DEVELOPMENT AND EVALUATION OF RABIES HEALTH EDUCATION MODULE (RaHEM) TO IMPROVE KNOWLEDGE AND ATTITUDE AMONG DOG OWNERS IN KELANTAN

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by

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TABLE OF CONTENTS

LIST OF PUBLICATIONS

1. Mohammad Basir, M. F., Mohd Hairon, S., Ibrahim, M. I., Wan Mohamad, W. M. Z., Mohd Fuzi, N. M. H., Rosli, A. S., Abdul Rahman, M. S., & Rosedi, A. (2025). Development and Validation of Rabies Health Education Module (RaHEM) for Dog Owners in Kelantan, Malaysia: An ADDIE Model. Journal of Epidemiology and Global Health, 15(1), 12. https://doi.org/10.1007/s44197-025-00355-4

2. Mohammad Basir, M. F., Mohd Hairon, S., Tengku Ismail, T. A., Che' Muda, C. M., & Abdul Halim, H. I. (2023). The Determinants of Non-compliance on Rabies Vaccination in North-West Peninsular Malaysia. Journal of Epidemiology and Global Health, 13(1), 1–10. https://doi.org/10.1007/s44197-022-00080-2

LIST OF PRESENTATIONS

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7. Mohammad Basir, M. F., Mohd Hairon, S., Ibrahim, M. I., Wan Mohamad, W. M. Z., Mohd Fuzi, N. M. H., Rosli, A. S., & Abdul Rahman, M. S. (2023, July 10-11). Knowledge, attitude and behaviors towards rabies prevention among dog owners in Kelantan, Malaysia [Poster presentation]. 2nd International INTERACT Symposium on One Health & One Medicine, Oklahoma, USA [Hybrid].

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

A   Acknowledgement of Approval for Questionnaire Deployment in Research

B   The Questionnaire and Study Proforma Booklet

C   The Stakeholder Interview Guide

D   The Content Validation Form

E   The Face Validation Form

F   The Participants Information Sheet

G   The Participants Informed Consent Form

H   Acknowledgement of Ethical Approval by the JePEM-USM

I   Acknowledgement of Completed Registration by the NMRR

J   Acknowledgement of Clinical Trial Registration by the ANZCTR

K   Acknowledgement of Collaboration Approval by the DVS Malaysia

L   The SEAOHUN 2023 One Health Scholarship Award Service Contract

M   Acknowledgement of Project Approval for the TIPPS

N   Acknowledgement of Travel Award for SEAOHUN International Conference

O   The Snapshot of RaHEM MOOC Platform

P   Capturing The Research Journey: Photographic Documentation

Q   The Front Page of Journal Publication

R   The Certificates of Academic Achievements

LIST OF ABBREVIATION

RaHEM	Rabies Health Education Module
WHO	World Health Organization
PEP	Post-Exposure Prophylaxis
PrEP	Pre-Exposure Prophylaxis
RIG	Rabies Immunoglobulin
OIE	Organization for Animal Health
FAO	Food and Agriculture Organization of the United Nations
GARC	Global Alliance for Rabies Control
IPH	Institute for Public Health
NHMS	National Health and Morbidity Survey
KAP	Knowledge, Attitudes and Practices
SDG	Sustainable Development Goal
MOH	Ministry of Health Malaysia
DVS	Department of Veterinary Services
DVSO	District Veterinary Services Office
DOSM	Department of Statistics Malaysia
OR	Crude Odds Ratio
AOR	Adjusted Odds Ratio
CI	Confidence Interval
MOOCs	Massive Open Online Courses
RCT	Randomized Controlled Trial
CAB-ZDQ	Cognitive, Affective & Behaviour of Zoonosis Disease Questionnaire
ROC	Receiver Operating Characteristic
ADDIE	Analysis, Design, Development, Implementation and Evaluation
HBM	Health Belief Model
I-CVI	Item-Level Content Validity Index
S-CVI/Ave	Scale-Level Content Validity Index/Average
I-FVI	Item-Level Face Validity Index
S-FVI/Ave	Scale-Level Face Validity Index/Average
MANOVA	Multivariate Analysis of Variance
SD	Standard Deviation
USAID	United States Agency for International Development
SEAOHUN	Southeast Asia One Health University Network
TIPPS	Tabung Insentif Pembangunan Pengajian Siswazah
USM	Universiti Sains Malaysia
AUC	Area Under the Curve
adj.	Adjusted

LIST OF SYMBOLS

β	Regression Estimate
<	Less than
≤	Less than & equal
>	More than
=	Equal
α	Significance Level (Alpha)
f^2	Effect Size for Regression (Cohen's f^2)
Wilks λ	Wilks Lambda
η^2	Effect Size for ANOVA (Eta Squared)
r	Correlation Coefficient

ABSTRAK

Pembangunan dan Penilaian Modul Pendidikan Kesihatan Rabies (RaHEM) untuk Meningkatkan Pengetahuan dan Sikap dalam Kalangan Pemilik Anjing di Kelantan

Latar Belakang: Rabies kekal sebagai isu kesihatan awam pada peringkat global terutama dalam kalangan pemilik anjing yang disebabkan oleh jurang perbezaan dalam pengetahuan, sikap, dan amalan (KAP) berkaitan pencegahannya. Inisiatif pendidikan kesihatan sedia ada didapati kurang komprehensif dan tidak berdaya tahan untuk jangka masa Panjang. Oleh yang demikian, terdapat keperluan bagi pembangunan modul yang berstruktur dan berasaskan bukti sainstifik bagi meningkatkan pengetahuan berkaitan penyakit rabies serta memupuk sikap yang positif dalam kalangan pemilik anjing. Pendekatan One Health dapat memastikan bahawa aspek kesihatan manusia, peranan haiwan serta persekitaran turut diambil kira dalam usaha pencegahan rabies.

Objektif: Untuk menentukan tahap dan faktor yang berkaitan dengan KAP berkaitan penyakit rabies serta membangunkan, mengesahkan, dan menilai RaHEM dalam meningkatkan hasil tersebut dalam kalangan pemilik anjing di Kelantan, Malaysia.

Metodologi: Kajian ini dilaksanakan dalam tiga fasa. Fasa pertama melibatkan reka bentuk kajian hirisan lintang yang dijalankan ke atas 232 pemilik anjing dewasa, di mana mereka melengkapkan kaji selidik yang telah disahkan. Analisis regresi logistik digunakan untuk mengenal pasti faktor yang berkaitan dengan KAP. Seterusnya, RaHEM dibangunkan dengan menggunakan kerangka Analisis, Reka Bentuk, Pembangunan, Pelaksanaan dan Penilaian (ADDIE) termasuk proses pengesahan kandungan dan muka dalam fasa kedua. Fasa ketiga melibatkan kajian rawak terkawal

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(RCT) dengan 80 pemilik anjing untuk menilai skor pengetahuan dan sikap selepas satu bulan. Analisis MANOVA digunakan untuk menilai perubahan skor antara kumpulan intervensi dan kumpulan kawalan.

