collect and report data, and to assess impacts can help to demonstrate the socio-economic importance of rabies, the vaccination impact and to increase the political commitment (Lembo et al., 2010; Tenzin and Ward, 2012). Indeed, in many countries, rabies remains neglected and a low-priority disease due to a lack of evidence on its burden as well as on the control interventions' impact. The number of unreported bite and rabies cases is usually high in sub-Saharan Africa. In Burkina Faso where there is no active surveillance of rabies and, while an average of twenty-five human cases is reported per year (Sondo et al., 2014; Burkina Faso, 2016), no data is available regarding the livestock losses

caused by the disease. In addition, its impact in terms of costs (from vaccine purchase, travel to vaccination sites) and losses (children premature death, working time loss) is equally unknown. Therefore, in the absence of such information, such a disease may not be felt as an important public health threat for national policy – makers in comparison with other major animal and human diseases that are highly publicized, like acquired 104odell deficiency syndrome (AIDS), highly pathogenic avian influenza (HPAI), Ebola hemorrhagic fever, malaria and the current COVID-19 (Cavaca et al., 2019). In the long run, this contributes to putting a strain on rabies control, reinforcing a kind of « vicious circle of indifference » as termed by Dodet et al. (2009). We argue that strengthening personnel and efficient use of existing resources can improve the control of rabies in the country. This implies an equitable distribution of veterinary and medical expertise and human resources between urban and rural areas, preventing work overload in areas with low staffing levels (Rwashana et al., 2014; Renmans, 2018). In the long run, work overload reduces the motivation and enthusiasm of the personnel, leading to a loss of initiative and the ability of proposing innovative solutions. In this context, the « lack of financial resources » in countries, regularly presented as the main cause of ineffectiveness of rabies control (Lembo et al., 2010), is highly debatable (Saadi et al., 2021). Indeed, rabies is declared as a national priority disease, and while its control seems to be a concern for the technical services (e.g. animal health, public health, municipalities), no integrated control strategy or program has ever been developed in the country.

3.5.4. Political and organizational dynamics

On the political and organizational side, the lack of a national rabies control program was discussed by most of the stakeholders as the main weakness of dog vaccination governance in Burkina Faso. Human rabies is currently listed as one of the neglected tropical diseases for the national control program developed by the Ministry of Health (Burkina Faso, 2016). Unfortunately, animal rabies was not considered. Initiating a different national rabies control program for animals would not be cost-effective, creating additional financial support needs from the government and international partners. It would obviously miss the opportunity to take advantage of intersectorial synergies as promoted by the One Health approach (Darkaoui et al., 2017; Lechenne et al., 2017). The direct risk of separate initiatives is that they enter in competition for resources. In contrast, integrated programs allow the pooling of resources and knowledge, which is particularly needed in low-income countries (Narrod et al., 2012; Marcotty et al., 2013; Cleaveland et al., 2014). However, such an integrated initiave requires

strong leadership, communication and governance to provide the expected outcomes (Stephen and Stemshorn, 2016; Lechenne et al., 2017; Vesterinen et al., 2019).

The present study describes the cycles by which the vaccination governance plays a central role in dog rabies vaccination and the potential way to leverage those dynamics. The way the key technical services are organized to handle vaccination-related activities (vaccine distribution, short campaign organization, communication) indeed influences the dog owners compliance with vaccination (Varghese et al., 2014; Hitziger et al., 2021). It also impacts the participation of private veterinarians and the interest from other partners, including civil society, NGOs and international institutions (Marks et al., 2010). In turn, the diversity of actors involved in rabies control requires a strong leadership capable of creating synergies among actors and preventing competition for resources (Stephen and Stemshorn, 2016; Emerson, 2017). Therefore, key actions would aim at empowering stakeholders to strengthen ownership of the programs, to ease data sharing and favor transparency and trust between national stakeholders and with their international partners. However, such efforts all remain dependent on the degree of genuine prioritization of rabies on the political agenda but also among the diverse missions of technical services. Besides the lack of data that is highlighted in the present causal loops, we postulate here that the lack of effective prioritization of rabies might depend on socio-professional stakes of involved actors, which would deserve further investigation enlighted by adapted frameworks from sociology of organisations (Crozier and Friedberg, 1977).

3.5.5. Significance and usefulness of the study

To our knowledge, this study is the first proposing a system view on the possible causes of low dog vaccination coverage. In line with this objective, the study included a diverse panel of stakeholders, reflecting the complex nature of the intervention. Causal loop diagramming contributed to visualize the issue of dog rabies vaccination in a low-income setting, in a manner of facilitating its understanding by the involved stakeholders. Going beyond a first impression of overwhelming complexity, this conceptualization represents a first step to identify and promote actionable solutions. However, as a research work, the present descriptive approach does not directly offer such actionable recommendations. It provided a visualization of the dog rabies vaccination issue in different perspectives, helping a common understanding as well as the conception of transdisciplinary and actionable solutions. Indeed, these diagrams now need to be mobilized in participatory workshops to reflect with stakehoders on the entry points and

leverages that can be mobilized to induce changes in the system. Indeed, the vicious cycles identified may all be turned into virtuous cycles, provided that simultaneous efforts on key leveraging variables are identified and implemented. Balancing cycles appear as points of attention or barriers to be lifted to achieve this turn of events towards a favorable trend. Rather than a desperating set of problems, these causal loop diagrams appear as a set of gearings to be actioned. As suggested here above, further studies will be needed at the various parts of the system to produce a fine-grained understanding of the mechanism at play. For example, the outcome of interrelated causal loops will crucially depend on the distinct time delays of each of these loops. Our interviews did not generate any data on such delays, which remain fully to explore and will influence the prioritization of actions.

Nevertheless, the results already point to main actions for an improvement of rabies control in Burkina Faso. Three areas of action can be pinpointed as first steps:

1. **Awareness raising** – This study pinpoints practical aspects to be included in a renewed communication strategy: the detrimental habit of killing the biting dogs, the need for responsible dog-owning (against free-roaming and in favor of caring owners), and the right of owners to request official vaccination certificates.
2. **Data gathering and advocacy** – The sound functioning of a rabies surveillance and vaccination program would provide for such data and political awareness. However, initial data and awareness has to be produced in order to initiate this virtuous cycle. Action-research may play a role in producing these policy-relevant data. In order to combine this need with the previous point of awareness-raising in the community, pilot studies could target community-based surveillance of rabies, using apps associated with key-messages, in a stimulating collective action providing relevant feedbacks to users and contributors.
3. **Governance improvement** – The multiplicity of stakeholders calls for a clear leadership to take advantage of synergies and counter competition effects. The challenge of rabies appears here common with other zoonoses (low multisectoral engagement, inadequate resource allocation for sustainable actions, lack of locally-tailored strategies). Therefore, an integrated rabies strategy for the planning and funding of activities should be taken in charge at the level of the recently instituted national One Health Platform.

3.5.6. Strengths and limitations of the study

The strengths of this study included the fact that interviews were conducted and transcribed by the researcher, reducing translation bias. The study also included a large panel of stakeholders,

reflecting the complexity of dog rabies vaccination. In addition, the use of a causal loop based-research allows examining the barriers and facilitators affecting dog vaccination coverage, in the context of the broader rabies vaccination system. To our knowledge, this study is the first of its kind exploring the possible causes of low dog vaccination coverage in Burkina Faso with a focus on complexity. Using causal loop diagramming in this study contributed to capture the complexity involved in dog rabies vaccination in a low-income setting. There are, however, some weaknesses to this study. Indeed, interviews were conducted in only three administrative regions and the study did not include rural areas. Therefore, described factors associated with the vaccination coverage that we found may not be fully representative for the situation across all the locations of the country. In addition, the CLDs described in this study were not built through a participatory process, and therefore may not reflect all the field stakeholder categories' understanding of the dog vaccination challenges. Hence, the study reflects an interpretation of stakeholders' narratives by the research team, and then still needs to be confronted to stakeholder viewpoints and critiques.

3.6. Conclusion

The study provided a systemic view of social, economic, technical, political and organizational factors that affect the implementation of dog vaccination in Burkina Faso. The causal loop analysis facilitated the understanding and explanation of relationships between different factors and loops that influence the vaccination coverage in the dog population in Burkina Faso. Definitely, the study captures very well the complexity of One Health issues and rabies control in particular and puts in practice systems thinking in research. These findings constitute a starting point for further prioritization of the factors identified and the actions required to improve dog vaccination and rabies control.

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CHAPITRE 4

Etude 3 :

One Health strategic planning: Multi-criteria decision analysis to prioritize rabies interventions in Burkina Faso

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Madi Savadogo[1,2,5,6&], Peegdsom Simplice Assomption Yameogo[1,3], Thomas-Julian Omoijade Irabor[1,3], Rianatou Bada-Alambédji[4], Nicolas Antoine-Moussiaux[1,3]

1.Fundamental and Applied Research for Animal and Health (FARAH), Faculty of Veterinary Medicine, University of Liège, Belgium; **2.** Unité de recherche sur les Maladies à potentiel épidémique, Maladies émergentes et Zoonoses, Département de Biologie Médicale et Santé Publique, Institut de Recherche en Sciences de la Santé, Ouagadougou, Burkina Faso ; **3.** Department of Public Health, Faculty of Medicine, University of Liège, Liège, Belgium; **4.** Service de Microbiologie-Immunologie et Pathologie Infectieuse, Département de Santé Publique et Environnement, Ecole Inter-Etats des Sciences et Médecine Vétérinaires, Dakar, Sénégal ; **5.** Direction de la Santé Animale, Direction Générale des Services Vétérinaires, Ministère de l'Agriculture, des Ressources Animales et Halieutiques, Ouagadougou, Burkina Faso ; **6.** Rabies Free Burkina Faso, Ouagadougou, Burkina Faso

[&]Corresponding author : Madi Savadogo (savadogo.madi@yahoo.fr)

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CHAPITRE 4: ONE HEALTH STRATEGIC PLANNING: MULTI-CRITERIA DECISION ANALYSIS TO PRIORITIZE RABIES INTERVENTIONS IN BURKINA FASO

4.1. Abstract

Background: Rabies is recognized among the top five priority zoonotic diseases in Burkina Faso. As in other endemic countries around the world, implementing the One Health approach is a best way towards rabies control. In 2022, Burkina Faso adopted a national strategic plan (NSP) with the aim of advancing collaborative efforts towards the elimination of domestic dog-mediated human rabies by 2030. The first two years following the adoption of this strategic plan were characterized by a low level of commitment from involved stakeholders and unsuccessful implementation due to a wide range of constraints that those stakeholders are facing.

Methods: To review the ongoing strategy with these stakeholders, a multi-criteria decision analysis (MCDA) approach has been proposed to establish a prioritization of interventions. Participatory workshops joined relevant 45 institutional and community stakeholders (22 participants for human health group, 23 participants in animal health group, 45 participants for the plenary session) involved in animal and human rabies control, as well as actors from other sectors or civil society. The method was applied in parallel in two groups centred around sectoral participants from human and animal health, then combined through discussions in plenary sessions.

Results: Overall, 41 interventions were selected, related to data collection and analysis, prevention and control (e.g. Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance), laboratory diagnosis (e.g. Laboratory investigations of all suspected cases of rabies in animals), dog population management (e.g. Promotion of good waste management practices among communities), advocacy and public awareness (e.g. Development and implementation of an information-education-communication action plan on rabies), and cross-cutting issues (e.g. Development and dissemination of rabies case definitions). Seven analysis criteria were defined by the stakeholders, related to rabies elimination, strategic and operational aspects, One Health capacity development, and social impact. The results revealed distinct prioritization between the sectoral groups. However, a relative agreement could be highlighted on the importance ascribed to a set of cross-sectoral interventions, including harmonization of procedures for surveillance, data sharing as well as

prevention and control. Accordingly, interventions perceived as sector-specific were attributed with the lowest scores.

Conclusion: The results of the study inform decision-makers regarding the interventions that are best supported by implementing stakeholders, hence showing the potential for increased their ownership, commitment, and eventually efficacy.

Keywords: Zoonoses, Rabies, Strategic planning, Multi-criteria decision analysis, Integrated approaches, Rabies elimination, Public Health, One Health, Tropical Medicine, Global health, Burkina Faso

4.2. Introduction

Animal-mediated human rabies remains a global public health threat as it is responsible for a number of human deaths, with available estimates ranging from 13,743 [1-2] to 59,000 annually [3]. This major zoonotic disease affects domestic animals, wildlife and human. Moreover, previous investigations have highlighted the importance of the dog in the epidemiological cycle of the disease, as this animal is responsible for over 90% of human rabies cases [2,4-5]. To support the achievement of the third Sustainable Development Goal (SDG3) - Ensure healthy lives and promote well-being for all at all ages - a global strategic plan was launched in 2015 with the ambition of eliminating human rabies transmitted by domestic carnivores by 2030. The global strategy has triggered the operationalization and the strengthening of intersectoral collaboration, and joint assessment tools have been developed, such as the Performance of Veterinary Services (PVS) evaluation of WOAH, the International Health Regulations (IHR, 2005) tools of WHO, and the Quadripartite One Health Joint Plan of Action, to provide guidance to countries towards rabies elimination.

Despite the efforts undertaken over the years, the threat has not been significantly reduced. Like many African countries, Burkina Faso has been struggling with this animal and human health problem for decades [6-9]. To control the disease, the national authorities introduced various initiatives including rabies vaccination of domestic carnivores and post-exposure prophylaxis for bitten persons. However, the incidence of rabies cases in animals remains considerable with regularly recorded animal bites and human rabies cases by medical and veterinary services [10-11]. According to previous studies, an average of 11500 bite cases and 40 human deaths are reported annually, while post-exposure prophylaxis completion among bitten people remains challenging [4,5,11]. Indeed, only two centers (located in the two main cities of the country, Ouagadougou and Bobo Dioulasso) are able to provide post-exposure prophylaxis. In addition,

the national rabies surveillance system lacks sensitivity and responsiveness in both animal and human health. The two surveillance systems remain un-connected, thus not enabling the integrated management of rabies. Therefore, although rabies has been a notifiable disease in Burkina Faso for decades, it remains highly under-reported [5,8]. The only laboratory with rabies diagnostic capacities belongs to the animal health sector and is located in Ouagadougou. In addition, significant rabies control measures such as dog vaccination, human pre- and post-exposure prophylaxis, public awareness raising, responsible dog ownership are still not or incompletely implemented. For example, dog vaccination remains very low (ranging from 8% in rural areas to 36% in urban area), while post-exposure prophylaxis delivery is characterized by a frequent shortage of inputs and lack of knowledge among health workers [5,11].

Over the past decade, the fight against animal and human rabies in the country has been characterized by substantial progress. Many studies conducted on animal and human rabies have gradually improved the availability of epidemiological evidence across the country [4-6,11-12]. Subsequently, the One Health zoonotic diseases prioritization conducted in 2017, in the scope of the multisectoral engagement of animal, human and environment health, resulted in rabies being selected as the second disease of most concern, in a list including anthrax, brucellosis, highly pathogenic avian influenza and dengue [13]. These national efforts culminated in the creation of a formal national One Health coordination platform in 2019 [14], comprising specialized bodies, such as the thematic committee in charge of zoonotic diseases. This thematic committee, whose mandate is to formulate recommendations to improve the control of rabies and other zoonotic diseases of interest, includes stakeholders that represent domestic animal health, human health, environment and wildlife health, territorial administration, education and research entities, civil society organizations as well as international institutions. All these advances have contributed to the adoption in November 2022 of a national integrated strategic plan (NSP) aimed at ending domestic dog-mediated human rabies in the country by 2030. The NSP is aligned with the global strategic plan to end human deaths from dog-mediated rabies by 2030 [15]. It was developed by a consultant on basis of the results from the in-country stepwise approach towards rabies elimination (SARE) process, and of a template proposed by the United Against Rabies initiative, including World Organization for Animal Health, United Nations Food and Agriculture Organization, World Health Organization, and Global Alliance for Rabies Control [16-17]. However, almost two years after the NSP was adopted, the fight against the disease has not generated a satisfactory commitment from the various sectors and stakeholders, highlighting the challenge of such

cross-sectoral initiatives in general but also issues tied the social, economic and political context of Burkina Faso.

As with all zoonotic diseases, animal-mediated human rabies epidemiology is associated with complex social and ecological systems, and its control continues to be challenged by constant changes, because multiple entities and stakeholders are concerned [18-19]. Due to the socio-epidemiological features of the disease, the adoption and the implementation of control measures require effective participation of different sectors, disciplines and administrations. This is highly encouraged under the aegis of the One Health approach and provides the basis for the global strategy to eliminate human dog-mediated rabies by 2030 [15,19]. Indeed, rabies epidemiology is tied to the multiple interactions between domestic animals, wild animals, humans and their shared environment. Therefore, beyond biological knowledge and tools (including effective vaccine known since 1885), rabies control requires integrative approaches, considering the social-cultural, institutional, environmental and ecological determinants that can influence the dynamics of the virus transmission and propagation. This complexity entails the need for continuous improvement of the way transdisciplinary and multi-sectoral approaches are defined and implemented with the full participation of stakeholders, adapting interventions to local realities and spurring the needed ownership of these otherwise exogenous national strategies. Indeed, several prevention strategies exist and include interventions targeting individuals, such as the postexposure prophylaxis, as well as interventions implemented at the community level (e.g. awareness raising), including environmental waste management measures. The effectiveness of these interventions can be influenced by various factors, including social factors in the target community (knowledge, perceptions, behaviors). Implementing some of these actions may also generate unintended parallel impacts, for example on the cultural values, environment or the economy, which can counterbalance the advantages and even call into question their relevance. Moreover, these social factors and the impacts of interventions may vary depending on the local context and according to the epidemiological and social realms. Moreover, given the scarcity of resources, decision-makers are increasingly pushed to optimize public health investments, focusing on high-impact interventions. The objective of this study was therefore to examine the key issues to be considered when evaluating the effectiveness and prioritizing interventions for rabies elimination. To this end, embracing the vision and expectations of different categories of stakeholders is a key ingredient to the success of any strategy [20-21]. Therefore, participatory decision-making tools become

essential, considering the multi-sectoral and multi-actor environment of rabies management. The study methodology is based on Multi-Criteria Decision Analysis (MCDA).