Keputusan: Kajian keratan hirisan lintang mendapati bahawa 53.0% peserta mempunyai pengetahuan yang baik, 26.7% menunjukkan sikap yang positif, dan 40.0% mengamalkan langkah pencegahan rabies yang baik. Faktor yang berhubung kait dengan hasil ini termasuk status pendidikan, kehadiran dalam program kesedaran rabies, bilangan anjing peliharaan, tempoh pemilikan anjing, saiz isi rumah, skor pengetahuan, kumpulan umur, dan kaedah memperoleh anjing. Modul akhir mengandungi 5 topik utama, 11 unit, dan 32 objektif pembelajaran. Kesemua skor Indeks Pengesahan Kandungan (CVI) dan Indeks Pengesahan Muka (FVI) melebihi kadar yang diterima secara umum iaitu 0.83 bagi setiap unit, topik, dan keseluruhan modul. Kajian rawak terkawal menunjukkan perbezaan yang signifikan antara kumpulan intervensi dan kawalan (Wilks' $\lambda = 0.63$; $F(2,77) = 22.92$; p-value < 0.001; partial $\eta^2 = 0.41$). Analisis perbandingan cara berpasangan Bonferroni menunjukkan peningkatan skor yang lebih ketara dalam kalangan kumpulan intervensi bagi skor pengetahuan dan sikap.

Kesimpulan: Kajian ini mendedahkan tahap KAP berkaitan rabies yang rendah dalam kalangan pemilik anjing di Kelantan yang mana menekankan keperluan modul pendidikan kesihatan yang berstruktur ketika mengenal pasti faktor berhubung kait dengannya melalui pendekatan One Health. Pembangunan, pengesahan, dan keberkesanan RaHEM telah terbukti menjadikannya potensi sebagai alat pendidikan kesihatan yang berimpak tinggi, khususnya dalam meningkatkan pengetahuan dan sikap secara sinergi. Modul ini memperkukuh peranannya dalam mempertingkatkan

usaha pencegahan rabies yang sejajar dengan matlamat di peringkat global dan nasional untuk membasmi kematian manusia akibat rabies yang ditularkan oleh anjing menjelang tahun 2030.

Kata Kunci: Intervensi Rabies, Pemilik Anjing, Kursus Pembelajaran Dalam Talian Terbuka (MOOC), Pengetahuan, Sikap dan Amalan (KAP), Malaysia

ABSTRACT

Development and Evaluation of Rabies Health Education Module (RaHEM) to Improve Knowledge and Attitude among Dog Owners in Kelantan

Background: Rabies remains a global public health concern, particularly among dog owners, due to persistent gaps in knowledge, attitudes, and practices (KAP) related to its prevention. Existing health education initiatives often lack depth and long-term sustainability. This highlights the need for a structured and evidence-based module to enhance rabies-related awareness and promote positive attitudes among dog owners. Integrating the One Health approach ensures that rabies prevention efforts address not only human health but also the role of animals and the environment.

Objectives: To determine the levels and associated factors of rabies-related KAP, as well as to develop, validate and evaluate the RaHEM in improving these outcomes among dog owners in Kelantan, Malaysia.

Methodology: This study was conducted in three phases. Phase one employed a cross-sectional design with 232 adult dog owners completing the validated questionnaire, and logistic regression identified factors associated with KAP. Then, the RaHEM was developed using the Analysis, Design, Develop, Implementation and Evaluation (ADDIE) framework including the validation process through content and face validation during the second phase. Phase three followed by involving a randomized controlled trial with 80 participants to evaluate knowledge and attitude at one-month post-intervention. MANOVA was used to analyse score changes between the intervention and control groups.

Result: The cross-sectional study revealed that 53.0% of participants had good knowledge, 26.7% exhibited positive attitudes, and 40.0% demonstrated good practices toward rabies prevention. Key factors associated with these outcomes included education status, prior attendance at rabies awareness programs, number of pet dogs, duration of dog ownership, household size, knowledge scores, age groups, and dog acquisition methods. The final module includes 5 main topics, 11 units, and 32 learning objectives. All the Content Validation Index (CVI) and Face Validation Index (FVI) scores exceeded the acceptable threshold of 0.83 across all unit, topic, and overall module. The randomized controlled trial demonstrated a significant difference between the intervention and control groups (Wilks' λ=0.627; $F(2,77)$=22.921; p-value<0.001; partial η^2=0.408). Post hoc Bonferroni-adjusted pairwise comparisons revealed that the intervention group showed significantly greater improvements observed in the intervention group for both knowledge and attitude score.

Conclusion: The study reveals the low levels of rabies-related KAP among Kelantanese dog owners that emphasize the need for a structured educational module while identifying key associated factors through the lens of One Health. The successful development, validation, and proven effectiveness of RaHEM underscore its potential as an impactful health education tool, particularly in enhancing knowledge and attitudes synergistically. This module reinforces its role in strengthening rabies prevention efforts, aligning with global and national goals to eliminate dog-mediated human rabies deaths by 2030.

Keywords: Rabies Intervention, Dog Owners, Mass Open Online Course (MOOC), Knowledge, Attitude and Practice (KAP), Malaysia

CHAPTER 1

INTRODUCTION

1.1   Background

The bond between humans and canine dates back at least 14,000 years ago (Janssens *et al.*, 2018). However, millions of injuries are inflicted each year by dog bites, contributing to a significant number of deaths, particularly in low- and middle-income countries (Hampson *et al.*, 2015; World Health Organization, 2018a). Over the past two decades, the incidence of dog bites among children has remained consistently high, while the incidence among adults has tripled, making this a growing public health concern (Tulloch *et al.*, 2021). The consequences of dog bites extend beyond physical injuries, often leading to infections, most notably rabies (Hampson *et al.*, 2015; Patterson *et al.*, 2022).

Rabies is widely known for being lethal to humans once clinical symptoms appear (Fooks & Jackson, 2020). Due to the lack of effective curative therapies for rabies, primary prevention remains as the key strategy for controlling this deadly disease. This includes public awareness campaigns, widespread vaccination of both dogs and humans, and post-exposure prophylaxis (PEP) (Fooks & Jackson, 2020; Miranda & Miranda, 2020). The global burden of dog-mediated human rabies is devastating, resulting in approximately 59,000 human deaths annually, contributing to 3.7 million Disability-Adjusted Life Years and causing an estimated USD 8.6 billion in annual economic losses (Hampson *et al.*, 2015).

The World Health Organization (WHO), in collaboration with the World Organization for Animal Health (OIE), the Food and Agriculture Organization of the

United Nations (FAO), and the Global Alliance for Rabies Control (GARC), launched the United Against Rabies initiative in response to this burden. This initiative aims to eliminate dog-mediated human rabies by 2030, with one of the primary focuses is raising awareness and enhancing education (World Health Organization *et al.*, 2018).

Rabies has been documented in Malaysia since 1845, with systematically accessible data available since 1924. Despite various control measures, significant challenges persist (Ganesan & Sinniah, 1993). Canine rabies vaccination coverage remains suboptimal, hindering herd immunity, while non-compliance with widely available pre-exposure (PrEP) and post-exposure prophylaxis (PEP) remains a concern (Mohammad Basir *et al.*, 2023; Wada *et al.*, 2024). The rabies immune belt, designed to prevent cross-border transmission, also faces challenges, particularly in sustaining community engagement (Ganesan & Sinniah, 1993). As a result, Malaysia continues to struggle in maintaining its rabies-free status. Addressing these gaps requires a multifaceted approach, emphasizing stronger community participation and enhanced health education, as recommended by global and national health organizations(World Health Organization *et al.*, 2018; Institute for Public Health, 2021).

1.2   Statement of Problem

While the strong bond between a dog and its owner offers undeniable benefits, it can also lead to unsafe practices. Dog owners may believe that rabies preventive measures do not apply to them, adopting the mindset that "this won't happen to me" (Westgarth & Watkins, 2015; Owczarczak-Garstecka, 2020). The National Health and Morbidity Survey (NHMS) 2020 supports this claim, revealing that only 39.7% of dog owners reported engaging in good health-seeking behaviors, which puts them at risk of contracting rabies (Institute for Public Health, 2021).

It begs the question of why dog-mediated rabies deaths still happen despite very potent and safe vaccinations for both humans and domestic animals is available particularly in Malaysia. Malaysia has faced a substantial rabies burden since 2017, with 995 confirmed animal cases recorded up to 2023. Of these cases, 89.35 percent were identified in dogs, highlighting the dominant role of dog-mediated transmission. Even more alarming, 72 human cases were reported during this period, with a devastating fatality rate of 90.28%, resulting in 65 tragic deaths (Wada *et al.*, 2024). One of the key barriers in the battle against rabies is a community's lack of knowledge, which leads to false beliefs about the disease and its prevention (Rupprecht & Salahuddin, 2019). The findings from the NHMS 2020 support this argument in Malaysia, revealing that only 24.6% dog-owning respondents had a positive perception of rabies prevention, and only 45.2% (95% CI: 29.74, 61.56) demonstrated a high level of knowledge (Institute for Public Health, 2021). The battle to eliminate dog-mediated human rabies, both globally and nationally, remains an ongoing endeavour.

Another key contributor identified is the deficiency in responsible animal ownership practices, which has led to unattended, unvaccinated, and reproducing dogs. This issue arises when owners are unable to manage the excess number of animals, fail to provide proper containment, allowing pets to roam freely and engage in irresponsible breeding. These factors, along with inadequate pet care, reflect a broader lack of responsible dog ownership (Rupprecht & Salahuddin, 2019; Munir, Mokhtar & Arham, 2023). Data from the NHMS 2020 supports this statement as only 106 (44.5%) of the 238 respondents with pet dogs had registered them with local authorities, and just over half (52.5%) sent their dogs for regular annual checkups (Institute for Public Health, 2021).

Spatial distribution data on animal rabies cases, particularly in dogs, indicated that the most prevalent cases were in Southern Thailand in 2017. Although these cases remained concentrated in the same geographical areas, there was a wider spread in the following year, raising concerns for neighbouring states (Thanapongtharm *et al.*, 2021). It was hypothesized that canine rabies had been reintroduced into Perlis and Kedah through land movements, while outbreaks in Pulau Pinang and Terengganu were likely initiated by fishermen's boats. Both recurrences were linked to the endemic presence of rabies in Thailand (Loke *et al.*, 1998; Ahmed & Ibrahim, 2019). Consequently, Kelantan's location in the northeastern region of Peninsular Malaysia, sharing both land and maritime borders with Thailand, increased the risk of rabies reintroduction among canines and humans. These concerns were well-founded, as Malaysia had already established an "immune belt" along the Thailand-Malaysia border during its national elimination campaign in 1952 (Wada *et al.*, 2024).

1.3 Rationale

Numerous studies have been conducted in regions where human rabies is prevalent, examining households regardless of dog ownership (Nejash *et al.*, 2017; Sor *et al.*, 2018; Bouaddi *et al.*, 2020; Hagos *et al.*, 2020; Li *et al.*, 2021; Lungten *et al.*, 2021; Spargo *et al.*, 2021; Ubeyratne *et al.*, 2021; Bahiru *et al.*, 2022). Furthermore, to the best of our knowledge, limited research in Malaysia has specifically assessed the levels of knowledge, attitudes, and practices (KAP) related to rabies among dog owners. The recent NHMS 2020 focused broadly on household respondents (94.4%), with only a small fraction being dog owners (5.6%) whereas a survey of dog owners in Penang primarily targeted on free-roaming dogs rather than household pets (Dorothy *et al.*, 2020; Institute for Public Health, 2021). Therefore, this study seeks to

bridge the KAP gap by focusing on those at risk (dog owners) that increase the risk of rabies exposure. Understanding these gaps will provide essential insights to stakeholders and offer the evidence needed to design and implement targeted educational interventions on rabies preventive measures, not only for Kelantan but for Malaysia as a whole. This study will enhance public health strategies aimed at reducing the risk of rabies transmission and protecting both human and animal populations through the dog owners.

While numerous studies and international health agendas emphasize the needs of health education interventions for rabies prevention that has positive impacts on enhancing KAP, many of these interventions have predominantly targeted children and adolescents, including in Malaysia. The sustainability of these programs, particularly those integrated into school curricula, has been questioned, thus revealing a significant gap in current efforts (Global Alliance for Rabies Control, 2015; Kanda *et al.*, 2015; Wu *et al.*, 2016; Burdon Bailey *et al.*, 2018; World Health Organization *et al.*, 2018; Bodkin & Hakimi, 2020; Herlitz *et al.*, 2020; Halim *et al.*, 2021). The NHMS 2020 report highlights the importance of targeting dog owners, who serve as the primary caregivers for domestic dogs as the main reservoir of rabies (Institute for Public Health, 2021). This rationale strongly supports focusing on adult dog owners, who play a critical role in disrupting the rabies transmission chain.