MCDA provides a systematic and rigorous method to guide decision-making involving a multiplicity of actors, objectives and values. MCDA was developed at the mid of the 20th century in the field of industry and business management, to overcome the limitations of analysis that inadequately reduced complex decision-making to the consideration of a limited set of stakes, most often linked to financial perspectives [22-23]. Over the years, their use has spread to several socio-economic areas, including agriculture [24], environment [25], and public health [26]. Indeed, MCDA has been used in previous studies for risk assessment and communication [27-28], emerging diseases prioritization [29-30], analysis of public acceptance in antimicrobial resistance control [31] and designing zoonotic diseases surveillance and control strategies [32]. These reports highlight the usefulness of the method in addressing the cross-cutting and complex challenges that characterize health issues. Therefore, extending the use of MCDA to support the evaluation of One Health strategies, comparing potential alternatives, may improve both implementation and effectiveness.

This study applies MCDA to prioritize interventions proposed in the national integrated strategic plan to end human deaths from domestic dog-mediated rabies by 2030 in Burkina Faso. It aims at identifying high-impact interventions in local contexts, improving the ownership and adequacy of decision-making in the implementation of national strategies.

4.3. Material and methods

4.3.1. Study period and area

The study was conducted from May to June 2024 through two participatory workshops that brought together relevant national rabies stakeholders and experts. For logistical and security reasons, the workshops could enrol participants from six out of the thirteen administrative regions of the country (Tannounyan, Kadiogo, Nakambé, Nazinon, Guiriko, and Djoro). All administrative regions of the country have technical services responsible for planning and implementing animal health, human health, and environment-related interventions. Since 2019, as part of the implementation of the One Health approach across the country, several activities (including sensitization, joint investigations of rabies outbreaks) have been conducted to inform and train national and regional stakeholders on the challenges and issues related to global health security and the One Health approach [11].

4.3.2. Recruitment of stakeholders

In participatory approaches, the selection of stakeholders is a very critical step, as their visions and those of the entities to which they are affiliated can significantly influence the ability of the process to produce actionable solutions. This study considered as a stakeholder a person representing an entity or a group with direct responsibilities or with specific interests in animal-transmitted human rabies. A first list of stakeholders was obtained from previous study [19], and workshops conducted along the process for the development of national integrated strategic plan (unpublished national data). Subsequently, this list was reviewed by the facilitating team (i.e. the principal researcher, assisted by one human health expert and one animal health expert), discussing the relevance of each stakeholder until consensus was obtained. A final list of 45 stakeholders was established. Invitation letters were issued by the Ministry of Agriculture, Animal and Halieutic Resources and sent to stakeholders three weeks prior to the workshop start date, asking them to confirm their participation at least one week before start date. In the event of withdrawal, another stakeholder was proposed by the facilitators to receive an invitation. Finally, the workshops were attended by civil servant from the Ministry of Health (MoH, n=8), the Ministry of Livestock (MoL, n=9), the Ministry of Environment and Wildlife (MoE, n=5), the Ministry of Territorial Administration (MoT, n=3) and Ministry of National Defence (MoD, n=2). Additional participants were invited from research and education entities (n=2), civil society organizations (n=2), international institutions (n=2), private animal health services, and local communities (n=10). All participants are presented in Table 1.

Table 1: List of stakeholders involved in two groups and one plenary group discussions during the workshops

Groups	Stakeholders' disciplines or sectors	Types of organization	Number
Group 1 (human health group)	Human health	Civil society organization	1
		National public office	3
		Local public office	5
		Research institution	1
		International organization	1
	Security and defence	Army medical centre	1
	Environment	National public office	1
		Local public office	2
	Territorial administration	Administrative authorities	2
	Community	Religious leaders	3
		Community members	2
Total Group 1			***22***
Group 2 (animal health group)	Animal health	Civil society organization	1
		National public office	4

		Laboratory	2
		Local public office	3
		Private	2
		Livestock High school	1
		International organization	1
	Security and defence	Army veterinary service	1
	Environment	National public office	1
		Local public office	1
	Territorial administration	Administrative authorities	1
	Community	Religious leaders	2
		Community members	3
Total Group 2			***23***
Total of participants in the plenary group			**45**

4.3.3. Workshops for participatory prioritization

Two consecutive workshops were organized with the same participants (a two-day workshop organized in May 2024 in Manga, located in the administrative region of Nazinon, and a three-day workshop organized in June 2024 in Gaoua, located in the administrative region of Djoro). The first workshop aimed at harmonizing stakeholders' understanding of the issue. It consisted in presentations covering several rabies topics and expertise (including overview of priority zoonotic diseases in Burkina Faso, update on animal rabies control, update on human rabies control, rabies control and One Health operationalization, inter-sectoral strategy for dog-mediated human rabies elimination). Each day ended by exchanges and experience-sharing sessions between the stakeholders. The second workshop started with the presentation of the study and methodology. To ensure adequate interactive contributions and to allow at first for intra-sectoral agreements, participants were invited to form two sectoral working groups, one centred around human health and one centred around animal health. The stakeholders belonging to other sectors (i.e. environment, security and defence, territorial administration, community members) were divided in two similar and randomly assigned to the two sectoral groups (as detailed in Table 1). Indeed, in the field implementation of rabies control activities, the engagement of these cross-cutting actors is essential to ensuring the effectiveness of both sector-specific and cross-sectoral interventions. Considering the diversity of the stakeholders' backgrounds and the need to ensure their effective participation along the process, workshop was facilitated by three co-facilitators (i.e. the principal researcher, assisted by one human health expert and one animal health expert). The overall process included subsequent steps described as follows:

Step 1: Identification of meaningful interventions

Using the stepwise approach towards rabies elimination (SARE) tool [33] and the current national integrated strategic plan, six rabies control action packages were defined: data collection and analysis (DCA), prevention and control (P&C), laboratory diagnosis (LAB), dog population management (DPM), advocacy and public awareness (APA), as well as cross-cutting aspects, including legislation (CCI). In each group, participating stakeholders were invited to discuss and agree on at least five meaningful interventions within each of these six action packages. The interventions proposed by the 2 groups were summarized, discussed and validated during a plenary group session, with the objective of generating a consensual list of at least 30 alternatives considered relevant (**Annexe 1**).

Step 2: Definition of prioritization criteria

At this point, participating stakeholders discussed the developments in animal and human rabies control in the country, the key gaps and challenges, with the aim of establishing a comprehensive and shared understanding of the context [34]. Subsequently, in each group, consensual points were formulated in the form of criteria that can be used to rank identified interventions. To this end, on the basis of their understanding of the major issues regarding national efforts against animal-transmitted human rabies in the country, the facilitators proposed a list of three criteria, including proposed description and measurement scales. The aim of this support was to initiate and encourage discussions, as such an approach is often required to initiate and stimulate an active participation of stakeholders [32,35]. This list was presented, discussed and amended in each group. This step is important, as it enabled each sector, when considered individually, to identify and account for its most critical issues and expectations. Subsequently, the two lists of criteria validated in the two groups were presented, discussed, amended and adopted during a plenary session. The validated list of criteria with their categories, definitions and measurement scales is presented in **Annexe 2**.

Step 3: Weighting of prioritization criteria

Taking account of the representation of the stakeholders' value systems is essential in participatory decision process, which translates into the possibility to assign each criterion a weight that reflects its stakeholders' priorities or relative preferences [32,36]. In each group, participants were asked to divide 100 points among the seven identified criteria, allocating a higher number of points to criteria they believed to be more pivotal for advancing rabies control. Then, individual weights were summarized and discussed in each group to reach a consensus.

Finally, results obtained from the 2 groups were summarized, amended and validated during a plenary session (Figure 1).

Step 4: Intervention ranking for performance evaluation

The performance of an intervention is considered as the value of each criterion for the aforementioned intervention [37]. In the absence of quantitative evidence to support the criteria and measurement scales, the study relied on group discussions for expert's elicitation. Therefore, in each group, stakeholders discussed and assign a consensual score to each intervention on each criterion. Results by groups were summarized and discussed within the plenary session. On that basis, a plenary discussion was conducted to re-attribute consensual score to each intervention on each criterion, providing an integrative perspective to be compared to the sectoral ones.

Intervention score calculation

All data validated from the discussion sessions were entered into Excel spreadsheets by the team of facilitators. Subsequently, all computations were performed in Excel. For each selected intervention, a total score was obtained according to the following formula:

Individual intervention score = $(W_1 \times S_1) + (W_2 \times S_2) + ... + (W_i \times S_i)$, *where W corresponds to weights of respective criteria, and S the values of scales defined into each criterion*.

Thus, the interventions were ranked, representing an ordered ranking of most preferred to least preferred, taking all weighting schemes and intervention performance scores into account. Results presented in this study include the prioritization as conducted within the 2 groups as well as by the plenary group, which combines data from groups.

4.3.4. Ethical considerations

Ethical approval was obtained from the Research Ethical Committee of Université Cheikh Anta Diop (Protocole-0322/2018/CER/UCAD). All the participants to the workshops were informed about the background and purpose of the study, highlighting that their participation was voluntary, and information would be kept anonymous. In addition, the study was conducted in the scope of activities implemented by the Zoonotic Disease Thematic Working Group of the National One Health Coordination Platform.

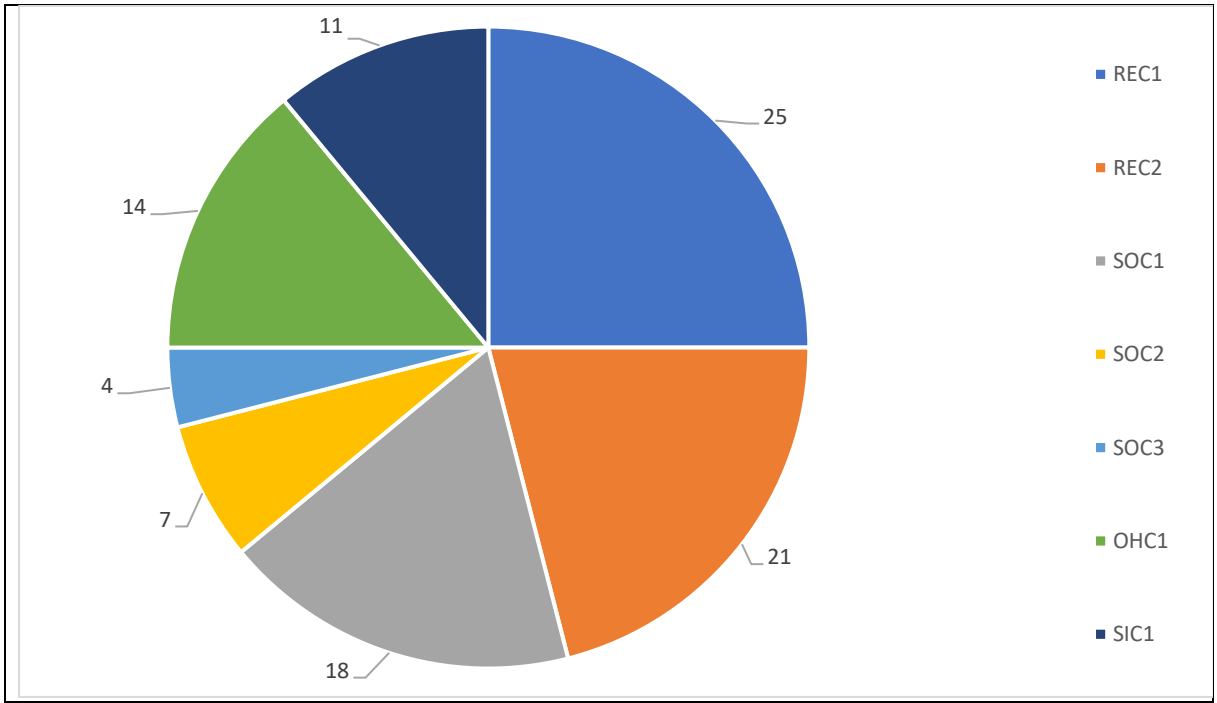
4.4. Results

4.4.1. Selected rabies interventions

Combining the two groups' choices, stakeholder discussions concluded on 41 interventions (**Annexe 1**), which were classified into 5 pre-defined action packages: data collection and analysis (DCA, 8 interventions), prevention and control (P&C, 10 interventions), laboratory diagnosis capacity (LAB, 6 interventions), dog population management (DPM, 7 interventions), advocacy and public awareness (APA, 5 interventions) and cross-cutting issues (CCI, 5 interventions).

4.4.2. Criteria for prioritization

From the discussions between stakeholders, seven criteria were defined for the assessment of the adequateness of interventions planned as part of the rabies national integrated strategic plan (**Annexe 2**). These criteria were classified into four categories: rabies elimination criteria (REC), strategic and operational criteria (SOC), One Health criteria (OHC) and social impact criteria (SIC). For each criterion, four qualitative measurement scales were described, ranked from 0 to 3 (*e.g. REC1: Reduction in incidence of animal cases; attributed scores were 0 for an intervention with no expected reduction of animal cases, 1 for an intervention resulting in a low reduction of animal cases, 2 for an intervention resulting in a moderate reduction of animal cases, or 3 for an intervention resulting in a significant reduction of animal cases*). Figure 1 shows the weighting of criteria. Rabies elimination criteria (REC1 and REC2) were attributed the highest weighting. Participants affected the lowest weights to two strategic and operational criteria, namely technical actionability (SOC2) and financial actionability (SOC3).



***REC1**: Reduction in incidence of animal cases; **REC2**: Reduction in incidence of human cases; **SOC1**: Strategic consistency; **SOC2**: Technical actionability; **SOC3**: Financial actionability; **OHC1**: building of cross-sector synergy; and **SIC1**: Level of public acceptance*

Figure 1: Weights allocated to the 7 criteria by participating stakeholders

4.4.3. Decision analysis of selected interventions in subgroups

For the human health group, total scores attributed to the interventions ranged from 1.90 to 5.11 (**Annexe 3**). The six preferred interventions were CCI4 (training decision-makers in One Health leadership), APA2 (development and implementation of an information-education-communication action plan on rabies), APA5 (development and implementation of an advocacy plan for stakeholder engagement and resources mobilization), CCI1 (development and dissemination of rabies case definitions), DPM7 (raising public awareness of responsible management of waste and domestic carnivores) and P&C (administration of PEP to all people exposed to animal bites).

For the animal health group, total scores ranged from 2.33 to 5.11 (**Annexe 4**), with the following six preferred interventions: DCA3 (development and dissemination of SOP for integrated rabies surveillance), DCA4 (development and dissemination of SOP for sharing epidemiological data on rabies), DPM7 (raising public awareness of responsible management of waste and domestic carnivores), CCI1 (development and dissemination of rabies case definitions), DCA5 (development and dissemination of SOP for the joint investigation of bite cases) and CCI2 (development and implementation of integrated bite case management).

CCI1 and DPM7 were thus top-ranked by the two groups. No intervention from the laboratory diagnosis package was present in the top six lists, the first intervention of that category ranking 17th in the human health group and 10th in the animal health group. DCA1 (study on the structure of domestic carnivore population) was listed among the six least preferred interventions for both groups.

4.4.4. Decision analysis of selected interventions in the plenary group

The plenary group decision analysis is presented in **Annexe 5**. Intervention scores varied from 1.64 to 5.36. The most preferred interventions were related to action packages such as data collection and analysis, prevention and control, dog population management, and cross-cutting and legislation issues. The combined top six preferred interventions were DCA3 (development and dissemination of SOP for integrated rabies surveillance), P&C6 (development and dissemination of SOP for biting dog observation), CCI1 (development and dissemination of rabies case definitions), DCA5 (development and dissemination of SOP for the joint investigation of bite cases), DPM2 (promotion of good waste management practices among communities), and DCA4 (development and dissemination of SOP for sharing epidemiological data on rabies). Least preferred interventions included DPM4 (control of reproduction in domestic carnivores using surgical techniques), P&C2 (training human health professionals in the administration of human PEP), LAB3 (introduction of rapid diagnostic tests for the detection of all animal rabies cases across the country), DCA2 (Study of the socio-economic impact of rabies in the country) and P&C7 (establishment of facilities for the observation of biting dogs).

4.5. Discussion

The study relied on the current national integrated strategic plan to ending domestic dog-mediated human rabies in Burkina Faso, having in mind that effective strategy planning should be a continuous processus [38]. While having a national strategy is essential for effective

disease control, both the approach used to develop the strategy and the content of the resulting plan merit critical reflection, particularly in light of evolving local contexts and the diverse rationales of involved stakeholders. In the current vision to control priority zoonotic diseases, the national decision-makers strongly emphasized the development of transdisciplinary and cross-sectoral capacities. Successfully implementing such a vision requires practical tools that promote stakeholder participation and commitment. The study demonstrated the application of participatory decision analysis tool to improve coordinated initiatives planning for rabies elimination. The study reports the first use of MCDA in the country to engage stakeholders in a perspective to continuously improving rabies strategic planning. Even more basically, this was also the first time in Burkina Faso that the stakeholders involved in the control of rabies are invited to participate directly and actively in identifying and assessing interventions, leading to a re-evaluation of priorities, such as the removal of the legislation-focused action package originally included in the global strategic plan [39].

In addition, by establishing criteria for comparing interventions, participating stakeholders expressed points that constitute their significant individual or collective interests, one of the core values of the national public health policy [40]. It is worth noting that out of the seven criteria defined, two (i.e., building of cross-sector synergy and public acceptability) were already mentioned in the national health development plan document [40-41], suggesting that the results are at least partially supportive of current plans. For all the above reasons, MCDA proved useful as a participatory approach for improved evaluation of rabies strategies and formulation of the best investment plan for diseases control [42-44].