By having a module that promotes rabies preventive measures, dog owners can reduce the transmission of rabies between domestic dogs, wild animals, humans, and livestock. This proactive approach not only protects the health of dog owners and their communities but also disrupts the broader rabies transmission dynamics by effectively

eliminating potential routes for the virus's spread. Consequently, this strategy serves to safeguard public health while also supporting economic stability.

This educational intervention aligns with global efforts, particularly the United Against Rabies collaboration, which aims to eliminate human deaths caused by dog-mediated rabies by 2030. Furthermore, this study contributes to the United Nations Sustainable Development Goal (SDG) 3, which seeks to end the epidemics of neglected tropical diseases, including rabies, by 2030. It also supports United Nations SDG 4 by enhancing health education, fostering lifelong learning, and promoting awareness of rabies as the deadliest zoonotic disease worldwide (World Health Organization *et al.*, 2018).

Ultimately, this study presents a scalable and sustainable educational intervention that addresses both public health concerns (dog bites and rabies), making it a key initiative in Malaysia's efforts to mitigate zoonotic diseases. This initiative not only strengthens national efforts but also contributes to global endeavours to combat rabies, ensuring that dog-owning communities are empowered to take proactive measures in preventing the spread of this fatal disease.

1.4   Research Questions

1.   What is the level of rabies-related KAP among dog owners in Kelantan?

2.   What are the factors associated with a good level of knowledge, a positive attitude, and good practice related to rabies among dog owners in Kelantan?

3.   Is the module (RaHEM) a valid tool for educating dog owners in Kelantan about rabies preventive measures?

4. How effective is the RaHEM in improving knowledge and attitude related to rabies among dog owners in Kelantan?

1.5 Objectives

1.5.1 General Objective

To determine the level and associated factors of rabies-related KAP, and to assess the validity and effectiveness of the RaHEM in improving knowledge and attitude among dog owners in Kelantan.

1.5.2 Specific Objectives

1. To estimate proportion of good knowledge, positive attitude and good practice related to rabies among dog owners in Kelantan

2. To determine the factors associated with a good level of knowledge, a positive attitude, and good practice related to rabies among dog owners in Kelantan.

3. To develop and validate the RaHEM for educating dog owners in Kelantan on rabies prevention.

4. To compare combined mean change in rabies-related knowledge and attitude scores among Kelantan's dog owner at one-month post intervention between intervention (RaHEM) and control group

1.6   Research Hypotheses

1. There is a significant association between human, animal and environmental factors with good knowledge, positive attitude and good practice related to rabies among dog owners in Kelantan.

2. The module (RAHEM) is a valid tool for educating dog owners in Kelantan on rabies preventive measures.

3. There will be at least one mean difference across groups (intervention and control) in at least one of the dependent variables (change in knowledge or attitude score related to rabies) or in combination at one-month post-intervention among dog owners in Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 The Epidemiology of Dog Bite

Although some studies have suggested that dog bites cause tens of millions of injuries each year, there are currently no global statistics on the frequency of such incidents. Most available data on the incidence and mortality rates associated with dog-related injuries come from high-income countries like the United States and the United Kingdom (Westgarth, Brooke & Christley, 2018; Tuckel & Milczarski, 2020). Data from 2001 to 2003 showed that about 4.5 million individuals in the United States were bitten by dogs annually, with 19% requiring medical attention and nearly 27000 individuals required reconstructive surgery (Tuckel & Milczarski, 2020). A community cross-sectional study conducted in Cheshire, United Kingdom, involving 1280 households revealed that nearly one-quarter of participants (24.8%, 95% CI: 21.7, 28.1) had been bitten by a dog at least once in their lifetime. However, only one-third of these incidents (33.1%) required medical attention, and 1.8% resulted in hospital admission (Westgarth, Brooke & Christley, 2018).

Malaysia has also seen a significant number of dog bite cases. Data from the Health Informatics Centre, Ministry of Health Malaysia, indicates that between 2017 and 2020, there were 71045 cases of potential rabid animal bites were reported (Yong *et al.*, 2020). Investigations by the Department of Veterinary Services (DVS) Sarawak found that 61% of these bites were caused by owned animals and 66% were due to provocation by the victims (Jawatankuasa Pengurusan Bencana Negeri Sarawak, 2022; Ten, 2022).

9

Another study conducted in Mukah Division, Sarawak, revealed that most bite cases (over 70%) involved domestic pets, with incidents largely occurring at home (Abdullah, Hassan & Ibrahim, 2023). This data is further supported by a study conducted in Perlis, which reported that out of 507 documented dog bite cases, more than half (58.4%) involved bites from owned dogs (Mohammad Basir *et al.*, 2023).

A cross-sectional survey conducted in the Satkhira Sadar sub-district of southwestern Bangladesh, which analysed 3200 households prove the association between having a dog at home and dog bites. The study's multivariable analysis demonstrated that households with pet dogs were twice as likely to experience dog bites (Odd Ratio [OR]: 2.13, 95% Confidence Interval [CI]: 1.40, 3.19), while those caring for or feeding community dogs faced a similarly elevated risk (OR: 2.04, 95% CI: 1.40,2.90) (Ghosh *et al.*, 2016). A comparable pattern is observed in Malaysia, where pet dogs are frequently allowed to roam freely, essentially becoming community dogs (Abdullah, Hassan & Ibrahim, 2023).

Moreover, findings from the United Kingdom indicate that dog owners with multiple dogs reported being bitten 3.3 times more frequently (95% CI: 1.13, 9.69; p-value = 0.03) than those who do not currently own a dog (Westgarth, Brooke & Christley, 2018). This behavior heightens the vulnerability of dog owners and those interacting with community dogs towards rabies, as dog bites remain the primary mode of transmission from dogs to humans. These findings underscore the critical importance of targeting dog owners as a key demographic in dog bite prevention efforts.

2.2   The Epidemiology of Human and Canine Rabies

Rabies is caused by viruses within the *Lyssavirus* genus and the *Rhabdoviridae* family, with all mammals susceptible to infection due to conserved cell receptors associated with the central nervous system (Jackson, 2018; Marston *et al.*, 2018). The transmission dynamics of rabies, as depicted in figure 2.1, involve complex interactions between domestic dogs, wild animals, livestock, and humans. Domestic dogs serve as a key vector, contributing to nearly 99% of human rabies deaths globally, and are considered the most significant threat to public health. Wild animals, such as foxes, skunks, coyotes, and raccoons, act as important reservoir hosts, sustaining rabies in wildlife populations and perpetuating its spread to domestic dogs and livestock (Gilbert A., 2018; Rupprecht & Salahuddin, 2019). Rabies primarily spreads through the bite of an infected animal, though rare cases occur through ingestion of infected animal tissue or contamination of oral mucosa. Human-to-human transmission is uncommon and typically occurs through organ transplantation, as evidenced by documented outbreaks in multiple countries (Lu, Zhu & Wu, 2018). The incubation period for rabies varies considerably, typically spanning 20 to 90 days but can range from several days to multiple years (Fooks & Jackson, 2020).
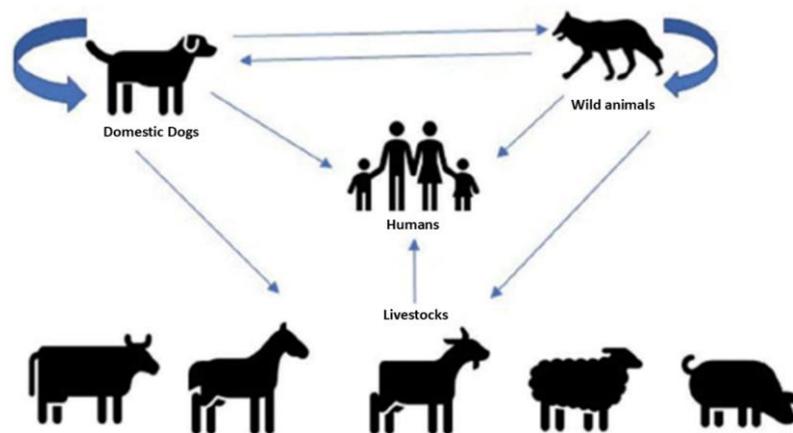
Figure 2.1: The complex dynamics of rabies transmission involving domestic dogs, wild animals, humans, and livestock adapt from Rupprecht & Salahuddin (2019).

The global burden of rabies has been estimated through various modeling studies, beginning in 2005, approximately 55000 human rabies deaths annually. This estimate was revised in 2015 to 59000 deaths per year and further increased in 2019 to around 74000 deaths annually. However, estimates vary widely, with figures ranging from 14000 to 175000 deaths per year (Swedberg *et al.*, 2024). Most of these deaths (98%) were caused by rabies virus infections transmitted through dog bites, which will hereafter be referred to as "dog-mediated rabies" (Hampson *et al.*, 2015; Fooks & Jackson, 2020). Approximately half of human rabies deaths occur in Asia (59.6%) and followed by Africa (36.4%), with India accounting for 35% of the global estimate. However, the highest per capita death rates were projected to occur in the poorest sub-Saharan African countries, as illustrated in Figure 2.2 (Hampson *et al.*, 2015).
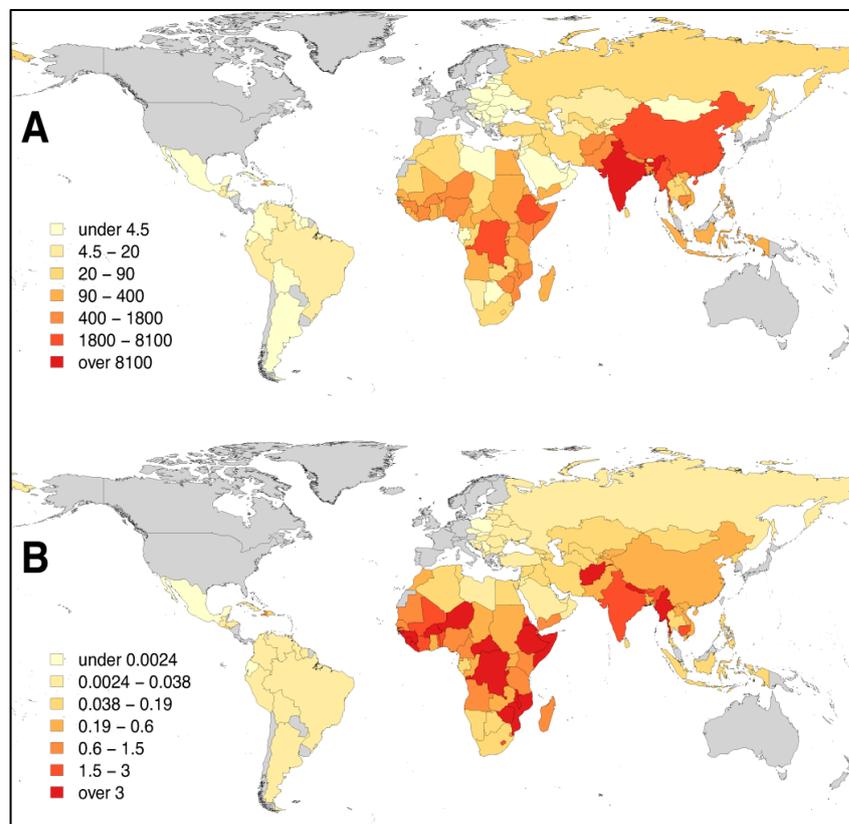
Figure 2.2: The global distribution of estimated human deaths (A) and death rates per 100,000 persons (B) due to rabies. Figure adopted from Hampson *et al.* (2015).

The WHO, through its Global Health Observatory, mapped the presence of dog-mediated human rabies by country in 2022, confirming the distribution seen in 2015. A notable observation is that dog-mediated rabies has been eliminated in most developed countries, particularly in Northern America, Western Europe, Japan, the Republic of Korea, Australia, New Zealand and a few isolated countries in Asia and South America. However, many other developing and underdeveloped countries, continue to struggle with controlling and eliminating rabies endemicity (Fooks & Jackson, 2020). Most Southeast Asian countries, including Indonesia, the Philippines, Vietnam, Myanmar, Laos, Cambodia, and Thailand, continue to struggle with rabies, with dog-mediated human rabies remaining a significant public health issue. In contrast, Singapore and Brunei are the only countries in the region that have successfully eliminated both dog-mediated human rabies and canine rabies. Meanwhile, Malaysia has reported sporadic cases of dog-mediated human rabies, with dog rabies remaining limited to a few areas as illustrated in Figure 2.3.
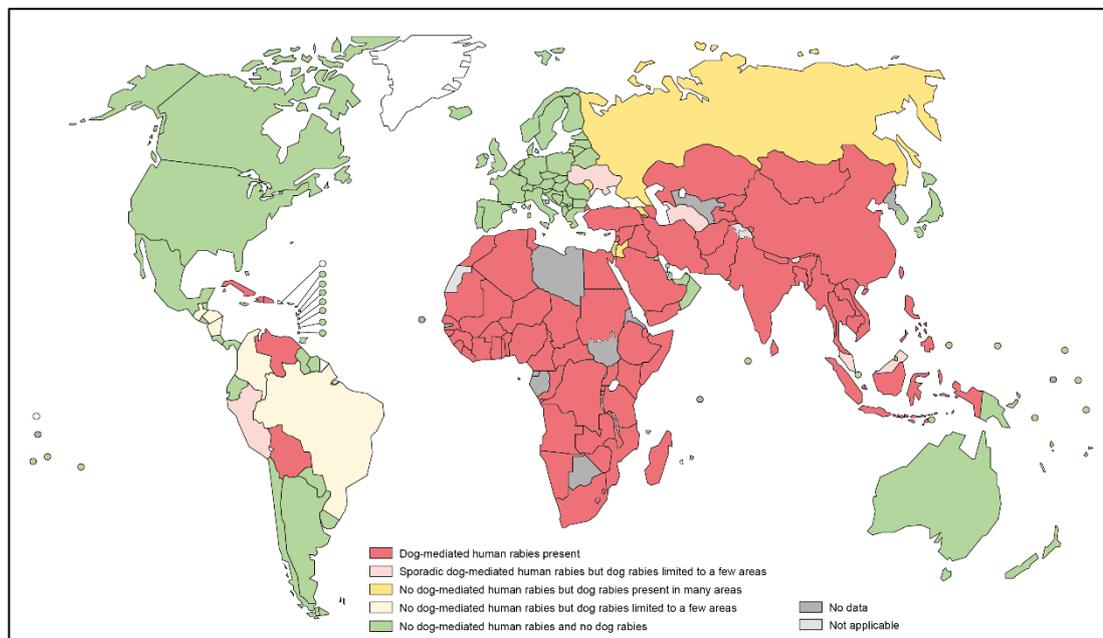
Figure 2.3 Global distribution of dog-mediated human rabies by country in 2022. The figure was released on 26th May 2024 by the Control of Neglected Tropical Disease, World Health Organization.