The various interventions on which the participating stakeholders agreed covered key action packages recommended by the public health leading global institutions, and from which the national rabies strategic plan was subsequently developed [15,17,33]. This observation highlights that the use of MCDA is not intended to compromise the technical content of ongoing strategy, but rather to better inform decision-makers about the areas for investment that are best supported by local implementers, so as to increase effectiveness of rabies control initiatives. From another perspective, despite the local context characterized by limited human and financial resources allocated for rabies control [8,19,45], the stakeholders placed little importance on criteria of technical and financial actionability. This attitude may be interpreted as an awareness of the difficulty of overcoming the scarcity of resources, then leading to focus on criteria with high-impact towards rabies elimination. Furthermore, the consistency of interventions with a rabies elimination strategy was also considered as of critical interest for

stakeholders. The findings are consistent with those obtained by Del Rio Vilas et al. [42] in the Pan American Health Organization member states and Aenishaenslin et al. [32] in Canada, who reported that criteria considered to be of high-impact on animal health and human health were highly weighted by stakeholders.

When it comes to the prioritization of interventions, it was noted that cross-sectoral and collaborative initiatives were highly valued by the stakeholders. Indeed, interventions that promote standardization of procedures as well as coordinated initiatives across the sectors, mainly in the fields of epidemiological surveillance, prevention and control of animal and human rabies, were largely recognized as fundamental (more detailed description of prioritized interventions is provided in **Annexe 6**). In addition to the fact that the consistency of surveillance and prevention with rabies elimination objectives was previously demonstrated [15,46-49], the observation suggests that efforts deployed as part of the National One Health Coordination Platform's activities have probably increased awareness among stakeholders of the potential of capacity building for structuring the rabies multi-sectoral system. Nevertheless, the distinct prioritization by the human health and the animal health groups highlights the relevance of promoting One Health practice to harmonize viewpoints and tools, conduct joint and coordinated interventions to effectively control rabies and other cross-sectoral and transboundary public health threats. Compared to human health group, the interventions prioritized by animal health group were more cross-sectoral oriented. The top six preferences that emerged from the plenary group then proved more aligned with the animal health group prioritization, which may reflect a shift and convergence of perspectives towards actionable and shared solutions. This shift may have resulted from the discussions conducted by all the stakeholders at the end of each group session [50], allowing for gradual alignment which goes beyond the sole adhesion to the pre-existing viewpoint from the one or the other party. The significance of these discussions can be illustrated by the fact that DPM7 (raising public awareness of responsible management of waste and domestic carnivores), which was selected among the top six for both groups, was downgraded to 33rd position in the plenary group.

The plenary group prioritization also indicates a strong preference for procedure-related interventions. In a context where the practice of One Health is still being learned, as is the case in Burkina Faso, this preference may reflect a desire among stakeholders to first agree on common practices, embodied by common tools and standardized operating procedures. This may help operationalize One Health, providing a practical meaning to the approach, and clarify each party’s roles and responsibilities, hence preventing potential conflicts. Yet the whole

context in which the process was conducted, and particularly the fact that the workshop was organized by the animal health sector, may suggest a different interpretation of this adhesion of the human health actors to the animal health sectoral views. Indeed, Burkina Faso is in the early stages of the One Health implementation and its actors express a clear need for collaborative capacity building. Therefore, a tendency to adhere to the organizers' views may be also interpreted as a gesture of goodwill from the invited actors in the early steps of a new partnership. This uncertainty was previously described by van de Kerkhof [51], exploring the constraints of consensus in cross-group dialogues.

The significant contribution of MCDA approaches in improving decision towards coordinated management of zoonotic diseases was previously reported by several authors [32,42,52-53]. An additional point of interest at the end of the process was related to low prioritization of technically complex interventions, including decentralization of laboratory diagnosis capacities, control of reproduction in domestic carnivores and mass vaccination of domestic carnivores against rabies. This attitude of the stakeholders can be explained by the fact that, in the Burkina Faso context, these types of interventions are perceived as belonging solely to the animal health sector. Here, we need to build a communication and advocacy strategy that demonstrates the irreplaceable role of effective animal rabies management in the elimination of human rabies [54-57].

This study supports the usefulness of inter-sectorally negotiated MCDA in guiding important decision-making in the face of increasingly complex public health issues. Nevertheless, its scaling would require taking into account a number of limitations encountered during the study. First, due to time constraints, it was not possible to conduct an individual performance evaluation of the interventions by each of the participating stakeholder, which would be needed to better account for perspective diversity and avoid the group purely engulfing the value of minority perspectives. Moreover, whether intra-sectoral agreements were sought along the process, the sectoral grouping randomly involved non-human health and non-animal health stakeholders. This may provoke among these non-sectoral stakeholders a tendency to let the viewpoints of the group's sectoral members dominate the discussions. The richest way to benefit from the distinct views from non-health actors remains therefore an open question. Considering the findings, the following recommendations were proposed:

- Improve the gains generated through the collaboration between sectors, by supporting the implementation of top-ranked interventions, in particular those strengthening institutional capacities, harmonization of procedures and practices, transdisciplinary collaboration;

- Institutionalize mechanisms for dialogue within the National One Health Coordination Platform to sustain exchanges, discussions and awareness-raising regarding actions recognized as instrumental in rabies elimination strategies, but poorly classified by stakeholders, with a view to improving their consideration and feasibility;
- Adopt the MCDA methods and regularly update the prioritization as national strategy is implemented for continuous improvement.

4.6. Conclusion

The participatory decision analysis method applied in this study made it possible to identify cross-sectoral and collaborative interventions highly valued by the stakeholders. However, the difference of rankings between animal health and human health groups, low ranking of certain very technical interventions, with a demonstrated strong impact on rabies reduction, but perceived as being very sector-based ones, remain major topics to be considered in the dialogue between stakeholders on the implications of the One Health approach for effective zoonoses control. Therefore, considering the ever-changing social and epidemiological context, future progress in the field of rabies control, as well as learnings and feedbacks from the multiple stakeholders, MCDA process should be considered as an iterative practice supporting a more general intersectoral process of organisational learning.

4.7. References

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Annexe 1: List of 41 interventions used in the process of prioritization

Action packages	Codes	Interventions
Rabies data collection and analysis (DCA)	DCA1	Study on the structure of domestic carnivore population
	DCA2	Study of the socio-economic impact of rabies in the country
	DCA3	Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance
	DCA4	Development and dissemination of SOP for sharing epidemiological data on rabies
	DCA5	Development and dissemination of SOP for the joint investigation of bite cases
	DCA6	Training human health professionals in integrated rabies surveillance
	DCA7	Setting up an integrated electronic platform for sharing information on rabies
	DCA8	Training animal health professionals in integrated rabies surveillance
Rabies prevention and control (P&C)	P&C1	Administration of human postexposure prophylaxis (PEP) to all people exposed to animal bites
	P&C2	Training human health professionals in the administration of human PEP
	P&C3	Training human health professionals in the management of bite cases
	P&C4	Organization of rabies vaccination campaigns for domestic carnivores
	P&C5	Training animal health professionals in good animal vaccination practices
	P&C6	Development and dissemination of SOP for biting dog observation
	P&C7	Establishment of facilities for the observation of biting dogs
	P&C8	Training animal health professionals in animal restraint techniques
	P&C9	Administration of preexposure prophylaxis (PrEP) to all persons at high risk of exposure to rabies infection
	P&C10	Post-vaccination sero-monitoring in domestic carnivores
Laboratory diagnosis capacity (LAB)	LAB1	Setting up a sample shipping integrated system
	LAB2	Laboratory investigations of all suspected cases of rabies in animals
	LAB3	Introduction of rapid diagnostic tests for the detection of all animal rabies cases across the country
	LAB4	Laboratory investigations of all suspected cases of rabies in humans
	LAB5	Training human health professionals in sample collection
	LAB6	Training animal health professionals in sample collection

Dog population management (DPM)	DPM1	Development and implementation of a dog population management action plan
	DPM2	Promotion of good waste management practices among communities
	DPM3	Training animal health professionals in responsible management of domestic animals
	DPM4	Control of reproduction in domestic carnivores using surgical techniques
	DPM5	Control of reproduction in domestic carnivores using chemical techniques
	DPM6	Organization of stray dog culling campaigns
	DPM7	Raising public awareness of responsible management of waste and domestic carnivores
Advocacy and public awareness (APA)	APA1	Assessment of Knowledge-Attitudes-Practice (KAP) on rabies
	APA2	Development and implementation of an information-education-communication action plan on rabies
	APA3	Assessment of One Health stakeholders training needs
	APA4	Integrating rabies education into primary and secondary school curricula
	APA5	Development and implementation of an advocacy plan for stakeholder engagement and resources mobilization
Cross-cutting issues, including legislation (CCI)	CCI1	Development and dissemination of rabies case definitions
	CCI2	Development and implementation of integrated bite case management
	CCI3	Training One Health professionals in community awareness of rabies prevention
	CCI4	Training decision-makers in One Health leadership
	CCI5	Promotion of the use of mobile technologies in rabies control initiatives

Annexe 2: Criteria and description of measurement scales used to prioritize interventions

Category	**Criteria**	**Description of each scale of the criteria**	**Score**
Rabies elimination criteria (REC)	REC1: Reduction in incidence of animal cases	Intervention with no expected reduction of animal cases	0
		Intervention resulting in a low reduction of animal cases	1
		Intervention resulting in a moderate reduction of animal cases	2
		Intervention resulting in a significant reduction of animal cases	3
	REC2: Reduction in incidence of human cases	Intervention with no expected reduction of human cases	0
		Intervention resulting in a low reduction of human cases	1

		Intervention resulting in a moderate reduction of human cases	2
		Intervention resulting in a significant reduction of human cases	3
Strategic and operational criteria (SOC)	SOC1: Strategic consistency	Intervention not required for rabies elimination	0
		Intervention considered marginal for rabies elimination	1
		Intervention considered useful, not essential for rabies elimination	2
		Intervention considered essential for rabies elimination	3
	SOC2: Technical actionability	Intervention considered technically unfeasible at present	0
		Intervention considered technically difficult to implement, requiring skills or equipment not available locally	1
		Implementation of intervention requires moderate upgrading in technical resources	2
		Intervention considered easy to implement with available technical resources	3
	SOC3: Financial actionability	Very expensive and no available or mobilizable budget	0
		High cost or improbable budget for intervention	1
		Moderate cost intervention or likely to be funded	2
		Low-cost intervention or budget already available or easy to mobilize	3
One health criteria (OHC)	OHC1: building of cross-sectoral synergy	Completely sector-based intervention, with no links to other sectors	0
		Mostly sector-based intervention, with occasional collaboration	1
		Intervention involves two sectors with a partial collaboration	2
		Intervention requires or reinforces strong intersectoral collaboration	3
Social impact criteria (SIC)	SIC1: Level of public acceptance	Intervention more likely to be refused by the community	0
		Intervention with low risk of acceptance by certain groups in the community	1
		Intervention may require advance awareness raising	2
		Intervention well perceived within the community	3

Annexe 3: Human health group ranking of the interventions

Interventions	Score	Rank
CCI4 - Training decision-makers in One Health leadership	5.11	1
APA2 - Development and implementation of an information-education-communication action plan on rabies	4.85	2
APA5 - Development and implementation of an advocacy plan for stakeholder engagement and resources mobilization	4.84	3
CCI1 - Development and dissemination of rabies case definitions	4.84	4
DPM7 - Raising public awareness of responsible management of waste and domestic carnivores	4.68	5
P&C1 - Administration of human postexposure prophylaxis (PEP) to all people exposed to animal bites	4.47	6
P&C2 - Training human health professionals in the administration of human PEP	4.46	7
DCA6 - Training human health professionals in integrated rabies surveillance	4.26	8
APA3 - Assessment of One Health stakeholders training needs	4.25	9
CCI2 - Development and implementation of integrated bite case management	4.22	10
DCA3 - Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance	4.20	11
DCA4 - Development and dissemination of SOP for sharing epidemiological data on rabies	4.20	12
DCA5 - Development and dissemination of SOP for the joint investigation of bite cases	4.20	13
P&C9 - Administration of preexposure prophylaxis (PrEP) to all persons at high risk of exposure to rabies infection	4.19	14
APA1 - Assessment of Knowledge-Attitudes-Practice (KAP) on rabies	4.14	15
DPM6 - Organization of stray dog culling campaigns	4.11	16
LAB2 - Laboratory investigations of all suspected cases of rabies in animals	3.97	17
P&C3 - Training human health professionals in the management of bite cases	3.95	18
LAB5 - Training human health professionals in sample collection	3.93	19
P&C6 - Development and dissemination of SOP for biting dog observation	3.87	20
DCA8 - Training animal health professionals in integrated rabies surveillance	3.84	21
P&C5 - Training animal health professionals in good animal vaccination practices	3.75	22
LAB1 - Setting up a sample shipping integrated system	3.72	23
LAB6 - Training animal health professionals in sample collection	3.68	24
DPM1 - Development and implementation of a dog population management action plan	3.65	25
P&C8 - Training animal health professionals in animal restraint techniques	3.62	26

DPM2 - Promotion of good waste management practices among communities	3.47	27
CCI3 - Training One Health professionals in community awareness of rabies prevention	3.44	28
CCI5 - Promotion of the use of mobile technologies in rabies control initiatives	3.32	29
DPM3 - Training animal health professionals in responsible management of domestic animals	3.31	30
APA4 - Integrating rabies education into primary and secondary school curricula	3.13	31
DPM5 - Control of reproduction in domestic carnivores using chemical techniques	3.02	32
P&C4 - Organization of rabies vaccination campaigns for domestic carnivores	2.92	33
DCA7 - Setting up an integrated electronic platform for sharing information on rabies	2.91	34
LAB4 - Laboratory investigations of all suspected cases of rabies in humans	2.81	35
DPM4 - Control of reproduction in domestic carnivores using surgical techniques	2.68	36
LAB3 - Introduction of rapid diagnostic tests for the detection of all animal rabies cases across the country	2.66	37
DCA2 - Study of the socio-economic impact of rabies in the country	2.51	38
P&C7 - Establishment of facilities for the observation of biting dogs	2.21	39
DCA1 - Study on the structure of domestic carnivores	2.19	40
P&C10 - Post-vaccination sero-monitoring in domestic carnivores	1.90	41

Annexe 4: Animal health group ranking of the interventions

Interventions	**Score**	**Rank**
DCA3 - Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance	5.11	1
DCA4 - Development and dissemination of SOP for sharing epidemiological data on rabies	5.11	2
DPM7 - Raising public awareness of responsible management of waste and domestic carnivores	5.11	3
CCI1 - Development and dissemination of rabies case definitions	5.05	4
DCA5 - Development and dissemination of SOP for the joint investigation of bite cases	4.92	5
CCI2 - Development and implementation of integrated bite case management	4.87	6
P&C6 - Development and dissemination of SOPs for biting dog observation	4.51	7
APA1 - Assessment of Knowledge-Attitudes-Practice (KAP) on rabies	4.51	8
P&C2 - Training human health professionals in the administration of human postexposure prophylaxis (PEP)	4.4	9

LAB6 - Training animal health professionals in sample collection	4.33	10
CCI5 - Promotion of the use of mobile technologies in rabies control initiatives	4.3	11
LAB5 - Training human health professionals in sample collection	4.29	12
LAB2 - Laboratory investigations of all suspected cases of rabies in animals	4.23	13
DCA6 - Training human health professionals in integrated rabies surveillance	4.21	14
P&C4 - Organization of rabies vaccination campaigns for domestic carnivores	4.19	15
P&C8 - Training animal health professionals in animal restraint techniques	4.19	16
DPM2 - Promotion of good waste management practices among communities	4.05	17
P&C5 - Training animal health professionals in good animal vaccination practices	4.04	18
APA2 - Development and implementation of an information-education-communication action plan on rabies	4.02	19
P&C10 - Post-vaccination sero-monitoring in domestic carnivores	3.97	20
APA5 - Development and implementation of an advocacy plan for stakeholder engagement and resources mobilization	3.95	21
CCI4 - Training decision-makers in One Health leadership	3.95	22
DPM1 - Development and implementation of a dog population management action plan	3.9	23
CCI3 - Training One Health professionals in community awareness of rabies prevention	3.86	24
LAB4 - Laboratory investigations of all suspected cases of rabies in humans	3.68	25
LAB1 - Setting up a sample shipping integrated system	3.61	26
DPM3 - Training animal health professionals in responsible management of domestic animals	3.61	27
P&C3 - Training human health professionals in the management of bite cases	3.55	28
P&C1 - Administration of human PEP to all people exposed to animal bites	3.42	29
DCA2 - Study of the socio-economic impact of rabies in the country	3.41	30
P&C9 - Administration of preexposure prophylaxis (PrEP) to all persons at high risk of exposure to rabies infection	3.35	31
LAB3 - Introduction of rapid diagnostic tests for the detection of all animal rabies cases across the country	3.2	32
DCA7 - Setting up an integrated electronic platform for sharing information on rabies	3.09	33
P&C7 - Establishment of facilities for the observation of biting dogs	3.09	34
DPM6 - Organization of stray dog culling campaigns	2.98	35
DCA1 - Study on the structure of domestic carnivores	2.92	36
APA3 - Assessment of One Health stakeholders training needs	2.91	37

DPM5 - Control of reproduction in domestic carnivores using chemical techniques	2.85	38
DCA8 - Training animal health professionals in integrated rabies surveillance	2.5	39
DPM4 - Control of reproduction in domestic carnivores using surgical techniques	2.34	40
APA4 - Integrating rabies education into primary and secondary school curricula	2.33	41

Annexe 5: Plenary group ranking of the interventions

Interventions	**Score**	**Rank**
DCA3 - Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance	5.36	1
P&C6 - Development and dissemination of SOP for biting dog observation	5.14	2
CCI1 - Development and dissemination of rabies case definitions	5.09	3
DCA5 - Development and dissemination of SOP for the joint investigation of bite cases	5.00	4
DPM2 - Promotion of good waste management practices among communities	4.96	5
DCA4 - Development and dissemination of SOP for sharing epidemiological data on rabies	4.79	6
P&C4 - Organization of rabies vaccination campaigns for domestic carnivores	4.49	7
APA2 - Development and implementation of an information-education-communication action plan on rabies	4.49	8
LAB6 - Training animal health professionals in sample collection	4.48	9
LAB5 - Training human health professionals in sample collection	4.18	10
LAB2 - Laboratory investigations of all suspected cases of rabies in animals	4.12	11
P&C8 - Training animal health professionals in animal restraint techniques	4.01	12
APA4 - Integrating rabies education into primary and secondary school curricula	3.96	13
CCI5 - Promotion of the use of mobile technologies in rabies control initiatives	3.95	14
CCI4 - Training decision-makers in One Health leadership	3.78	15
CCI2 - Development and implementation of integrated bite case management	3.77	16
DPM6 - Organization of stray dog culling campaigns	3.75	17
APA5 - Development and implementation of an advocacy plan for stakeholder engagement and resources mobilization	3.69	18
P&C10 - Post-vaccination sero-monitoring in domestic carnivores	3.56	19
APA1 - Assessment of Knowledge-Attitudes-Practice (KAP) on rabies	3.45	20