Human rabies remains endemic in China, the Philippines, and Vietnam, all of which are part of the Western Pacific Region. Consequently, this region has not yet achieved rabies elimination status. Malaysia had been recognized as one of the countries in the Western Pacific Region with rabies-free status prior to 2015.

Malaysia recorded its first incidence of canine rabies in 1925 in the state of Perlis, which borders Thailand, a country where dog-mediated human rabies is endemic (Navanithakumar *et al.*, 2019). Numerous substantial rabies outbreaks occurred in 1945 in Province Wellesley (now known as Seberang Perai) and Perak, followed by another outbreak in 1952 in Selangor (Ganesan & Sinniah, 1993). The epidemiology of rabies in both dogs and humans in Malaysia from 2015 to 2023 highlights significant public health concerns. During this period, 92834 animal samples were submitted for rabies testing, with 995 samples (approximately 1.1%) testing positive for the virus. Most of these positive cases were identified in dogs, accounting for 89.4% of all confirmed rabies cases. Among domestic dogs, owned pets contributed to nearly half (43.7%) of the confirmed rabies cases. The study reported a mean effective reproductive number (Re) of 2.03 (standard error: 0.09) for canine rabies outbreaks in Malaysia during this period. Sarawak was the most affected state, responsible for nearly 98% of confirmed canine rabies cases in Malaysia. In contrast, states in northern peninsular Malaysia, including Kedah, Perak, Perlis, and Pulau Pinang, reported fewer cases, with confirmed rabid dogs ranging from three to nine cases per state (Wada *et al.*, 2024). Kelantan was the only state in the northern region that did not report any canine rabies cases within that period.

Besides that, a total of 72 individuals were confirmed to have rabies, of whom 65 succumbed to the disease, resulting in a high fatality rate of 90.3% between 2015

and 2023. Most human rabies cases were reported in Sarawak, while Selangor reported two cases, one of which had died (Wada *et al.*, 2024). In recent cases, it was observed that patients were bitten by their free-roaming, unvaccinated pet dogs. Epidemiological investigations revealed that nearly half (51.3%) of all human rabies cases were bitten by owned dogs (Abdullah, no date; Bernama, 2022). Moreover, poor health-seeking behavior following bites, failure to report the deaths of pets to authorities, and the adoption of stray dogs as pets were common contributing factors in many of the reported cases (Abdullah, no date; Bernama, 2022). The data in Malaysia were supported by the study in Pakistan where households with pets' dog are 1.36 times more likely (OR = 1.36; 95% CI: 1.04,1.76, p-value = 0.024) to have contact with rabies compared to non-pet owner (Ahmed *et al.*, 2020).

Pets owners were found to be at a higher risk for rabies exposure due to several gaps in awareness and preventive measures. 69.0% of pet owners were unaware of rabies vaccination campaigns, and the likelihood of being unaware was much higher (OR = 1.96; 95% CI: 1.26, 2.16, p-value < 0.001) for pet owners compared to non-pet owners. Furthermore, 38% of pet owners had not vaccinated themselves against rabies, with their odds of not being vaccinated also significantly higher (OR = 1.58; 95% CI: 1.04, 1.76, p-value = 0.024) than those of non-pet owners. This trend extended to their health-seeking behavior, as 52.0% of pet owners did not seek medical advice after a suspected animal bite, and they were nearly twice as likely (OR = 1.97; 95% CI: 1.04, 1.76, p-value = 0.024) to neglect seeking medical advice compared to non-pet owners. This lack of action may have contributed to the high number of rabies-related fatalities reported by pet owners, with 65.0% of pet owners experiencing rabies-related deaths within their family, and the odds of this occurrence being significantly higher (OR = 1.73; 95% CI: 1.11, 1.91, p-value = 0.006) than in non-pet owning households. Lastly,

54.0% of pet owners lacked knowledge of the clinical signs of rabies in animals, and they were more likely than non-pet owners to be unaware of these critical signs (OR = 1.20; 95% CI: 1.01, 1.63, p-value = 0.035). This combination of lack of awareness, vaccination, and health-seeking behaviors highlights the elevated risk that pet owners face when it comes to rabies exposure (Ahmed *et al.*, 2020).

2.3   The KAP Model

The KAP survey is a comprehensive tool designed to gather data on the understanding, beliefs, and behaviors of a targeted population regarding a specific subject (Zarei *et al.*, 2024). KAP are fundamental elements in models of behavioral change. Knowledge refers to the understanding of information, encompassing both conscious and non-symbolic perceptions of meaning. Attitude represents an individual's positive or negative evaluation of an object or situation, while practice pertains to routine actions that are shaped by prevalent social norms and beliefs.

One of the primary criticisms of the KAP model is its assumption of a linear relationship, where knowledge directly influences attitudes, which in turn affect practices that oversimplifying the complexities of human practice (Sridhar *et al.*, 2016). However, empirical evidence suggests a positive correlation between KAP. A study conducted in Ethiopia found significant correlations between knowledge and attitude (r = 0.888, p-value < 0.001), knowledge and practice (r = 0.706, p-value < 0.001), and attitude and practice (r = 0.775, p-value < 0.001). These findings demonstrate that enhancing knowledge remains a driver in shaping attitudes and encouraging protective practices (Ali, Ahmed & Sifer, 2014).