P&C1 - Administration of human postexposure prophylaxis (PEP) to all people exposed to animal bites	3.44	21
P&C5 - Training animal health professionals in good animal vaccination practices	3.41	22
DPM3 - Organization of stray dog culling campaigns	3.37	23
DCA1 - Study on the structure of domestic carnivore populations	3.35	24
DPM5 - Control of reproduction in domestic carnivores using chemical techniques	3.29	25
DPM1 - Development and implementation of a dog population management action plan	3.26	26
DCA7 - Setting up an integrated electronic platform for sharing information on rabies	3.23	27
DCA8 - Training animal health professionals in integrated rabies surveillance	3.19	28
APA3 - Assessment of One Health stakeholders training needs	3.11	29
DCA6 - Training human health professionals in integrated rabies surveillance	3.11	30
P&C3 - Training human health professionals in the management of bite cases	3.06	31
CCI3 - Training One Health professionals in community awareness of rabies prevention	3.05	32
DPM7 - Raising public awareness of responsible management of waste and domestic carnivores	2.96	33
LAB4 - Laboratory investigations of all suspected cases of rabies in humans	2.79	34
P&C9 - Administration of preexposure prophylaxis (PrEP) to all persons at high risk of exposure to rabies infection	2.77	35
LAB1 - Setting up a sample shipping integrated system	2.77	36
P&C7 - Establishment of facilities for the observation of biting dogs	2.66	37
DCA2 - Study of the socio-economic impact of rabies in the country	2.56	38
LAB3 - Introduction of rapid diagnostic tests for the detection of all animal rabies cases across the country	2.06	39
P&C2 - Training human health professionals in the administration of human PEP	1.95	40
DPM4 - Control of reproduction in domestic carnivores using surgical techniques	1.64	41

Annexe 6: Summary description of the top six interventions prioritized by groups

Top interventions prioritized by groups	Detailed description of the top interventions
Human health group prioritized interventions	
CCI4 - Training decision-makers in One Health leadership	The objective is to equip leaders with practical knowledge and tools to effectively coordinate between sectors, anticipate emerging threats, and implement integrated and sustain able policies. The training consists in strengthening their skills in promoting collaborative governance at the human, animal, and environmental health interface. It includes topics such as understanding One Health principles, participatory and cross-sectoral management, evidence-based decision-making, strategic communication, and health crisis management.
APA2 - Development and implementation of an information-education-communication action plan on rabies	This aims to enhance understanding, encourage dog vaccination, and promote safe practices in order to sustainably reduce the incidence of rabies. The development and implementation of a communication, information, and education plan on rabies aim to raise awareness among communities, professionals, and decision-makers about risks, prevention measures, and appropriate behaviours. This plan includes designing culturally appropriate messages, using diverse channels (traditional media, social networks, community campaigns, schools, health facilities, etc.) and strengthening the capacities of involved stakeholders.
APA5 - Development and implementation of an advocacy plan for stakeholder engagement and resources mobilization	This intervention aims to create an enabling environment for rabies control. This plan includes identifying and analyzing key actors, formulating tailored messages for each target group, establishing dialogue and influence strategies, and organizing high-level meetings. The objective is to strengthen political and institutional commitment, foster intersectoral collaboration, and ensure the availability of financial, material, and human resources needed to achieve rabies elimination goals.
CCI1 - Development and dissemination of rabies case definitions	This intervention ensures harmonized detection, reporting, and management of cases across the relevant sectors. This process includes adapting definitions to international standards, validating them at the national level, and disseminating them to human health, animal health, and laboratory services. The objective is to improve the quality of surveillance data, strengthen comparability across sectors and regions, and facilitate a rapid and coordinated response to advance towards rabies elimination in the country.
DPM7 - Raising public awareness of responsible	This intervention aims to reduce the risk of rabies transmission. This action includes promoting responsible dog care (vaccination, identification, control of roaming), raising community awareness on the importance of urban

management of waste and domestic carnivores	cleanliness and waste management, and engaging local authorities and community associations. The objective is to decrease the roaming dog population, limit risky interactions between animals and humans.
P&C1 - Administration of human postexposure prophylaxis (PEP) to all people exposed to animal bites	The administration of PEP to individuals at risk of rabies is a key measure for preventing human rabies. It involves the rapid assessment of exposure, immediate and proper wound cleaning, rabies vaccination, and the administration of rabies immunoglobulin according to relevant guidelines. The objective is to ensure prompt, accessible, and effective care for all exposed individuals, in order to prevent the occurrence of human rabies cases
Animal health group prioritized interventions	
DCA3 - Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance	The development and implementation of SOPs aim to harmonize practices in data collection, analysis, and sharing across the human, animal, and environmental health sectors. These SOPs cover key steps such as the detection of suspected cases, laboratory confirmation, reporting to the relevant authorities, and feedback to communities. The objective is to strengthen the quality and reliability of surveillance systems, promote interoperability between sectors, and enable a rapid and coordinated response (including integrated bite case management) contributing to rabies elimination.
DCA4 - Development and dissemination of SOPs for sharing epidemiological data on rabies	This aims to establish clear and harmonized mechanisms for information exchange across the human, animal, and environmental health sectors. The SOPs define the types of data to be collected, stakeholder responsibilities, frequency and channels of transmission, as well as validation and feedback processes. The objective is to ensure transparency, improve the quality of shared data, strengthen intersectoral coordination, and support rapid, evidence-based decision-making for rabies control.
DPM7 - Raising public awareness of responsible management of waste and domestic carnivores	Increasing awareness for responsible dog ownership and waste management aims to reduce the risk of rabies transmission. This action includes promoting responsible dog care (vaccination, identification, control of roaming), raising community awareness on the importance of urban cleanliness and waste management, and engaging local authorities and community associations. The objective is to decrease the roaming dog population, limit risky interactions between animals and humans.
CCI1 - Development and dissemination of rabies case definitions	This intervention ensures harmonized detection, reporting, and management of cases across the relevant sectors. This process includes adapting definitions to international standards, validating them at the national level, and disseminating them to human health, animal health, and laboratory services. The objective is to improve the quality

	of surveillance data, strengthen comparability across sectors and regions, and facilitate a rapid and coordinated response to advance towards rabies elimination in the country.
DCA5 - Development and dissemination of SOP for the joint investigation of bite cases	This intervention aims to strengthen collaboration between the human health, animal health, and other relevant sectors. These SOPs define the roles and responsibilities of each stakeholder, outline investigation steps (notification, collection of information on the biting animal, follow-up of bitten persons, laboratory analyses, postexposure prophylaxis provision), and establish coordination and communication mechanisms among technical services. The objective is to ensure rapid and coordinated management of bite cases, reduce the risk of rabies transmission, and improve data quality to guide prevention and control interventions.
CCI2 - Development and implementation of integrated bite case management	Establishing procedures for an integrated management of bite cases aim to ensure prompt, coordinated, and appropriate care of exposed individuals, while ensuring proper follow-up of the animals involved. These SOPs define key steps: risk assessment, immediate wound washing, administration of post-exposure prophylaxis, clinical and/or laboratory follow-up of the biting animal, as well as communication between human health, animal health, and community. The objective is to reduce the risk of rabies transmission, optimize the use of available resources, and improve data quality to guide prevention and control strategies.
Plenary group prioritized interventions	
DCA3 - Development and dissemination of standard operating procedures (SOP) for integrated rabies surveillance	The development and implementation of SOPs aim to harmonize practices in data collection, analysis, and sharing across the human, animal, and environmental health sectors. These SOPs cover key steps such as the detection of suspected cases, laboratory confirmation, reporting to the relevant authorities, and feedback to communities. The objective is to strengthen the quality and reliability of surveillance systems, promote interoperability between sectors, and enable a rapid and coordinated response (including integrated bite case management) contributing to rabies elimination.
P&C6 - Development and dissemination of SOP for biting dog observation	This intervention aims to harmonize the management of rabies high-risk situations. These SOPs specify practical modalities for capture or quarantine, the duration and conditions of quarantine, the daily clinical monitoring of the animal, as well as the respective responsibilities of veterinary services, owners and local authorities. The objective is to detect early any signs of rabies in the biting animal, guide the management of exposed individuals, and strengthen community trust in the rabies surveillance and control system.
CCI1 - Development and dissemination of rabies case definitions	This intervention ensures harmonized detection, reporting, and management of cases across the relevant sectors. This process includes adapting definitions to international standards, validating them at the national level, and disseminating them to human health, animal health, and laboratory services. The objective is to improve the quality

	of surveillance data, strengthen comparability across sectors and regions, and facilitate a rapid and coordinated response to advance towards rabies elimination in the country.
DCA5 - Development and dissemination of SOP for the joint investigation of bite cases	This intervention aims to strengthen collaboration between the human health, animal health, and other relevant sectors. These SOPs define the roles and responsibilities of each stakeholder, outline investigation steps (notification, collection of information on the biting animal, follow-up of bitten persons, laboratory analyses, postexposure prophylaxis provision), and establish coordination and communication mechanisms among technical services. The objective is to ensure rapid and coordinated management of bite cases, reduce the risk of rabies transmission, and improve data quality to guide prevention and control interventions.
DPM2 - Promotion of good waste management practices among communities	This action includes raising community awareness on proper waste collection and disposal, establishing accessible collection points, and engaging local authorities, schools, and community associations. The objective is to limit the availability of food sources for roaming dogs, prevent the spread of zoonotic diseases such as rabies, and improve the cleanliness and safety of living environments.
DCA4 - Development and dissemination of SOP for sharing epidemiological data on rabies	This aims to establish clear and harmonized mechanisms for information exchange across the human, animal, and environmental health sectors. The SOPs define the types of data to be collected, stakeholder responsibilities, frequency and channels of transmission, as well as validation and feedback processes. The objective is to ensure transparency, improve the quality of shared data, strengthen intersectoral coordination, and support rapid, evidence-based decision-making for rabies control.

CHAPITRE 5

Etude 4 :

The Rabies Free Burkina Faso initiative: An example of how One Health-oriented civil society organizations can contribute towards the achievement of the rabies Zero by 30 goal

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Madi Savadogo[1,2,3], Laibané Dieudonné Dahourou[1,4], Abdoul Kader Ilboudo[1,2,5], Sidwatta Guy Ilboudo[1,5], Hamidou Zangré[1,6], Grissoum Tarnagda[1,2], Zacharia Souli[1], Alima Hadjia Banyala Combari[1,7], Ramata Diarra[1], Mémouna Bidima[1], Marina Gracienne Bintou Traoré[1], Charles Dieudonné Mandé[1], Kongnimissom Apoline Sondo[1,8], Katinka de Balogh[9]

[1]Rabies Free Burkina Faso, Ouagadougou, Burkina Faso; [2] Institut de Recherche en Sciences de la Santé, Centre Nationale de la Recherche Scientifique et Technologique, Ouagadougou, Burkina Faso; [3] Fundamental and Applied Research for Animals and Health (FARAH), Faculty of Veterinary Medicine, University of Liege, Belgium; [4]Institut des Sciences de l'Environnement et du Développement Rural, Université de Dédougou, Burkina Faso; [5] International Livestock Research Institute, Ouagadougou, Burkina Faso; [6] Direction Générale des Services Vétérinaires, Ministère de l'Agriculture des Ressources Animales et Halieutiques, Ouagadougou, Burkina Faso; [7] Institut de l'Environnement et de la Recherche Agricole, Centre Nationale de la Recherche Scientifique et Technologique; [8] Unité de Formation et de Recherche en Sciences de la Santé, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso; [9] Division of Infectious Diseases and Immunology, Department Biomolecular Health Sciences, Faculty of Veterinary Medicine, University of Utrecht, Utrecht, the Netherlands

Corresponding author : Madi Savadogo (savadogo.madi@yahoo.fr)

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CHAPITRE 5: THE RABIES FREE BURKINA FASO INITIATIVE: AN EXAMPLE OF HOW ONE HEALTH-ORIENTED CIVIL SOCIETY ORGANIZATIONS CAN CONTRIBUTE TOWARDS THE ACHIEVEMENT OF THE RABIES ZERO BY 30 GOAL

5.1. Abstract

While technologies, tools and expertise have proven that countries can be made safe from dog-mediated human rabies, the disease remains a major public health threat in Burkina Faso. The paper reports the experience and success stories of Rabies Free Burkina Faso, an initiative established in 2020 as an example of civil society organization that promotes One Health for integrated rabies control in Africa. As recommended in the Global strategic plan, rabies elimination requires a systematic One Health approach, enhancing pre-exposure and postexposure prophylaxis, dog population management, dog vaccination, awareness raising, diagnosis, surveillance, funding as well as policies and regulations. Rabies Free Burkina Faso was established on 28 September 2020 as not-for-profit organization and aims to strengthen the use of a One Health approach as a non-governmental, multidisciplinary initiative dedicated to promoting rabies elimination. Categories of interventions developed by Rabies Free Burkina Faso cover awareness raising, training and One Health capacity building, dog rabies vaccination, seeking vaccines and providing support, including financial resource to communities to ensure that bite victims are appropriately provided with post-exposure prophylaxis, research, community engagement and joint outbreak investigation in collaboration with competent authorities. Reported success stories confirm the relevance of roles that can be played by Rabies Free Burkina Faso supporting animal health and human health authorities in the fields of rabies control and One Health development in the country.

Keywords: Public Health, Zoonoses, One Health, Not-for-profit organization, Rabies education, Transdisciplinary

5.2. Background

Rabies is a serious challenge for animal health and human health, particularly in low- and middle-income countries like Burkina Faso. It affects wild and domestic animals, and is transmitted to humans predominantly through bites, licks and scratches from rabid animals, mostly dogs [1]. Despite some initiatives regarding rabies prevention and control having been implemented (dog vaccination, policy development, postexposure prophylaxis, awareness creation for general public or specific groups) by national authorities in charge of animal health and human health, the available data indicates that the disease has been present in Burkina Faso

for decades [2,3,4]. Moving ahead, the global rabies elimination strategy developed by the Tripartite (World Health Organization, Food and Agriculture Organization of the United Nations, World Organisation for Animal Health) and Global Alliance for Rabies Control (GARC), recommends One Health action at national, regional and international levels to meet the global objective of zero human deaths from dog-mediated rabies by 2030 [5]. The One Health concept promotes multisectoral, transdisciplinary, transboundary, and community-oriented collaboration [6]. Global health threats such as emerging antimicrobial resistance, foodborne diseases, zoonoses (e.g. highly pathogenic avian influenza, tuberculosis, Ebola, rabies), and the COVID-19 pandemic highlighted that human health, animal health and environment health are interconnected [7,8]. Overall, the importance of the One Health approach for rabies control is widely recognized, and the disease is even mentioned as a model for One Health capacity building [5]. According to the GARC website the theme identified for the celebration of World Rabies Day 2023 is «Rabies: All for 1, One Health for all» (https://rabiesalliance.org/world-rabies-day).

In Burkina Faso, canine rabies is endemic with several human cases recorded every year [2,3,9]. It is under-reported and the available data do not allow to determine the real burden of the disease in the country. The fight against rabies in the country involves different public and private entities, especially in human health and animal health sectors [10,11,12]. Postexposure prophylaxis is provided by two rabies vaccination centres located in Ouagadougou and Bobo Dioulasso, the biggest cities of the country. Health facilities across the country are involved in the management of human cases and surveillance of human rabies is performed by technical services of the Ministry of Health both at the national and local levels. When it comes to the prevention and control of animal rabies, interventions such as policy development, dog vaccination, laboratory diagnosis, and surveillance are conducted by the veterinary services of the Ministry of Livestock. In addition, private veterinarians play key roles, including dog vaccination, awareness raising, biting dog observation and rabies vaccine supply. A study conducted by Savadogo et al. provides a more in-depth characterization of actors and roles in rabies control in the country [12]. In the absence of an operational integrated bite case management approach [13], the communication and data sharing between the stakeholders involved in the control of the disease are lacking, especially between medical and veterinary services. Multi-sectoral engagement and One Health collaboration, including community education are needed for effective rabies control. Currently, it still appears, that the fight against rabies remains a concern of only government entities, leaving aside the potential contributions

that civil society organizations could strengthen national efforts including resource mobilization.

This paper presents the model and success story of the Rabies Free Burkina Faso initiative, the first One Health oriented civil society organization dedicated to rabies prevention and control in Burkina Faso. It set out to enable rabies control and working at the frontline in the fight against rabies. It to supports government and partners' efforts by strengthening awareness raising, building One Health capacity and mobilizing diverse stakeholders across disciplines for integrated surveillance and response (e.g. joint investigation, dog vaccination, postexposure prophylaxis). In what follows, we describe the different steps from the idea to the establishment of Rabies Free Burkina Faso, the areas of intervention and corresponding success stories, the challenges identified, and finally the key lessons learned. This paper intends to be inspirational for other countries encountering similar conditions and challenges in the elimination of dog-transmitted rabies.

5.3. The establishment of Rabies Free Burkina Faso

5.3.1. Reasons for creating a civil society organization

The relevance of civil society activism for improved health systems has been documented in the Global South, for example in the fields of health policy making, acquired immunodeficiency syndrome control as well as maternal and reproductive health [14,15,16]. In response to the prioritization of rabies and a recognized need of strengthened control of the disease in the country, Rabies Free Burkina Faso was launched in 2020. It is an example of building on achievements of the rabies community, demonstrating concrete accomplishments in the fight against the disease. In order to better inform decision-makers, founding members of the association have devoted many years to conduct situational research and build evidence on the rabies epidemiological status [3,9] as well as develop an understanding of community knowledge, attitudes and practices [17,18]. Subsequently, during the national One Health zoonotic diseases prioritization (OH-ZDP) conducted in 2017, rabies was ranked among the top five priority zoonotic diseases together with anthrax, tuberculosis, highly pathogenic avian influenza, and dengue [19].