Moreover, social desirability bias remains a limitation, as respondents in KAP surveys may overreport positive attitudes and practices, leading to potential distortions in practice data. Despite these limitations, the KAP model remains valuable for initial assessments of community knowledge and attitudes regarding specific health issues (Zarei *et al.*, 2024). The KAP model has been widely used in public health to assess and influence practice towards disease prevention and control. Surveys based on this KAP concept have been extensively utilized globally as tools for establishing baseline community level of knowledge, and rabies research is no exception. Numerous studies have been conducted in regions with high human rabies prevalence, focusing on households irrespective of dog ownership status, including the latest NHMS (Hagos *et al.*, 2020; Institute for Public Health, 2021; Lungten *et al.*, 2021; Ubeyratne *et al.*, 2021; Bahiru *et al.*, 2022). Besides that, KAP surveys also were widely used as measurement tools to evaluate the effectiveness of health education programs which provide quantifiable insights into changes in KAP score following an intervention (Sridhar *et al.*, 2016; Zarei *et al.*, 2024)

2.4 Existing Rabies-Related KAP Questionnaires

The assessment of rabies-related KAP across various studies has employed diverse questionnaire designs, reflecting both shared approaches and distinct variations. This section critically reviews the questionnaires used in literature, emphasizing applicability to our study. The reviewed questionnaires were derived from studies conducted in Amhara, Bhutan, Kigali, Chiro, Mekelle, and Malaysia. None of these questionnaires had specific names, except for the Malaysian questionnaire, which is officially referred to as the Cognitive, Affective, and Behaviour of Dog-Associated Zoonotic Disease Questionnaire (CAB-ZDQ)

17

(Ntampaka *et al.*, 2019; Rinchen *et al.*, 2019; Hagos *et al.*, 2020; Yong *et al.*, 2021; Ahmed *et al.*, 2022; Bahiru *et al.*, 2022). The cognitive domain of the CAB-ZDQ corresponds to knowledge about rabies, the affective domain assesses attitudes toward risk factors related to dog-mediated zoonotic diseases, particularly rabies, and the behavioural domain evaluates health-seeking practices following a dog bite. Despite the difference in theoretical naming, the core constructs measured in CAB-ZDQ remain comparable to those assessed in KAP-based questionnaires used in other studies (Institute for Public Health, 2021; Yong *et al.*, 2021). Therefore, this questionnaire was included as one of the selected tools for review, and the terminology used throughout this study will be referred to as KAP to ensure consistency and comparability with other studies.

The majority of KAP studies on rabies have followed a standardized structure, assessing three key domains through a combination of closed-ended questions. Knowledge and practice domain is typically measured using multiple-choice questions or dichotomous responses (e.g. "Yes" or "No") enable objective assessment of factual understanding about rabies, including rabies transmission, potential animals, symptoms, and prevention for humans and animals as well as actionable practice on seeking medical attention after a bite, washing the wounds and wound management as seen in the studies from Amhara, Bhutan, Kigali, Mekelle and Malaysia (Ntampaka *et al.*, 2019; Rinchen *et al.*, 2019; Hagos *et al.*, 2020; Yong *et al.*, 2021; Bahiru *et al.*, 2022). Attitude is commonly evaluated through Likert-scale items, capturing individuals' perceptions and beliefs as seen in the studies from Amhara, Bhutan and Malaysia (Rinchen *et al.*, 2019; Yong *et al.*, 2021; Bahiru *et al.*, 2022).

However, substantial differences exist in the validation processes and mode of data collection employed for these questionnaires. The NHMS questionnaire stands out due to its comprehensive validation, which included content validation, factor analysis, reliability assessment, and pilot testing (Yong *et al.*, 2021). However, the rabies-related KAP from Amhara and Chiro relied solely on pilot testing (Hagos *et al.*, 2020; Ahmed *et al.*, 2022; Bahiru *et al.*, 2022). While Kigali City employed principal component factor analysis (PCFA) but still lacked the extensive validation process as evident in the NHMS (Ntampaka *et al.*, 2019). The rigorous validation process ensures the validity of the questionnaire to accurately measure rabies-related KAP.

The mode of questionnaire administration plays a crucial role in influencing response accuracy and minimizing bias. Studies have primarily used two approaches. The NHMS study adopting a self-administered format that minimizes the risk of interviewer bias and allows respondents to complete the questionnaire at their convenience (Institute for Public Health, 2021). Whereas the reliance on face-to-face interviews in Mekelle, Amhara, Chiro, and Kigali studies may introduce social desirability bias, potentially affecting the accuracy of responses (Hagos *et al.*, 2020; Ahmed *et al.*, 2022; Bahiru *et al.*, 2022).

These similarities and distinctions hold particular importance when selecting an appropriate tool for our research, with the NHMS questionnaire emerging as the most suitable choice for several compelling reasons. First, the NHMS questionnaire's robust validation ensures the validity and reliability of the findings which providing a strong methodological foundation. Second, its self-administered mode of administration aligns well with our study's context, as recruitment occurred during a mass program where this method was both practical and efficient. Additionally, being

developed and validated within Malaysia, the NHMS questionnaire offers a culturally and contextually acceptable tools that enhancing the applicability of our findings. Finally, the scope of assessments and structure of NHMS questionnaire aligns with other internationally published rabies-related KAP questionnaire further supports its appropriateness.

2.5   The Level of KAP towards Rabies

The terminology used in the original studies varied; however, they consistently referred to the same underlying concepts of good knowledge, a positive attitude, and good practice. This literature review adopts a standardised term that aligns with the study objectives to ensure consistency, facilitate comparison, and minimise ambiguity.

The proportions of individuals with good rabies knowledge vary considerably across regions and populations, ranging from 39% to 84.9%. A study in Mekelle City, Ethiopia reported a good knowledge level of 56.1% (95% CI: 52.2, 59.9), while the Amhara region of Ethiopia exhibited the highest proportion at 84.9% (Hagos *et al.*, 2020; Bahiru *et al.*, 2022). Both studies focused on general populations. While the study among dog owners, 53.3% (95% CI: 44.6, 61.9) in Kigali City, Rwanda, and 52.2% (95% CI: 52.2, 57.7) in Chiro, Ethiopia, demonstrated good knowledge. The lowest proportion was observed in Bhutan, where only 39% of cattle owners displayed good knowledge about rabies. The only data for Malaysia were recorded during the NHMS 2020 where 46.4% (95% CI: 42.5, 50.3) of the general population had good rabies knowledge, while a slightly lower proportion of 45.2% (95% CI: 29.7, 61.6) was observed among dog owners (Institute for Public Health, 2021).