This One Health zoonotic disease prioritization enabled key stakeholders (Ministry of Livestock, Ministry of Health, Ministry of Environment and Wildlife) and partners to develop multisectoral collaboration and coordination mechanisms. Taking examples from other countries in the sub-region [20, 21, 22], Burkina Faso set up a national One Health coordination

platform (Plateforme Nationale de Coordination One Health) in 2019 with the aim of providing stakeholders with a legal framework for the operationalization of the One Health approach [12]. Despite this government policy, this did not result in any significant initiatives for rabies control in the country. For example, the situation is characterized by low rabies surveillance, low dog rabies vaccination coverage, the lack of national rabies vaccination campaigns as well as frequent postexposure prophylaxis shortages. Moreover, following the outbreak of the SARS-CoV-2pandemic, in 2020 the annual World Rabies Day organized by the government as the national flagship to raise awareness, was cancelled. This was not surprising as rabies, despite its high burden in terms of human deaths in more than 150 endemic countries [23], is still considered a neglected infectious disease. The vicious circle of neglect of rabies described in African countries is very illustrative and has hindered the progress towards the elimination of the disease [24,25].

Nevertheless, since high level political will is increasing as shown by the selection of rabies among the top five priority zoonotic diseases, and the establishment of the national One Health coordination platform [26], founding members of Rabies Free Burkina Faso started thinking about mechanisms to address gaps and how best to support the government efforts through an action-oriented approach. Finally, on September 20, 2020, after the launch of the United Against Rabies Forum and the joint appeal by the Directors General of the Tripartite, the founding members decided to create a multidisciplinary organization dedicated to animal and human rabies elimination in Burkina Faso. This led to the establishment of Rabies Free Burkina Faso on 28 September 2020, highlighting the importance of World Rabies Day, as no government activity was planned to commemorate this global event that year.

5.3.2. Setting-up Rabies Free Burkina Faso to operationalize One Health

As required by national regulations concerning non-for-profit organizations, the process to establish Rabies Free Burkina Faso culminated in the official approval by the Ministry of Territorial Administration [27]. The approval is issued once the government is aware of the missions and areas of intervention of the entity to be created.

Phase one consisted of preparatory activities. All required legal documents (statutes, and rules of procedure) were elaborated according to the national requirement, and validated by a working group composed of veterinarians and medical doctors, as well as participants to be invited to a one day One Health workshop on 28 September 2020. Professionals from different disciplines (animal health, human health, environment, wildlife, anthropology and social

sciences, communication and journalism, biology, statistics, economics and management) and sectors (public, private, NGOs) were invited to this meeting with the objective of discussing the roles of their respective disciplines in rabies control, and the establishment of multidisciplinary association : Rabies Free Burkina Faso for strengthened One Health action for rabies control in Burkina Faso.

The workshop took place in Ouagadougou, the capital city of Burkina Faso. During the first half day, three presentations on animal and human rabies were provided. The first speaker was from the animal health sector and presented the epidemiology and the management of animal rabies. The second presentation was provided by the human health sector on the occurrence of human rabies cases and prevailing gaps in rabies prevention in humans in Burkina Faso. Discussions following these presentations highlighted a lack of rabies awareness among the general public [9], limited access to postexposure prophylaxis for people exposed to rabies [28] and the need of capacity strengthening for animal health and human health students and professionals [12,29]. Finally, the last speaker focused on the One Health concept and its added-value in achieving animal and human rabies elimination, in line with the Zero by 30 global objective [30]. The enthusiastic mobilization and discussions between the participants on this occasion demonstrated that such an integrated initiative was long needed by the actors. On the second half day, all participants agreed to co-found a multidisciplinary association dedicated to tackle rabies and validated the legal documents that had been developed (statutes, and rules of procedure), authorizing the appointment of a Coordination Committee for Rabies Free Burkina Faso. Embracing the spirit of the One Health concept, five Technical Coordination groups were established under the Coordination Committee: Animal Health, Human Health, Community Engagement, Communication, and Research & Innovations (Figure 1).

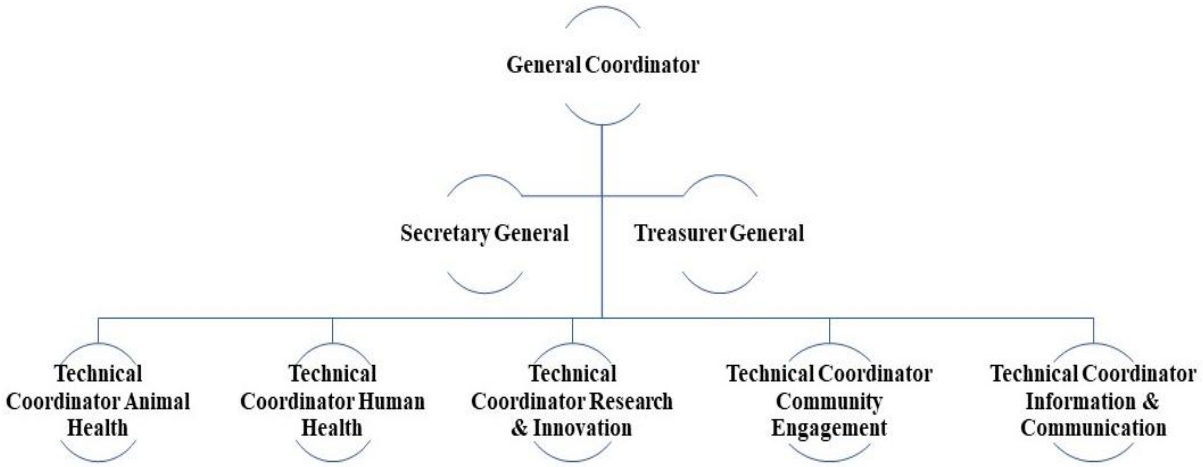

Figure 1 : Organization chart of Rabies Free Burkina Faso

The competent authorities were informed about the establishment of the civil society association. Subsequently, Rabies Free Burkina Faso was approved by the Ministry of Territorial Administration under registration number 000001115801 issued on 18 May 2021 (Figure 2). In addition, the creation of the association was published in the Official Journal of Burkina Faso (N°37, page 3065-3066, dated 16 September 2021). Since then, Rabies Free Burkina Faso has become part of national associations permitted to operate in the field of rabies control and related public health issues.

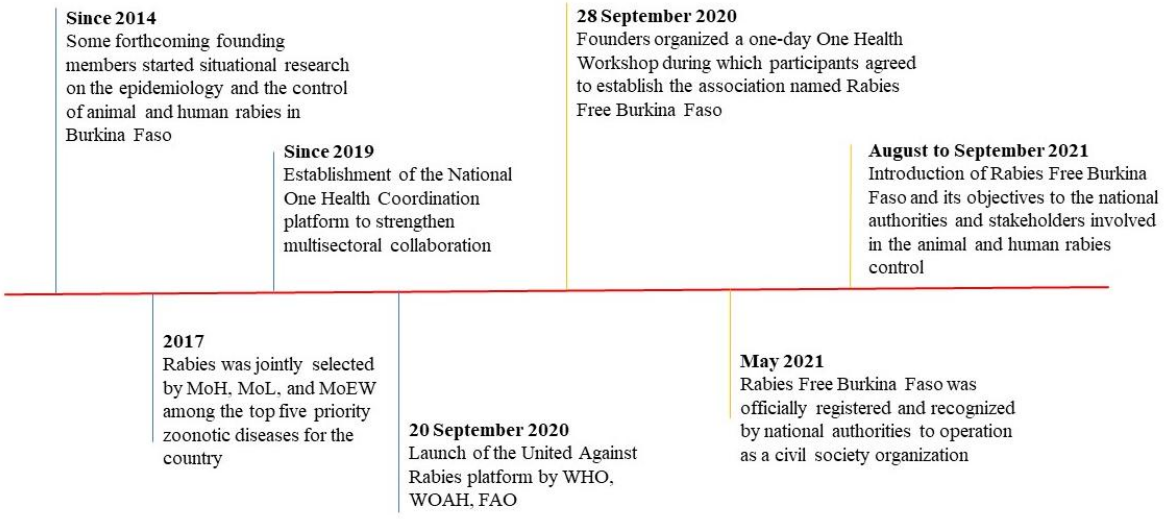

Figure 2 : Timeline summarizing most important events and steps having characterized the process of creation of Rabies Free Burkina Faso. MoH : Ministry of Health ; MoL : Ministry of Livestock ; MoEW : Ministry of Environment and Wildlife ; WHO : World Health Organization ; WOAH : World Organisation for Animal Health ; FAO : Food and Agriculture Organization of the United States

5.4. Areas of interventions and success stories

The most importante activities conducted by Rabies Free Burkina Faso since its establishment (September 2020) to date are presented in Table 1.

5.4.1. Education and awareness raising

Rabies Free Burkina Faso engaged in education and awareness raising among community members, students and professionals (animal health, human health, environment, etc.) regarding rabies prevention and control, especially since several studies evidence a lack of knowledge among the general public regarding animal species mostly involved in rabies transmission, routes of transmission, importance of dog vaccination, management of biting dogs, and postexposure prophylaxis including washing of bite wounds [3,9,31]. Addressing these gaps, Rabies Free Burkina Faso used social media, such as Facebook, Twitter, LinkedIn

and WhatsApp, to disseminate key messages on rabies prevention and control. In addition, members of the association provided radio and TV interviews to a range of online media, published articles on the disease control situation in the country, organized training workshops for professionals involved in the control of rabies, and presented oral communications during school events as well as national seminars and conferences (Table 1). As reported by various studies, up to 45% of human rabies cases occurred in children less than 15 years old [3,23,32]. Therefore, during World Rabies Day celebrations in 2021, awareness sessions were conducted within two ‘’amusement parks for children’’ located in Ouagadougou. These sessions aimed at sensitizing children about animals involved in rabies transmission, appropriate behaviours regarding roaming dogs, how to act in the event of being bitten by an animal, and the importance of notifying bites to their parents or other adults. Accordingly, flyers with key messages targetted children, their parents or accompanying adults were distributed. Some feedbacks collected by the team of Rabies Free Burkina Faso from the parents of attending children at the end of the awareness sessions confirmed the relevance of such community outreach.

« We are very grateful, we will spread messages received to stop rabies in our country » (A mother attending a session).

« These are simple measures. I heard about rabies when I was in primary school. Therefore, it’s a good initiative to remind us what to do to avoid rabies. » (A father attending a session).

Table 1 : Summary of key activities and contributions of Rabies Free Burkina Faso to animal and human rabies control in Burkina Faso

Categories of intervention	**Activities hosted/participated**	**Participants / Targeted groups**
Information, education and communication	September 28, 2020: One day One Health workshop on animal and human rabies control in Burkina Faso in the framework of World Rabies Day celebration	Professionals in charge of animal health, human health, livestock, wildlife, as well as researchers and teacher-researchers
	March 21, 2021: Hosting an interactive radio program sensitizing population on dog vaccination and postexposure prophylaxis	Dog owners, bitten persons, animal health professionals, human health professionals, general public
	September 12, 2021: Hosting an interactive radio program on rabies prevention and control, and the role of Rabies Free Burkina Faso initiative	Dog owners, bitten persons, animal health professionals, human health professionals, general public
	September 25 & 26, 2021: Hosting two awareness sessions with children about dog bite management and rabies prevention	School children, parents and supervisors
	September 28, 2021: Hosting radio and TV programs disseminating key messages on rabies prevention and control in the framework of World Rabies Day celebration	Dog owners, bitten persons, animal health professionals, human health professionals, general public
	January 9, 2022: One day awareness campaign (focus group and individual discussions) held in the Rural Commune of Sabou	Dog owners, household members
	July 21, 2022: Online public conference on One Health and rabies control in Burkina Faso, in collaboration with Food and Agriculture Organization (FAO) and United Against Rabies Forum (UAR)	Animal health, human health, wildlife and related professionals from Burkina Faso and the West African sub-region
	On continual basis: developing and disseminating key messages related to rabies control using social media such as Linkedin, Twitter, WhatsApp and Website	General public both at national and international levels
	From September 25 to October 6, 2022: Continued TV and radio broadcasting to raise awareness in the framework of World Rabies Day and World Animal Day (Animal care and prevention of diseases	General public both at national and international levels

	in animal, rabies and rabies prevention, dog vaccination, responsable animal ownership and implications for human health and well-being)	
Dog vaccination	September 31 to October 4, 2020: Participating in a mass dog vaccination campaign organized by the Ministry of Livestock in the city of Ougadougou	Dog owners
	March 1 to 31, 2021: Participating in mass a dog vaccination campagn organized by the Provincial Directorate of Livestock in Bobo Dioulasso	Dog owners
	January 9, 2022: One day dog vaccination campaign (combining fixed point and door-to-door approaches) held in the Rural Commune of Sabou	Dog owners
	October 7 to 9, 2022: Three days dog vaccination campaign (combining fixed point and door-to-door approaches) held in the area of Tengandogo located in Ouagadougou	Dog owners
Postexposure prophylaxis	November 8, 2020: Providing advice and financial support to initiate and secure postexposure vaccination for a child bitten by a roaming dog suspect for rabies	Bitten persons, family members
	January 2, 2021: Providing advice and financial support to initiate and secure postexposure vaccination for three children and one adult bitten by a confirmed rabid dog in Ouagadougou	Bitten persons, family members
	August 28, 2021: Providing advice and financial support to initiate and secure postexposure vaccination for three children and one adult bitten by a roaming dog suspect for rabies	Bitten persons, family members
	August 30, 2021: Providing advice and financial support to initiate and secure postexposure vaccination for one child bitten by a cat suspect for rabies	Bitten persons, family members
	September 6, 2021: Providing advice and financial support to initiate and secure postexposure vaccination for two children bitten by a dog suspect for rabies	Bitten persons, family members

	March 23, 2022: Providing advice and financial support to initiate and secure postexposure vaccination for three children bitten by a confirmed rabid dog in Ouagadougou	Bitten persons, family members
Surveillance	November, 2021: Initiating investigation that allowed laboratory confirmation of rabies in a suspected community goat (reported to be bitten by a roaming dog) in the Commune of Sabou	High risk community members and their owned animals
	November, 2021: Organisation of a joint investigation (involving animal health and human health sectors) in the community affected by a goat rabies case	Dog owners, breeders, local animal health professionals, local human health professionals, municipality officers, Regional directorates in charge of human health and animal health
Contribution to research-based evidence data collection	Different members of Rabies Free Burkina Faso were involved in research topics covering rabies epidemiology and surveillance [4,11], dog vaccination [24,31,37], dog ownership [9,31], postexposure prophylaxis [3,9,28,29], One Health in rabies control [10, 12, 24], community awareness about rabies [9,15,18], implications of dog and dog meat trading on rabies risk and control in communities [35]	Community members, public and private entities involved in rabies control and prevention
Partnership building related activities	July 26 to 27, 2021: Invited to attend the canine show (education on ownership and relevance of dog walking and vaccination for welfare) organised by Centrale Canine du Burkina Faso in Ouagadougou	Dog owners, general public
	September to October 2021: Invited to share Rabies Free Burkina Faso experience during the United Against Rabies Forum Annual Meeting[4]	Global rabies leading experts, national authorities, international partners, animal and public health professionals
	February, 2022: Invited to contributions to the national One Health strategic planning workshop hosted by the National One Health Coordination Platform in Koudougou, Burkina Faso	National stakeholders and partners involved in One Health operationalization process
	March 9 to 11, 2022: Invited to contribution to the SARE assessment in the framework of the National Strategic Plan for rabies elimination	National stakeholders and partners involved in rabies prevention and control
	April 4 to 15, 2022: Five members of Rabies Free Burkina Faso attended the International Training on Rabies Surveillance and	Animal and human health professionals and young researchers trained on rabies

	control, held in Abibjan, Cote d'Ivoire. A presentation on the success stories of Rabies Free Burkina Faso initiative was given to participants [36]	control with a focus on One Health capacities development in West and Central African regions
	August, 2022: Invited to contribution to the elaboration of National Zoonoses thematic committee regulatory documents hosted by the National One Health Coordination Platform in Ouagadougou, Burkina Faso	National stakeholders and partners involved in zoonoses control
	August 23 to 26, 2022: Invited to contribute to the zoonotic risk joint assessment workshop hosted by the National One Health Coordination Platform in Ouagadougou, Burkina Faso	National stakeholders and partners involved in zoonoses control
	September 28, 2022: Invited to talk about experience of Rabies Free Burkina Faso on the use of the One Health approach for rabies control	Global rabies leading experts, national authorities, international partners, animal and public health professionals

5.4.2. Improving access to postexposure prophylaxis for exposed persons

The two only post-exposure prophylaxis centers in Burkina Faso (located in the two biggest cities: Bobo Dioulasso and Ouagadougou) register nearly 10,000 bites cases each year (unpublished post-exposure prophylaxis facility records). Exposed persons have difficulties in accessing post-exposure prophylaxis, especially in remote areas. Direct and indirect costs associated with post-exposure prophylaxis are prohibitive for the general population and even worse, frequent post-exposure prophylaxis shortages increase the risk of persons bitten to contract rabies [33,34]. In such situations, Rabies Free Burkina Faso uses its network and social media channels to source post-exposure prophylaxis from private pharmacies from across the country, and at times from further afield. However, vaccine sourced from private pharmacies is at least 10 times more expensive than vaccines administered in a government post-exposure prophylaxis center, making it difficult for many families to afford these costs. In spite of limited financial resources, Rabies Free Burkina Faso was able to secure complete post-exposure prophylaxis for 13 vulnerable bite victims between January 2021 and March 2022 in Ouagadougou. However, if nothing is done to improve the availability, the accessibility and the delivery of rabies vaccines and immunoglobulins, any communication and outreach effort can lead to frustrations, loss of trust in health facilities, and in the long run become counterproductive.

5.4.3. Joint outbreak investigation and response

As reported in Tanzania [13], joint outbreak investigation is a major component of the integrated bite case management approach and key for the improvement of rabies surveillance and postexposure prophylaxis. Whenever Rabies Free Burkina Faso has been alerted on a bite case, if possible, a field visit is conducted to discuss with the local community, the local authorities as well as veterinary and medical officers, to search for unreported bite cases and provide appropriate guidance to community members. For example, a suspected case of goat rabies was reported in November 2021 in Sabou, located 80km from Ouagadougou. To the best of our knowledge, the authorities did not take any action by themselves. Therefore, the suspected goat was removed from its owner by the association, placed under veterinary observation by local animal health workers, and during the first week it died and a brain sample was submitted for laboratory investigations (Figure 3A). As the laboratory results confirmed rabies in the goat (Figure 3B), the association conducted an outbreak investigation and response activities on site. This rabies case in a goat implies that, although around 98% of human rabies

cases in the African countries are caused by dogs, the possibility of rabies virus transmission by livestock should not be overlooked in awareness messages, especially for agropastoral and rural communities. In Addition, local animal ownership practices being characterized by free-roaming of dogs and livestock, rabies cases in livestock are probably caused by infected dogs. An outbreak investigation team composed of veterinary and medical professionals conducted one day interviews with local decision-makers, animal health and human health workers, as well as the goat owner and local community members. Discussions with the stakeholders included the search for further information on the outbreak (e.g. possible contacts occurred between the rabid goat and humans or other animals), briefing the local animal health workers and human health workers on bites and rabies cases notification and management, sensitizing the livestock owning households on rabies, and identifying through a participatory approach the response actions to be taken. Indeed, one of the main recommendations that emerged from the discussions with the stakeholders was the organization of a campaign to vaccinate carnivores and sensitize communities. Therefore, following the investigation, Rabies Free Burkina Faso, in collaboration with local stakeholders (animal health and human health authorities, animal health office, human health center, municipality, private veterinarians, community animal health workers, and community leaders), organized a mass dog rabies vaccination campaign on 9 January 2022. Fixed point and door-to-door vaccination were conducted by multidisciplinary teams (each including one animal health worker and one human health worker) resulting in the vaccination of owned dogs (69) and cat (01) and senitization of over 140 community members to the appropriate practices in terms of dog ownership, the importance of dog vaccination and postexposure prophylaxis for rabies prevention and control. To the best of our knowledge, this is the very first time that such a joint rabies outbreak investigation followed by the implementation of disease control interventions (dog vaccination and community sensitization) was conducted in Burkina Faso. In addition, the success recorded throughout the response to this outbreak demontrates the relevance of adequate communication and cooperation between sectoral stakeholders involved in a community-oriented health intervention.

5.4.4. Advancing research on rabies

Rabies Free Burkina Faso is also committed to increase engagement of decision-makers and different stakeholders (public animal health and human health entities, non-government organisations, private enterprises, communities) through advocacy. As the disease has been long neglected [34], there was a lack of reliable data to inform prevention and control policies.

This gap highlights why Rabies Free Burkina Faso has such an important role to play. Therefore, understanding the importance of research-based evidence in advocacy and communication, the association contributed to generating data on various aspects related to rabies control. Different members of the association contributed to studies conducted in the country on topics that covered rabies epidemiology, risk associated with dog meat trade, dog vaccination coverage, dog ownership practices and challenges as well as opportunities for One Health collaboration for more effective rabies control (Table 1). Through the thesis supervision for final year-students in animal health and human health studies [35], our research activities provide an excellent channel creating interest and thus engaging the future professionals with the challenges of rabies control.

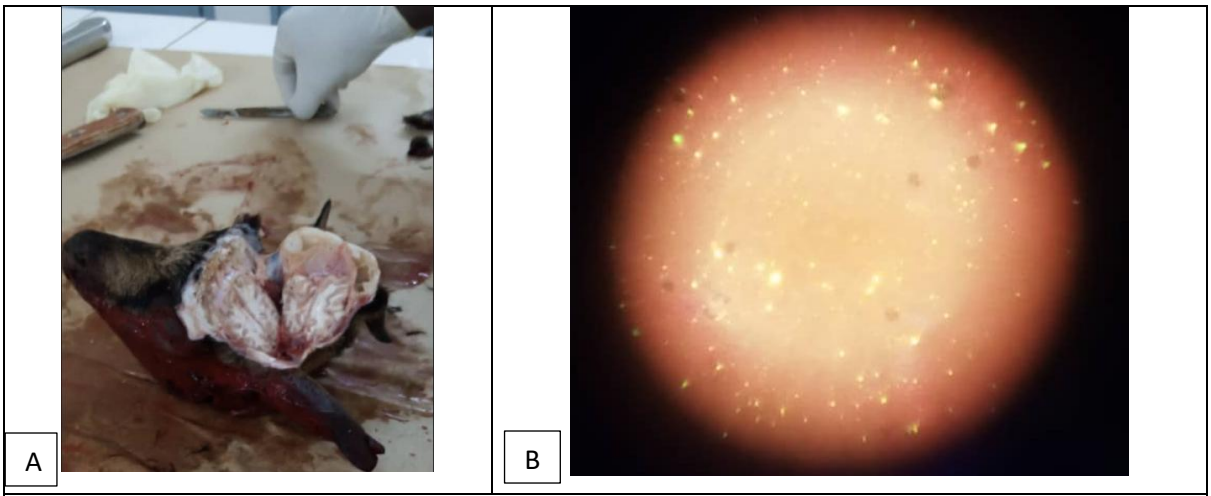

Figure 3 : Suspected rabid goat sample collection (A) and reading of the performed Fluorescent Antibody Test (B)

5.5. Main challenges identified

Although significant results have been achieved, these first two years of action have still encountered some challenges, such as :

- Lack of awareness about rabies – Both the general public and a significant proportion of professionals (human and animal health sectors) in contact with communities do not have adequate knowledge about rabies prevention and control measures. This lack of knowledge about rabies and its associated socio-economic as well as public health burden remains a major obstacle to stakeholders' commitment.
- Lack of resources – Even though the disease is now considered as a national priority zoonosis, entities involved in rabies control are chronically underfunded, including Rabies

Free Burkina Faso. In the specific case of Burkina Faso, this situation results in inadequate dog vaccination coverage and frequent postexposure prophylaxis shortages.

- Absence of rabies strategic plan – A national integrated strategic plan is currently being developed and needs to ensure synergic and well-coordinated interventions among stakeholders, including civil society associations like Rabies Free Burkina Faso.

5.6. Key lessons learned

Beside the challenges experienced, operating as a multidisciplinary, frontline association allowed the emergence of several lessons, pinpointed as follow:

- The contribution of civil society associations to public entities is critically important for increased health promotion within communities. Indeed, as an association, Rabies Free Burkina Faso offers a practical framework free from bureaucracy that characterizes many public agencies. As several members of the association are working for government or private agencies (e.g. Ministry of Health, Ministry of Livestock, Ministry of Environment, Universities, Research Institutes, Private clinics, Media stations), it further enables the mobilization of local expertise for cost-effective and highly impactful interventions. However, a close collaboration with public agencies, including Ministry of Health, Ministry of Livestock and the National One Health Platform, remains critical for sustainable actions.
- In addition to conventional media channels (radio and TV), mobile technologies, internet and popular social media (Facebook, LinkedIn, Twitter, WhatsApp) are innovative channels for information and communication dissemination among key stakeholders (including young population, professionals, decision makers, communities) both at country and global levels. At several times, Rabies Free Burkina Faso used social media for sourcing postexposure prophylaxis in private pharmacies across the country.

5.7. Conclusion and way forward

Beside the government efforts, enhancing initiatives towards increased health promotion, such as prevention of dog-mediated human rabies within the general public, requires the involvement of all relevant individuals and agencies. The Rabies Free Burkina Faso initiative constitutes a platform that puts together professionals (from a wide range of disciplines and backgrounds) and non-professionals, increasing commitment to support the government efforts towards rabies elimination. In addition, given its multidisciplinary character, Rabies Free Burkina Faso offers a concrete example of promoting One Health for integrated rabies control

at a non-government level. Therefore, the platform plans to further develop strong institutional grounding and an extended network through regional, provincial and local committees to further strengthen rabies prevention and control in Burkina Faso.

The lessons learned from setting up such an association allows us to make a few recommendations. Indeed, in a socio-political context characterized by an increasing lack of confidence in civil society initiatives, paying attention to a certain number of points in the approach may facilitate compliance of the stakeholders to such a multi-disciplinary platform.

- **Engagement and expertise**: The leaders of the initiative must be credible, with a strong knowledge of and commitment to rabies prevention and control;
- **Awareness**: The stakeholders need to be sensitized on the benefits of the One Health approach, particularly in the current context of increased emerging zoonoses (e.g. rabies) and other public health issues;
- **Relevance**: The leaders of the initiative should be convinced that rabies is a real health problem and that each person's knowledge and skills are required to make rabies history by achieving the Zero By 2030 goal.

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CHAPITRE 6

DISCUSSION GENERALE, PERSPECTIVES ET CONCLUSION

CHAPITRE 6 : DISCUSSION GENERALE, PERSPECTIVES ET CONCLUSION

6.1. Discussion générale

6.1.1. Synthèse commentée du parcours de la recherche

A travers les cadres théoriques et méthodologiques développés pour guider la conduite des différentes études, la recherche avait pour objectif de mieux informer le processus d'opérationnalisation de l'approche One Health au Burkina Faso, afin d'optimiser les efforts de prévention et de contrôle de la rage humaine transmise par les animaux domestiques. La revue de littérature a dépeint la problématique de la rage, les initiatives et approches mises en place pour son contrôle, les défis rencontrés, les succès et progrès réalisés jusque-là au niveau global, africain et national, mettant en évidence la faisabilité technique de son élimination dans les régions d'endémies (Zinsstag et al., 2017 ; Fahrion et al., 2017). Ce constat suggère la nécessité de prise en compte d'éléments contextuels tels que la multiplicité des secteurs et des acteurs concernés, les caractéristiques épidémiologiques faisant intervenir à la fois des animaux domestiques et sauvages, les facteurs socio-culturels et les comportements humains, ainsi que leurs implications en termes de perpétuelles mutations organisationnelles, institutionnelles, technologiques et écologiques (Widyastuti et al., 2015 ; Acharya et al., 2020 ; N'Guessan et 2022). En définitive, les gaps mis en évidence par la revue de littérature ont inspiré un cadre conceptuel et théorique intégré. Il présente les interdépendances entre des exigences techniques et organisationnelles de la lutte contre la rage d'une part, et des contingences sociologiques et écologiques d'autre part.

Face à cette réalité, l'étude 1 a été mise en place pour cerner de manière systémique l'ensemble du système multisectoriel de contrôle de la rage et comprendre les principaux défis inhérents à son organisation, à la multitude des parties en présence et aux caractéristiques de l'environnement socio-écologique dans lequel il opère. Cette approche a ainsi permis de décrire différents types de contraintes institutionnelles et interactionnelles dont la conversion en actions prospectives et concrètes peut contribuer à renforcer de manière significative et durable l'efficacité ainsi que la complémentarité des interventions dans une vision intégrative du contrôle de la maladie conformément aux principes de l'approche One Health (Nzietchueng et al., 2023 ; Milazzo et al., 2025). S'intégrant dans une sorte de prolongement cohérent de cette première étude, l'étude 2 a été conduite pour analyser les conditions de succès de la vaccination de masse des carnivores domestiques, domaine d'action dont les capacités à accélérer l'élimination de la rage ont été prouvées et fortement documentées dans plusieurs régions du monde (Zinsstag et al., 2017 ; González-Roldán et al., 2021 ; Aréchiga Ceballos et al., 2022).

Elle a révélé qu'à l'image de l'ensemble du système, la vaccination des carnivores domestiques, pouvant a priori être perçue comme un domaine d'action sectoriel, demeure fondamentalement multisectorielle. Sur le plan opérationnel, sa mise en œuvre efficiente repose sur une approche collaborative et synergique entre les acteurs concernés (Mosimann et al., 2017 ; World Health Organization, 2019 ; Ferguson et al. 2025). Partant de ce constat, et considérant que les programmes de lutte contre la rage se structurent en combinant plusieurs interventions relevant de domaines d'action complémentaires, l'on peut présager que la méthodologie utilisée ainsi que les conclusions de l'étude 2 puissent s'appliquer à d'autres domaines tels que la surveillance épidémiologique, la gestion des populations canines, la gestion de l'assainissement et des déchets, la prévention chez les personnes à risque élevé d'infection de rage, le plaidoyer et l'éducation du public sur la rage ainsi que les mesures de prévention et de contrôle.

Les études 1 et 2, appliquant chacune une méthode diagnostique distincte de la pensée systémique, ont été choisies pour leur complémentarité qui permet de comprendre à la fois les contraintes organisationnelles et opérationnelles. En effet, tandis que la théorie de Parsons (PSSAT) a permis une analyse organisationnelle et fonctionnelle du système à un niveau macro, la méthode des boucles causales (CLD) a offert une échelle plus réduite et plus opérationnelle, d'analyse et de visualisation des différentes rétroactions dynamiques qui influencent les programmes de vaccination antirabique des carnivores domestiques. Par conséquent, la diversité des acteurs précédemment évoquée ainsi que la multitude des interventions complémentaires, qu'impliquent de tels programmes dans un contexte de ressources limitées, interpellent sur la nécessité de dialogue entre les parties et de mutualisation des moyens pour mettre en place des actions efficientes et adaptées aux besoins locaux (Acharya et al., 2020). C'est dans cette optique que l'étude 3 a été réalisée. Elle avait pour objectif d'impliquer les différents acteurs à travers un processus de priorisation multicritère des interventions (MCDA) en vue d'améliorer l'acceptabilité, l'appropriation et l'efficacité de la stratégie nationale intégrée de l'élimination de la rage au Burkina Faso. Enfin l'étude 4 représente un cas d'étude utilisée pour conduire une mise en œuvre concrète de l'approche One Health dans la lutte contre la rage. Elle a consisté à l'établissement d'une organisation de la société civile intégrant des acteurs de divers disciplines pour développer le plaidoyer et faciliter l'adoption de l'approche One Health à l'interface entre les institutions publiques et les entités communautaires.

Finalement, les différentes études ont abouti à des résultats dont les discussions menées individuellement laissent présager d'une contribution potentielle à l'opérationnalisation de l'approche One Health pour une gestion efficace de la rage. Toutes choses qui permettront de réduire de manière significative l'impact de la maladie sur la santé publique, l'économie nationale et les moyens de subsistance des communautés vulnérables. Ainsi, leur mise à l'échelle à travers l'implication directe des acteurs terrain dans les processus de l'évaluation pourrait soutenir l'avancement des agendas de la santé publique tels que la campagne panafricaine de lutte contre la rage et l'objectif global de zéro cas de rage humaine à l'horizon 2030.

6.1.2. Intérêts de la démarche méthodologique et difficultés rencontrées

De nombreuses recherches conduites dans le domaine de la lutte contre la rage ont généré un volume considérable de connaissances dont l'objectif était de soutenir efficacement les programmes d'éradication de la maladie dans le monde (Zinsstag, 2013). Une part importante de ces travaux a porté sur les caractéristiques biologiques du virus (y compris la pathogénicité, la production du vaccin antirabique (Ahmad et al., 2021), les mécanismes de transmission aux réservoirs et hôtes intermédiaires (Singh et al., 2017), la surveillance génomique (Campbell et al., 2022) et sur la modélisation épidémiologique (WHO Rabies Modelling Consortium, 2020). La documentation relative à l'identification et la quantification des facteurs de risque de transmission et de propagation est assez abondante. Pendant ce temps, il y a une insuffisance de données capables d'expliquer les relations complexes qui régissent la dynamique de transmission de la maladie, ainsi que sur la manière de les exploiter pour informer efficacement pour l'opérationnalisation de stratégies innovantes de lutte. Or, le cadre théorique de notre recherche a démontré que la rage est une zoonose très complexe dont la gestion nécessite d'aller au-delà des aspects biologiques, pour envisager des approches systémiques, prenant en considération les contextes environnementaux, sociaux et culturels spécifiques à chaque milieu. Dans le contexte particulier du Burkina Faso, depuis la dernière décennie, de nombreuses études ont été mises en place sur la surveillance épidémiologique (De Benedictis et al., 2010 ; Sondo et al., 2015 ; Savadogo, 2021), la vaccination des carnivores domestiques (Savadogo et al., 2020 ; Savadogo et al., 2021 ; Dahourou et al., 2021) et prophylaxie postexposition (Savadogo et al., 2020). A ce jour, la place des facteurs socio-culturels dans l'adéquation et l'efficacité opérationnelle de lutte contre la rage reste à investiguer pour mieux informer les pratiques et politiques publiques.