The proportions of individuals with a positive attitude toward rabies control and prevention vary significantly across studies, with a broader range observed compared to knowledge levels, spanning from 17.0% to 98.6%. In Ethiopia, 56.2% of the general population in Mekelle City demonstrated a positive attitude, which is comparable to the 49.1% reported among dog owners in Chiro City (Hagos *et al.*, 2020; Ahmed *et al.*, 2022). The highest proportion of positive attitudes was also recorded in Ethiopia, where 98.6% of respondents in the Amhara region expressed a positive attitude toward rabies control and prevention (Bahiru *et al.*, 2022). The study that was conducted in Malaysia, a noticeable difference was observed between the general population and the dog owner community. The NHMS 2020 reported that 53.1% (95% CI: 49.3, 56.9) of the general population had a positive attitude toward rabies, compared to only 24.6% (95% CI: 13.4, 40.8) of dog owners who exhibited similar attitudes (Institute for Public Health, 2021). A study among cattle owners in Bhutan found that 65% (95% CI: 61.0, 69.6) held positive attitudes toward rabies control and preventive measures (Rinchen *et al.*, 2019). In contrast, the lowest proportion of positive attitudes was reported in Kigali, Rwanda, where only 17.0% (95% CI: 11.6, 24.9) of dog owners demonstrated positive attitudes toward rabies control (Ntampaka *et al.*, 2019).

The reported proportions of good practices across studies range from 39.7% to 66.4%, indicating considerable variability in adherence to recommended practices. NHMS 2020 in Malaysia reported that 42.2% (95% CI: 40.6, 43.8) of the general population demonstrated good practice, a figure slightly higher than the 39.7% (95% CI: 33.9, 45.8) observed among dog owners (Institute for Public Health, 2021). The general population in Mekelle City exhibited a proportion of good practices at 61.3% (95% CI: 57.5, 65.1), while the Amhara region reported a lower proportion at 43.0%.

The good practices towards rabies and its control among dog owners in Kigali, Rwanda was reported at 66.4% (95% CI: 57.9, 74.3) (Ntampaka *et al.*, 2019). Moreover, 47.2% (95% CI: 41.7, 52.8) of dog owners in Chiro, Ethiopia, were reported to have good rabies prevention and control practices, with those scoring equal or above the mean classified as having good practices (Ahmed *et al.*, 2022).

Numerous studies have explored KAP related to rabies, with most focusing on general community populations (Nejash *et al.*, 2017; Sor *et al.*, 2018; Bouaddi *et al.*, 2020; Hagos *et al.*, 2020; Li *et al.*, 2021; Lungten *et al.*, 2021; Spargo *et al.*, 2021; Ubeyratne *et al.*, 2021; Bahiru *et al.*, 2022). While these studies have provided a foundational basic understanding on the rabies prevention, they may not comprehensively capture the specific KAPs of dog owners. Despite their crucial role in rabies transmission and prevention, dog owners remain underrepresented in the literature. Only a limited number of studies have specifically examined their KAP towards rabies (Ameh, Dzikwi & Umoh, 2014; Ntampaka *et al.*, 2019). Overall, the comparison between the general population and dog owners reveals notable differences in their KAP related to rabies. The general population consistently demonstrated higher proportions of good knowledge and positive attitudes as compared to dog owners. However, both populations exhibited comparable proportions of good practices related to rabies prevention and control.

2.6 Factor Associated with rabies-related KAP

The One Health High-Level Expert Panel (OHHLEP) defines One Health as an integrated and unifying approach aimed at sustainably balancing and optimizing the health of humans, animals, and environment. This concept underscores the interconnectedness and interdependence of humans, animals, and environment,

emphasizing the need for collaborative efforts across sectors and disciplines. This approach is not merely theoretical but a practical necessity in tackling complex global health threats such as zoonotic diseases, antimicrobial resistance, food safety, and vector-borne infections. Over time, the One Health framework has gained increasing recognition within public health and animal health communities (Miao *et al.*, 2022).

2.6.1   The human factor

The KAP toward rabies are shaped by a range of factors that can be effectively investigate through the One Health framework. Human factors encompass the sociodemographic characteristics and experiences with dog ownership of dog owners.

2.6.1.1   Age

The influence of age on knowledge levels is complex and varies significantly depending on the context and population studied. A study conducted in Siem Reap Province, Cambodia, in 2014 found that respondents aged 30 to 39 were significantly more likely (Adjusted Odds Ratio [AOR] = 3.48; 95% CI: 1.07, 11.42; p-value = 0.04) to possess good knowledge compared to those under 30. However, no significant associations were found between good knowledge and respondents aged 40 to 49 (AOR = 1.46; 95% CI: 0.37, 5.85; p-value = 0.59) or those over 50 (AOR = 1.24; 95% CI: 0.29, 5.24; p-value = 0.77) when compared to those younger than 30 (Sor *et al.*, 2018). Furthermore, a study conducted in the Amhara region of Ethiopia found that participants aged 31 to 45 were 83% more likely (AOR = 1.83; 95% CI: 1.11, 3.03; p-value = 0.018) to have good knowledge compared to those under 30 (Bahiru *et al.*, 2022). However, a study in the Philippines among households found no significant association between KAP scores and age (Davlin *et al.*, 2014). Younger populations are more likely to engage with modern learning platforms, such as social media, which

may provide fragmented or incomplete information, potentially leaving them with gaps in their knowledge. In contrast, individuals aged 30 to 45 years, who also have access to social media, may have a more comprehensive understanding due to their exposure to past rabies outbreaks or heightened awareness campaigns within their communities (Tenzin, Namgyal & Letho, 2017).

A study conducted in China among dog bite victims, utilizing multivariate logistic regression analysis, was unable to establish a statistically significant association between attitudes toward rabies prevention and age group. This finding is consistent with the study conducted in the Philippines, which similarly found no significant relationship between attitudes toward rabies prevention and age (Davlin *et al.*, 2014; Li *et al.*, 2021). A recent study conducted in Oromia, Ethiopia, successfully established an association between age and positive attitudes toward rabies prevention. The study found that respondents aged 30–45 years were 50% lower odds to have a positive attitude compared to those aged 15–29 years (AOR = 0.50; 95% CI: 0.20,0.90; p-value <0.05). Similarly, respondents aged over 46 years were 60% lesser odds to exhibit a positive attitude (AOR = 0.40; CI:0.20, 0.90; p-value <0.05). These associations were identified through multiple logistic regression analysis, suggesting that individuals aged less than 30 may be more chance to hold positive attitudes toward rabies prevention compared to older age groups (Adem *et al.*, 2024). The lack of a consistent association between age with attitude across different studies highlights a significant research gap that could benefit from further investigation. Addressing this research gap is crucial for developing targeted public health strategies that foster positive attitudes across diverse populations.