Afin de contribuer à combler ces lacunes, tout en construisant des connaissances théoriques et opérationnelles capables de soutenir des pratiques et politiques intégratives de la santé publique, notre recherche a utilisé une approche fondée sur une combinaison de méthodes. Par conséquent, dans le cadrage méthodologique, une attention particulière a été accordée à la cohérence dans l'agencement des études successives et aux méthodes de collecte et d'analyse des données. Le premier volet de cette innovation méthodologique de la recherche tient au fait que le cadre méthodologique a été conçu pour conduire une analyse systémique, composée de différentes sections successives visant à : i) premièrement, appréhender les principaux défis institutionnels et organisationnels du système multisectoriel dans son ensemble ; ii) deuxièmement, comprendre le rôle de divers facteurs, consubstantiels à la complexité du système, dans l'efficacité opérationnelle des interventions (en particulier le contrôle de la rage canine par la vaccination de masse) ; iii) enfin, de proposer une approche participative pour l'élaboration de stratégies plus adaptées au contexte local et plus efficace dans la mise en œuvre. Dans un second volet, l'application du cadre méthodologique s'est basée sur une démarche qualitative et participative pour la collecte des données. En effet, organisés autour d'enjeux divers (économique, environnemental, social, culturel, organisationnel, technologique, technique), les interventions de santé publique sont par essence des systèmes complexes adaptatifs dont l'analyse requiert des méthodes participatives (Adam et de Savigny, 2012). D'une part, la dimension participative de notre recherche se situe au niveau de l'implication élargie des secteurs et des acteurs concernés par le contrôle de la rage, à différentes étapes de l'investigation, notamment via des entretiens individuels, des groupes de discussions focalisés et des ateliers de co-construction. Cette dimension place les perceptions, les pratiques, les attentes et les décisions des parties prenantes dans le processus de l'analyse. Ainsi, elle entre en droite ligne avec la vision transdisciplinaire de l'approche One Health qui veut que les communautés, les chercheurs, les gouvernements, les acteurs privés collaborent et mutualisent les efforts pour concevoir et conduire des actions contextualisées qui contribuent au développement de stratégies adaptatives de gestion des risques sanitaires à l'interface entre les animaux, les humains et l'environnement qu'ils partagent en commun (Duboz et al., 2018 ; Mettenleiter et al., 2023). D'autre part, le choix d'une méthode qualitative permet de mieux ancrer les résultats et les outils développés par la recherche dans leur contexte. Les atouts de la méthode qualitative sont liés à ses capacités à améliorer la compréhension de la problématique de la rage, en investiguant les déterminants sociaux, politiques et économiques pouvant influencer les expériences et les comportements humains. A la différence des méthodes traditionnelles de l'épidémiologique quantitative, qui reposent largement sur l'inférence

statistique pour décrire et mesurer un phénomène de santé et tester formellement des hypothèses de corrélation ou de causalité, les approches qualitatives permettent d'explorer, enrichir et conforter une hypothèse de recherche, plutôt que de la « tester » ou de la « valider » au sens strict. La rigueur de cette démarche interprétative tient alors à la triangulation des sources d'informations, des observations de terrain et à l'analyse croisée et systématique des données collectées par différents chercheurs (Wuest et al., 2002 ; Turner et al., 2021). Comme toute recherche, sa validité tiendra fondamentalement à l'honnêteté intellectuelle du chercheur et à sa capacité d'auto-critique, sa vigilance méthodologique face aux nombreuses possibilités de biais, observationnels ou interprétatifs. De telles connaissances pratiques issues de l'exploration des vécus, des expériences, des perceptions, ainsi que des attentes et des logiques des acteurs, lorsqu'elles sont agencées de manière cohérente avec les données de l'épidémiologie quantitative, ont le potentiel d'informer le développement de stratégies techniquement efficaces, économiquement efficientes et socialement acceptables (Jack, 2006 ; Brooke et al., 2017 ; Saadi et al., 2021). En définitive, les résultats de l'étude 1 et de l'étude 2 (Savadogo et al., 2022) ont montré la pertinence d'une large implication des acteurs mais également de la prise en compte des réalités locales. Ces résultats fondés sur une analyse approfondie des données de terrain, ont été obtenus grâce au choix porté sur des méthodes ayant un potentiel à favoriser l'innovation dans la lutte contre la rage. Ces méthodes utilisées comprenaient le cadre théorique de l'action des systèmes sociaux de Parsons (étude 1), la modélisation qualitative par les diagrammes des boucles causales (étude 2) et l'aide à la décision multicritère (étude 3).

Le cadre théorique de l'action des systèmes sociaux de Parsons ou Parsons' Social System Action Theory (PSSAT) : l'utilisation de cette méthode a offert la possibilité d'analyser le système de contrôle de la rage en prenant en considération tous les aspects de manière transversale, par opposition aux approches partielles ou fragmentées pouvant aboutir parfois à des résultats contradictoires (De Savigny et Adam, 2009 ; Sicotte, 1999). A titre d'exemple, si une méthode d'évaluation porte essentiellement sur l'allocation des ressources, la recherche peut avoir tendance à plus se focaliser sur la mesure des résultats ou des effets obtenus, oubliant les déterminants contextuels de l'efficacité de l'intervention de santé publique. Ainsi l'analyse du système a porté par exemple sur les entités qui le composent ainsi qui des interdépendances entre elles (De Savigny et Adam, 2009), sur l'influence des relations humaines et sociales qui s'établissent entre les différentes parties prenantes (Crozier et Friedberg, 1977), sur l'influence des facteurs externes inhérente à la nécessaire ouverture du système à son environnement

(Contandriopoulos, 2011), sur l'alignement des objectifs du système à ceux, parfois opposés ou implicites, des différentes parties prenantes (Crozier et Friedberg, 1977), ainsi que sur les outils internes de production et gouvernance pouvant être sources de conflits (D'Amour *et al*., 1999 ; Ridde, 2011). Le caractère intégratif du modèle a permis d'aborder le système multi-sectoriel de contrôle de la rage de manière systémique tout en conservant une vision d'ensemble.

La modélisation par la méthode des boucles causales ou Causal Loop Diagramming (CLD) : Le recourt aux boucles causales avait pour objectif d'apporter une compréhension plus structurée sur les facteurs influençant les programmations de vaccination massive des carnivores domestiques au Burkina Faso (Savadogo et al., 2021 ; Dahourou et al., 2021 ; Ferguson et al. 2025), et surtout les dynamiques interactives pouvant se construire entre ces facteurs. Cette compréhension est essentielle et l'utilisation des CLD a permis d'informer les acteurs sur les liens entre la structure du système de contrôle de la rage, les dynamiques se développant au sein des programmes de vaccination et leur influence sur l'efficacité de la vaccination de masse des carnivores domestiques. Les modèles mis au point dans le cadre de cette étude, intégrant des facteurs socio-économiques, culturels, politiques, organisationnels, techniques et financiers, constitue un outil précieux pour explorer de multiples interventions. Les CLD ont fourni des informations nécessaires sur plusieurs points d'attention à partir desquels des actions concrètes pourraient entrainer une amélioration significative des résultats des campagnes de vaccination de masse des carnivores domestiques contre la rage. Finalement, cette approche contribue à la prise de décisions éclairées en ce sens qu'elle fournit des alternatives à poursuivre tout en permettant d'anticiper sur les types de conséquences futures probables liées à chaque décision (Borshchev et Filippov, 2004 ; Renmans, 2018).

L'aide à la décision multicritère ou Multi-criteria Decision Analysis (MCDA) : si les deux précédentes méthodes ont permis d'impliquer les acteurs dans l'analyse, l'aide à la décision multicritère les a impliqués dans le processus de décision (Marttunen et al., 2015 ; Aenishaenslin et al., 2019). L'utilisation de cette approche répond à l'objectif d'aller au-delà de la description du problème, pour proposer des actions prospectives capables d'améliorer les programmes de lutte contre la rage dans le pays. La combinaison de deux approches sectorielle et multisectorielle, pendant les ateliers de discussions a permis de confirmer la nécessité permanente d'engager les différents secteurs concernés dans les processus de décisions relatives à la gestion des défis de l'approche One Health.

D'une manière générale, en tant que première application de la pensée systémique pour investiguer la problématique du contrôle de la rage au Burkina Faso, cette recherche a démontré la capacité des approches intégratives à favoriser la compréhension du système dans son ensemble et la conception de théories (locales ou dites « de moyenne portée ») pouvant inspirer des solutions adaptées aux réalités locales. Certes, les méthodes qualitatives adoptées par l'étude présentent de nombreuses caractéristiques qui leur confèrent un meilleur potentiel pour l'investigation des situations complexes à l'instar du contrôle de la rage humaine transmise par les animaux, mais leur utilisation nécessite de pouvoir anticiper et surmonter un certain nombre de défis. En effet, la première contrainte à laquelle la recherche a été confrontée était celle de l'adhésion des acteurs durant la phase de collecte de données. Certains d'entre eux pouvaient, a priori, n'avoir pas conscience de la mesure dans laquelle ils sont concernés par l'effort de lutte contre la rage (Allmark et Tod, 2006). A cela s'ajoute également les difficultés d'accès et de mobilisation de certains participants présents dans des localités éloignées. En effet, l'étude s'est déroulée dans un contexte de crise sécuritaire affectant plusieurs localités du pays. Pour surmonter ces défis, il a fallu user d'une flexibilité dans la programmation des rendez-vous avec les acteurs (tout en combinant entretiens individuels et focus groups), mais également de partenariats avec les responsables des institutions publiques et privées, les organisations de la société civile et les leaders communautaires pour une participation optimale des acteurs ciblés (Bieluch et al., 2017 ; Laird et al., 2020).

De pareilles études se doivent en outre d'inclure des étapes de restitution des résultats intermédiaires, car cela permet aux acteurs de mieux percevoir la valeur de leurs contributions et donc faciliter leur adhésion. C'est en cela que l'existence de la Plateforme Nationale de Coordination One Health représente une opportunité pour des restitutions et des mises en situations concrètes. Ces approches sont donc très exigeantes en termes de temps et de ressources logistiques et financières (Kacen et Chaitin, 2006 ; Kalman, 2019), nécessitant parfois des séances de discussions longues et répétées. Ce type de difficulté peut être anticipé par la mise en place d'une planification participative depuis le démarrage de la recherche, pouvant ainsi augmenter les chances de financement du projet. Face à la complexité de l'analyse des données inhérentes aux approches systémiques et qualitatives, il convient en amont de former les acteurs sur les outils, avant de les impliquer dans la co-construction des modèles pour une meilleure validité (Gourmelon et al., 2013 ; Taha, 2021 ; Irabor et al., 2025). Il est souvent reproché aux études qualitatives d'être subjectives, avec des résultats très contextuels et peu extrapolables. C'est pourquoi l'étude a développé un cadre méthodologique

rigoureux qui a privilégié la triangulation des données des entretiens avec les observations de terrain et des sources documentaires (Jonsen et Jehn, 2009). Par ailleurs, afin de s'assurer de la reproductibilité des différentes études, une description détaillée de leurs contextes et des méthodes utilisées y a été présentée.

6.1.3. Défis et enjeux des approches intégratives pour l'élimination de la rage

Comme dans de nombreux pays du Sud, la rage au Burkina Faso touche également les moyens de subsistance des communautés, notamment les plus vulnérables vivant dans les zones péri-urbaines et rurales (Coulibaly et Yaméogo, 2000 ; Sondo et al., 2015 ; Minoungou et al., 2021 ; Savadogo et al., 2023). Ces préoccupations ont émergé de manière assez récurrente dans les narratifs des acteurs qui ont participé aux différents entretiens, laissant ainsi présager que la maladie constitue une priorité socio-économique et sanitaire. Cette perception de la rage observée auprès des parties prenantes du terrain conforte les résultats du processus multisectoriel de priorisation des zoonoses qui avaient identifié en 2017 la maladie comme la deuxième zoonose prioritaire du pays, à côté de l'anthrax ou charbon bactéridien, de la brucellose, de l'influenza aviaire hautement pathogène et de la dengue, respectivement (Burkina Faso, 2017 ; Mpouam et al., 2021). C'est dans ce contexte que le pays a opté depuis 2019 pour l'institutionnalisation et l'opérationnalisation de l'approche One Health à travers l'établissement de la Plateforme Nationale de Coordination One Health (PNCOH). S'alignant sur les domaines techniques du règlement sanitaire international 2005, la PNCOH est structurée en sept commissions thématiques spécialisées, l'une d'elles ayant été mandatée pour gérer les risques sanitaires liés aux zoonoses dont la rage. La commission thématique regroupe des entités publiques et privés des secteurs concernés, des institutions de recherche, des institutions internationales et des organisations de la société civile. Les résultats issus des regards croisés apportés par l'utilisation des approches systémiques ont apporté une meilleure compréhension sur les principaux points de blocage et les leviers d'action pour favoriser une gestion intégrée de la rage humaine transmise par les animaux.

En dépit des efforts de formalisation de l'approche One Health par le gouvernement, les études ont révélé une fragmentation persistante des initiatives développées au sein du système multisectoriel de prévention et de contrôle de la rage, se traduisant par une insuffisance de communication, de coordination stratégique et d'alignement des objectifs entre les acteurs. Au cours des premières années de la politique de promotion de l'engagement multisectoriel dans le pays, cette situation pouvait être imputée à une méconnaissance des enjeux de la

collaboration (Savadogo et al., 2021 ; Asaaga et al., 2022) et de la valeur ajoutée en termes de performance opérationnelle et économique par rapport à la juxtaposition de stratégies sectorielles conduites indépendamment (Zinsstag et al., 2011 ; Auplish et al., 2024). Les répercussions négatives de la faible collaboration sur l'efficacité des mesures de contrôle de la rage ne sont plus à démontrer, tout au moins entre les entités médicales et vétérinaires. Ainsi, le manque de résultats notables relativement au contrôle de la rage humaine, observé au bout d'une dizaine d'années de mise en œuvre du programme national contre les maladies tropicales négligées, pourraient s'expliquer par l'absence d'intégration de tous les acteurs pertinents, en particulier ceux en charge de la santé animale, de l'environnement et de la faune sauvage (Burkina Faso, 2016 ; Savadogo et al., 2022). Afin d'inverser cette tendance, la formalisation de l'approche One Health devrait être soutenue par la mise en place d'outils et de procédures favorisant la compréhension des rôles et responsabilités des différents acteurs et de ce fait leur mobilisation optimale. Dans cette perspective, l'élaboration et l'application des instruments de la gestion intégrée des cas de morsure doivent être envisagées de manière prioritaire. En effet, la gestion intégrée présente des capacités avérées d'apporter de la valeur ajoutée à la surveillance de la rage dans un délai raisonnable. Des déficits de coordination ont été également mis en évidence par l'étude 2 portant sur la vaccination antirabique des carnivores domestiques. A travers plusieurs boucles de stabilisation, les résultats ont décrit comment les interventions peu ou pas coordonnées produisent des effets négatifs sur l'efficacité opérationnelle de la vaccination, maintenant une faible couverture vaccinale au sein des carnivores domestiques. Ce point mérite une attention particulière car jusque-là, la vaccination canine a toujours occupé une place décisive dans toutes les stratégies ayant permis de réduire significativement voire éviter totalement l'infection des humains par la rage (Zinsstag et al., 2017 ; Gutierrez-Cedillo et al., 2024). Par ailleurs, les résultats suggèrent que le renforcement de l'efficacité opérationnelle des campagnes de vaccination de masse requiert l'implication de diverses parties prenantes, y compris les municipalités, les organisations associatives et communautaires dans l'élaboration des plans de vaccination et de communication pour l'engagement communautaire. A cela s'ajoutent les opportunités qu'offrent l'intégration des nouvelles technologies et la digitalisation en vue de favoriser la diffusion rapide et transparente des informations destinées aux différentes catégories d'acteurs (Monroe et al., 2021 ; Hausenkamph et al., 2022). Les barrières au développement des synergies requises sont multiples. Toutefois, à travers l'analyse multicritère, l'étude 3 a mis en évidence des possibilités au sein du système d'aboutir à des compromis favorables à la coopération, malgré que sur le plan sectoriel, les priorités peuvent être différentes ou divergentes. En effet, malgré

une profonde disparité observée entre les priorités définies individuellement par les secteurs, l'approche multisectorielle de négociation basée sur des critères transparents a permis l'établissement de consensus autour d'activités favorables à la pratique de la collaboration (Aenishaenslin et al., 2019). Ce constat interpelle donc les décideurs sur la nécessité de la dynamisation, dans le cadre de l'animation de la PNCOH, de cadres pour promouvoir le dialogue et la co-construction.

Dans ce contexte de faible intégration, ajouté au fait que la transdisciplinarité est souvent méconnue ou négligée dans les politiques et stratégies de santé publique, il est important de rappeler que la prise en considération de la participation communautaire dans les processus de co-construction est essentielle pour l'optimisation de l'efficacité des interventions de santé publique (Saadi et al., 2021 ; N'Guessan et al., 2022). Malheureusement, l'analyse du système de lutte contre la rage a révélé l'absence d'initiatives robustes portant sur l'éducation, l'information et l'engagement du public. Cette situation n'est pas sans conséquence sur les résultats attendus sur le terrain. Cela a été confirmé par l'étude 2 dont les observations ont démontré que diverses dynamiques sociales, culturelles et économiques conditionnent l'adhésion et la participation des populations aux programmations de vaccination canine. L'implication de la communauté à toutes les étapes du processus, y compris l'identification du problème et la recherche de solutions, détermine le degré d'acceptabilité sociale des stratégies (Saadi et al., 2021). Finalement, la prise en compte de la perception sociale parmi les critères définis par les acteurs eux-mêmes pour la priorisation des interventions lors des ateliers MCDA indique une prise de conscience de l'importance des déterminants socio-culturels dans les échecs ou les succès des programmes en santé publique. Des observations similaires ont été rapportées par plusieurs auteurs (Castillo-Neyra et al., 2017 ; N'Guessan et al., 2022 ; Janeaim et al., 2024 ; Branda et al., 2025). L'intérêt croissant pour les agents de santé communautaire (Nsensele et al., 2024 ; Ouédraogo et al., 2025) et les agents communautaires de santé animale (Barroga et al., 2018 ; Leight et al., 2022 ; Ouedraogo, 2024) dans les pays en développement repose non seulement sur un besoin de rapprocher les services médicaux et vétérinaires des populations, mais surtout de mieux les impliquer dans la recherche de solutions adaptées aux réalités locales et répondant efficacement aux besoins réels.

Dans les pays à ressources limitées comme le Burkina Faso, les politiques en faveur de programmes ambitieux de développement sanitaire, et en particulier dans le domaine de la lutte contre une maladie longtemps négligée comme la rage (Dodet et al., 2008 ; Lembo et al., 2010), sont souvent confrontées à l'insuffisance de mobilisation et d'allocation des ressources

matérielles et financières. En effet, le pays s'est résolument engagé pour la promotion de l'approche One Health depuis 2019, conduisant à son institutionnalisation depuis le niveau central jusqu'au niveau déconcentré. Cependant, face à la faiblesse des financements apportés par le gouvernement, situation aggravée par le défi sécuritaire, les actions de lutte contre la rage restent encore très dépendantes de la contribution des partenaires au développement. Toutefois, l'absence de mécanisme local de coordination de la mobilisation des ressources relevée dans l'étude 1, favorisant le maintien de financements sectoriels pratiqués par ces partenaires, est source d'allocations inadéquates des ressources aux différentes parties. Cette situation engendre également des contraintes logistiques, techniques, et organisationnelles, endiguant continuellement les capacités de planification adaptative nécessaires pour créer un réel alignement des appuis extérieurs sur les préoccupations sanitaires des populations. A titre illustratif, l'analyse de la vaccination canine a révélé une insuffisance de personnel vétérinaire, des défaillances dans la chaîne de froid, la tenue irrégulière des campagnes de vaccination de masse des carnivores et de renforcement des capacités des parties prenantes sur les moyens de prévention. On se rappelle qu'en absence de financement durable, une crise sanitaire ponctuelle comme la COVID-19 avait entrainé une interruption brutale des actions (rupture de prophylaxie postexposition, manque de vaccin contre la rage canine, absence d'activités de sensibilisation et de renforcement des capacités des acteurs) de contrôle et de prévention contre la rage (Royal Society of Tropical Medicine and Hygiene, 2021 ; Nadal et al., 2022 ; Savadogo et al., 2023). Ces constats soulignent l'importance de mettre en place des mécanismes de financement durable, pour les programmes d'élimination de la rage, fortement soutenus par des ressources nationales. Par ailleurs, de tels mécanismes pourraient renforcer la pratique de planification multisectorielle en facilitant l'intégration et la coordination d'actions à fort impact sur la réduction de l'incidence de la rage telles que la vaccination des carnivores domestiques, la prophylaxie postexposition, la gestion de l'assainissement ou des déchets ménagers, mais dont les enjeux peuvent à tort être rattachés à des secteurs spécifiques.

Les résultats ont également mis en évidence d'importants défis de gouvernance de l'intégration des interventions de lutte contre la rage par une mise en œuvre effective de l'approche One Health. En effet, l'intégration est d'autant plus complexe à piloter par les décideurs qu'elle porte à la fois sur plusieurs domaines d'action tels que la vaccination des carnivores domestiques (Savadogo et al., 2022), la surveillance et la collecte des données, la prise en charge des cas de morsures (Lushasi et al., 2020), la gestion des carnivores domestiques (Brookes et al., 2020), le plaidoyer et l'éducation du public (Lechenne et al., 2017). En outre,

elle exige une mutualisation de connaissances et de compétences d'acteurs certes concernés par le problème de la rage de manière générale, mais agissant dans des secteurs, dans des disciplines et à des niveaux institutionnels très disparates pour rechercher collectivement des solutions adaptées au contexte (Ruegg et al., 2019 ; Mettenleiter et al., 2023). Partant de ces éléments, le premier défi majeur de l'intégration de la lutte contre la rage au Burkina Faso est relatif à l'exigence de création des conditions nécessaires à la collaboration entre les acteurs. A ce nouveau, l'enjeu pour le pays sera d'œuvrer à mettre rapidement en place une organisation institutionnelle dotée de procédures transparentes qui favorisent une allocation équitable de ressources à toutes les entités concernées. Le second défi de la gouvernance One Health porte sur l'exigence de création des conditions suffisantes pour maintenir et renforcer la collaboration des acteurs de la lutte contre la rage. Cela suppose qu'il est attendu des décideurs la mise en place de moyens opérationnels permettant de mesurer la valeur ajoutée réelle de la collaboration (Zinsstag et al., 2023), par exemple la réduction des cas de rage humaine, la baisse de l'incidence de la rage dans les populations animales, l'amélioration de la prise en charge d'autres urgences sanitaires qui intéressent les acteurs en présence. D'une manière générale, les résultats de la recherche appellent à l'amélioration des capacités de pilotage stratégique, du partage des rôles entre les acteurs, de leur responsabilisation à différents niveaux et de l'intégration institutionnelle afin d'optimiser la mobilisation des ressources (connaissances, compétences, finances) nécessaires à l'élimination de la maladie.

6.1.4. Positionnement critique de la recherche dans l'évolution institutionnelle du contrôle de la rage

Cette recherche s'inscrit dans un contexte institutionnel et politique en mutation et se nourrit d'un parcours personnel engagé du chercheur, qui fait de lui un acteur à part entière du changement dans le domaine de la lutte contre la rage au Burkina Faso. En effet, le projet de recherche a été construit dans la continuité de plusieurs actions précédemment initiées depuis 2014 par le chercheur en tant qu'acteur privé et dont l'objectif visait à améliorer la prise de conscience sur l'ampleur de la rage dans le pays. Dans un contexte où la maladie est fortement négligée et caractérisée par l'insuffisance de données (Dodet et al., 2008), les actions entreprises ont ainsi contribué à générer une masse critique d'informations pour améliorer la connaissance de l'épidémiologie de la rage animale et humaine (Savadogo, 2015 ; Savadogo et al., 2020 ; Savadogo et al., 2021 ; Minoungou et al., 2021 ; Savadogo et al., 2021 ; Dahourou et al., 2021 ; Savadogo et al., 2021). Dans une seconde phase, le besoin de mettre en relation la recherche scientifique et l'action publique a conduit le chercheur vers la mise en place en

2020 d'une organisation de la société civile (Savadogo et al., 2023, Etude 4) qui constitue un outil opérationnel d'intervention sur le terrain (Royal Society of Tropical Medicine and Hygiene, 2021 ; Savadogo et al., 2023 ; Savadogo et al., 2024). Dans la foulée, le chercheur est devenu en 2023 un acteur institutionnel après avoir intégré l'administration publique en charge de la santé animale. Un tel parcours du chercheur qui passe d'individu engagé, à acteur associatif, puis à acteur institutionnel dans le domaine du contrôle de la rage positionne le présent travail à l'interface entre la recherche scientifique et les politiques publiques institutionnelles. Ainsi, elle a servi d'assise pour le développement de l'association Rabies Free Burkina Faso. Dans son évolution, la recherche à travers les analyses conduites dès les premières années a contribué à informer l'élaboration de premier plan stratégique national intégré en 2022. Subséquemment, ce plan stratégique a été intégré dans le programme national « *Strengthening Disease Surveillance Systems, Laboratory Capacity, and Staff Skills in Public Health Emergency Preparedness and Coordination* » financé par le *Pandemic Fund* en 2023 (World Bank Group, 2023; Burkina Faso, 2024). Ainsi, la création de Rabies Free Burkina Faso et le lien établi avec les politiques publiques donne à la recherche une portée transformatrice.

Il est important de mentionner que toutes ces étapes se sont succédées tout en s'inscrivant dans une dynamique nationale de montée en puissance d'une politique en faveur de l'approche One Health. L'articulation de la recherche aux dynamiques nationales ainsi que les expériences à différents niveaux du système permet au chercheur d'apporter une lecture critique et constructive des faiblesses du système actuel de lutte contre la rage, tout en proposant des voies concrètes de transformation à travers des approches participatives, transdisciplinaires et systémiques. L'élimination de la rage n'est pas seulement une question technique mais nécessite un changement de paradigme en matière de gouvernance sanitaire, reconnaissant l'ampleur et l'impact socio-économique de la maladie dans les populations les plus affectées afin d'en faire une priorité dans les politiques publiques, aussi pour des enjeux de justice sociale. Les évolutions techniques et institutionnelles enregistrées ces dernières années et soutenues par les activités de recherche rendent l'objectif de l'élimination de la rage atteignable, si certaines conditions sont réunies, parmi lesquelles on peut relever :

- La **mise à jour et l'harmonisation des textes** sur les responsabilités des ministères, des collectivités territoriales, des organisations de la société civile, des institutions de recherche, des communautés et des partenaires internationaux en matière de lutte contre la rage au Burkina Faso. Les travaux déjà entamés et qui ont permis l'adoption de procédures

opérationnelles standards (prophylaxies préexposition et postexposition, vaccination canine, mise en observation des animaux mordeurs, surveillance intégrée, investigation conjointe des foyers) doivent être poursuivis pour leur diffusion et leur application effective ;

- L'**intégration d'indicateurs de performance** relatifs au contrôle de la rage dans les plans d'actions des ministères (santé humaine, santé animale, environnement, administration territoriale, enseignement et recherche) et institutions concernées afin de sécuriser une ligne budgétaire dédiée à la rage dans ces structures pour un financement durable de la stratégie d'élimination. A titre illustratif, la vaccination des carnivores domestiques contre la rage a été intégrée en 2024 dans la campagne nationale de vaccination contre les maladies animales prioritaires et des zoonoses. Des exemples similaires doivent être renforcés et démultipliés au sein des différentes entités concernées ;
- L'amélioration de la **coordination dans la mobilisation de l'appui technique et financier** de la communauté internationale, des organisations africaines et sous-régionales (AES, OOAS, CRSA, UA-BIRA, CDC Afrique, OMS, OMSA, FAO, UNEP) ainsi que des organisations non-gouvernementales pour une allocation équitable entre les institutions en charge des interventions structurantes et locales conformément à la stratégie nationale intégrée. Les modèles de mobilisation de financement via des projets collaboratifs à l'image du *Pandemic Fund* doivent être encouragés et consolidés ;
- Le renforcement de **l'action de la société civile** pour accroître l'engagement communautaire à l'aide de programmes d'éducation et de sensibilisation adaptés aux réalités linguistiques, culturelles et sociales locales. La société civile peut également jouer un rôle d'interface et de plaidoyer entre les communautés et les services publics en faisant remonter les contraintes et les besoins locaux ;
- La poursuite et l'approfondissement des **activités de recherche participative**, **évaluative et opérationnelle** pour soutenir l'actualisation des stratégies basée sur des données probantes relatives aux leviers de changement positif ;
- La promotion de la **culture du dialogue et de la priorisation concertée** des enjeux liés au contrôle de la rage animale et humaine, en s'appuyant sur des outils d'aide à la décision multicritère et des ateliers de co-construction permettant de prendre en considération des attentes et expertises des acteurs politiques, institutionnels, associatifs et communautaires dans l'élaboration des politiques publiques et des programmes d'élimination de la rage humaine transmise par les carnivores domestiques au Burkina Faso.

Finalement, l'objectif de l'élimination de la rage au Burkina Faso ne pourra être réalisé ni par la seule volonté politique, ni par des actions institutionnelles ponctuelles, ni par des campagnes isolées de sensibilisation. La lutte contre la rage repose sur une synergie d'actions cohérentes et durables portées par une vision partagée, une stratégie intégrative et une approche décentralisée et coordonnée. Avec sa situation privilégiée à l'interface entre la production scientifique, l'action citoyenne et les politiques publiques, la présente recherche démontre que l'élimination de la rage humaine transmise par les animaux au Burkina Faso est possible si les efforts d'intégration intersectorielle, d'engagement communautaire, de renforcement des capacités et d'appropriation de la stratégie nationale par tous les acteurs sont coordonnés et consolidés de manière durable.

6.2. Perspectives

Dans cette thèse, différentes méthodes combinant des approches intégratives et participatives ont été appliquées pour l'évaluation des déterminants de la performance opérationnelle du système multisectoriel ainsi que des actions mises en place afin de contrôler la rage selon une perspective One Health. En ce qui concerne particulièrement les études 1 et 2, les données ont été collectées auprès de divers acteurs du système avec pour but de prendre en considération, aussi largement que possible, les perspectives et attentes de ces derniers. La phase d'analyse des données a utilisé des outils (PSSAT et CLD) qui ont révélé de réelles potentielles en termes d'animation de sessions transdisciplinaires de co-construction. Toutefois, eu égard à des contraintes logistiques, cette analyse a été réalisée pour l'essentiel par le chercheur et ses collaborateurs. Dans ces conditions, sans une implication plus profonde des acteurs de terrain à cette importante étape, il difficile de considérer les études répondent aux exigences de la vision systémique souhaitée. En effet, les chercheurs ne peuvent interpréter les résultats que sous leurs prismes. Par ailleurs, quant à l'étude 3 (ayant utilisé la méthode MCDA), elle a regroupé les acteurs à l'aide d'ateliers de co-construction qui ont permis d'élaborer les critères et les interventions utilisés pour la priorisation. En raison de contraintes logistiques, l'évaluation de la performance des interventions n'a pas pu être conduite individuellement par les participants. Or, la recherche de consensus entre les participants présente toujours un risque élevé de refléter des positions ou avis d'acteurs ayant une forte influence. Dans ce contexte, nous dégageons les perspectives ci-après dont les prises en compte pourraient consolider les méthodes en vue de la mise en place d'outils opérationnels pour des évaluations systémiques en santé publique. Ces perspectives peuvent être structurées autour des points suivants :

1. Dans le cadre de l'animation de la Plateforme Nationale de Coordination One Health ou de ses différents organes (par exemple, la Commission Thématique Zoonoses), il s'avère nécessaire de **créer une équipe multidisciplinaire** comprenant des chercheurs et des acteurs de terrain et qui sera chargée de mobiliser ces approches à travers des sessions participatives d'abord pour approfondir la problématique de la rage abordée par la recherche, ensuite pour les adapter pour la gestion d'autres défis de l'approche One Health tels que les autres zoonoses prioritaires, la résistance aux antimicrobiens, la sécurité sanitaire des aliments et les pollutions environnementales.
2. Les résultats de l'analyse du système multisectoriel peuvent être approfondies en y apportant **le regard critique des acteurs de terrain** pour réduire la part de l'interprétation de l'équipe de recherche. Une telle approche, qui remet l'outil et les résultats en discussion avec les parties prenantes, a plusieurs avantages. Elle permet non seulement de mieux prendre en compte les réalités du terrain, de réadapter le cadre PSSAT au besoin pour le rendre plus opérationnel, mais également de faciliter l'appropriation des résultats de l'évaluation par les décideurs et acteurs de mise en œuvre.
3. Il en est de même pour les **boucles causales** dont la remise en discussion avec les parties prenantes de la vaccination contre la rage chez les carnivores domestiques est nécessaire pour mieux ancrer les résultats au contexte. En outre, ces boucles causales pourraient être élargies à d'**autres domaines d'action** tels que la prophylaxie postexposition, la gestion intégrée des cas de morsure, l'éducation et l'engagement communautaire, la gestion de la population canine, la surveillance épidémiologique. Par ailleurs, une fois la modélisation qualitative de la lutte contre la rage consolidée, il serait utile d'envisager la **quantification des variables** clés engagées à travers les différentes boucles dans la perspective d'une modélisation quantitative d'accompagnement, indispensable pour l'exploration et le choix des meilleurs scénarios d'investissement sur la base d'objectifs temporels maitrisés.
4. Concernant la priorisation des interventions, elle permet de réajuster la stratégie intégrée de lutte en reflétant au mieux les attentes de toutes les parties prenantes. Elle s'est révélée comme un outil transparent de dialogue pour l'établissement de consensus nécessaire à l'opérationnalisation de la collaboration multisectorielle et multidisciplinaire. Pour sa consolidation, l'exercice peut être répété avec l'accompagnement de l'équipe multidisciplinaire souhaitée plus haut. Il s'agira dans ce cas de donner le nécessaire pour permettre une évaluation de la performance des interventions par toutes les parties à la priorisation de manière individuelle. Une telle démarche permettra de **prendre en compte**

le point de vue exprimé de chaque acteur, réduisant ainsi l'effet des acteurs influents, pour une meilleure adéquation avec les réalités du terrain.

6.3. Conclusion générale

La rage est une zoonose endémique associé à des conséquences socio-économiques et sanitaires graves affectant les populations vulnérables au Burkina Faso. Les différentes actions entreprises depuis l'accession du pays à la souveraineté internationale en 1960 n'ont toujours pas permis de contenir la menace. Les études conduites dans le cadre de la thèse visaient à proposer des outils d'analyses systémiques et participatives capables de soutenir l'élaboration de stratégies intégrées d'élimination adaptées aux réalités locales. Notre hypothèse de départ était que l'application des approches intégratives devrait permettre de générer une compréhension des dynamiques qui influent sur l'efficacité des mesures de lutte contre la rage au Burkina Faso. L'étude 1 et l'étude 2 menées de manière complémentaire ont confirmé la complexité de la lutte contre la rage, en révélant l'importance de plusieurs facteurs organisationnels, socio-culturels, techniques ainsi que des comportements humains dans les dynamiques épidémiologiques et l'efficacité des mesures de contrôle. L'analyse systémique du dispositif multisectoriel a mis en évidence une fragmentation persistante avec un faible alignement stratégique entre les secteurs et acteurs, l'insuffisance des capacités opérationnelles liée à un déficit financier et logistique, l'insuffisance de la mobilisation communautaire et les défis de gouvernance intégrative relativement à la diversité des acteurs et des domaines d'actions. S'intéressant particulièrement au domaine de vaccination antirabique canine, l'étude 2 révèle son caractère fondamentalement multifactoriel. En effet, les résultats obtenus ont permis de comprendre comment, par des relations de cause à effet (boucles causales de renforcement ou de stabilisation), différentes variables socio-culturelles, économiques, techniques, organisationnelles, et politiques affectent l'efficacité opérationnelle de la vaccination canine de masse dans le pays. A la lumière des résultats des deux premières études, il est apparu nécessaire de renforcer l'intégration structurelle et fonctionnelle du système pour une synergie accrue entre les actions de contrôle de la rage. La troisième étude s'est alors appuyée sur les approches participatives pour améliorer la planification stratégique de l'élimination de la rage dans le pays. En appliquant l'aide multicritère à la décision, elle a révélé des priorités distinctes entre les secteurs concernés. Toutefois, un accord relatif a pu être mis en évidence à travers un consensus porté sur un ensemble d'interventions intersectorielles, y compris l'harmonisation des procédures de surveillance, le partage des données ainsi que la prévention et le contrôle. Le cadre méthodologique utilisé par l'étude a permis de décrire les

principaux défis dont la conversion en des actions prospectives permettrait de soutenir le développement de stratégies intégrées, plus efficaces et adaptées au contexte local. Dans ce sens, les résultats de l'étude 3 ont prouvé que lorsque des espaces de dialogues participatifs sont créés, les acteurs sont capables d'identifier collectivement des critères transparents répondant aux enjeux de l'élimination de la rage, et leur permettant de bâtir un consensus sur des actions synergiques et coordonnées et de les dérouler dans le cadre d'une vision intégrative de la santé publique. En effet, la pratique de l'approche One Health à travers l'initiative Rabies Free Burkina Faso présage du potentiel de telles approches dans l'adoption et la consolidation des stratégies à l'échelle locale. Par sa nature multidisciplinaire, cette initiative représente un exemple concret de promotion et de mise en œuvre de l'approche One Health pour un contrôle intégré de la rage en appui aux acteurs institutionnels.

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