THE EVIDENCE

www.evidencejournals.com

Review Article | One Health

Check for updates

Rabies control in Asia through one health interventions – a scoping review

Ayush Sharma[1], Frederick Satiro Vaz[2], Urvi Swami[3], Sowntappan Balasubramanian[4], Gopi Kumbha[5], Nimisha Bhuyan[6], Nabhira Aftabi Binte Islam[7], Pawan Kumar[8*]

[1] Department of Community Medicine School of Public Health, Post Graduate Institute of Medical Education and Research Pgimer, Chandigarh, India.
[2]Community Medicine, Goa Medical College, Panaji, Goa, India.
[3] ICMR-Vector Control Research Centre, Puducherry, India.
[4] Centre for One Health, National Centre for Disease Control, New Delhi, India.
[5] Department of Epidemiology, South Asia Field Epidemiology and Technology Network, Delhi, India.
[6] Indian Institute of Public Health Shillong, Shillong, India.
[7] Preventative and Social Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka, India.
[8] Department of Community Medicine and School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, Chandigarh, India.

Correspondence: pawankumar705c@gmail.com

Abstract

Background: Rabies, a deadly zoonotic disease, remains a major public health issue in Asia, demanding urgent and effective interventions. Embracing the One Health approach, which integrates human, animal, and environmental health, presents a comprehensive framework for tackling rabies. This study explores how such a holistic strategy can enhance rabies control and eradication efforts in Asia, where the disease continues to pose a significant threat. By fostering multi-sectoral collaboration and blending veterinary, medical, and environmental sciences, the One Health approach aims to streamline surveillance, control, and ultimately, the elimination of rabies.

Methods: This study employs a scoping review methodology to assess the effectiveness of One Health interventions in the management and outcomes of rabies across various Asian contexts, exploring the associated challenges and achievements. Following the Arksey and O'Malley five-step framework and adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines, this review seeks to uncover critical themes, identify trends, and highlight gaps within the realm of rabies control in Asia.

Results: Our review included studies showcasing the application of One Health strategies in combating rabies across different Asian contexts. These studies emphasize the critical role of technological innovations, community engagement, and multi-sectoral collaboration in effective rabies control. Innovations like mobile apps for surveillance and social media for education, coupled with traditional control methods, have shown promise. The success of these strategies underlines the need for culturally adapted approaches and unified efforts spanning health, animal, and environmental sectors.

Conclusion: The One Health approach significantly contributes to rabies control efforts in Asia, promising strides towards its management and eventual eradication. This strategy, emphasizing stakeholder collaboration, technological use, and sensitivity to socio-economic and cultural contexts, paves the way for a rabies-free future. Future research should extend One Health applications to other zoonotic diseases, assess the scalability of interventions, and enhance surveillance systems, reinforcing global health security against rabies and other public health challenges.

Keywords: *lyssavirus; dog-mediated rabies; zoonotic diseases; one health approach; stray animal control; intersectoral collaboration; veterinary medicine*

evidence Journals

Cite this Article

Sharma A, Vaz FS, Swami U, Balasubramanian S, Kumbha G, Bhuyan N, Islam NAB, Kumar P, Rabies control in Asia through one health interventions – a scoping review. The Evi. 2024:2(1):1-.
DOI:10.61505/evidence.2024.2.1.68
Available From https://the.evidencejournals.com/index.php/j/article/view/68

Received:	2024-05-29
Accepted:	2024-05-30
Published:	2024-06-10

Evidence in Context

• Promotes integrating human, animal, and environmental health to fight rabies in Asia. • Underlines the effectiveness of technological innovations and community engagement. • Points to mobile apps and social media as key tools in rabies control. • Stresses the need for culturally tailored approaches and multi-sector collaboration. • Advocates for extending the One Health approach to other zoonotic diseases.

To view Article

Introduction

Rabies, a neglected zoonotic disease, continues to be a significant global health threat, causing considerable mortality worldwide, particularly in Asia [1]. Transmitted mainly through infected animal bites, rabies impacts all mammalian species, with the majority of human cases attributed to dog bites [2]. The virus is prevalent among other wildlife species, such as bats, cats, raccoons, skunks, and foxes, especially noted in regions like the Americas and Europe [3,4]. Although, nearly 90% of fatal human cases are traced back to bites from rabid dogs [5]. The highest incidence rates were observed in Asia, with 60% cases, followed by Africa at 36.4% [6]. Every year, more than 50,000 lives are claimed by rabies, highlighting the fatal nature of the disease [7]. Rabies poses not only a significant threat to health but also leads to considerable economic costs, with global estimates reaching around US$ 8.6 billion annually [8].

Asia faces a critical rabies problem, with the highest global death rates, where India contributes to 35% of these fatalities [2,9,10] closely followed by neighbouring Bangladesh [1]. Countries like Nepal, Myanmar, Bhutan, Thailand, and Indonesia experience moderate incidences of rabies, contributing to over half of the global cases linked to dog transmission [6]. Every nine minutes, rabies claims a life in Asia, with India experiencing the greatest loss of life and significant declines in quality of life, as measured by disability-adjusted life years (DALYs) [9]. Moreover, the financial burden of post-exposure prophylaxis (PEP) in Asia is the highest, with costs soaring to US$1.5 billion each year [1]. The disproportionate burden in Asia, particularly in India and Bangladesh, highlights the urgent need for enhanced rabies control measures, including widespread vaccination of dogs, public awareness campaigns, and improved access to affordable and effective PEP. Addressing these challenges is critical for reducing the incidence of rabies and alleviating its substantial health and economic impacts in Asia [11].

Addressing rabies in Asia necessitates a comprehensive One Health approach that synergizes public health education, animal management, and environmental stewardship. This entails not only raising awareness about rabies prevention and the significance of immediate care and post-exposure prophylaxis (PEP) but also ensuring PEP's accessibility and affordability, especially in underserved areas [5]. Key to this integrated strategy is the humane management of stray dog populations via Animal Birth Control (ABC) programs, directly tackling the primary rabies vector. Moreover, reinforcing legal frameworks and policies, such as mandatory dog registration and encouraging responsible pet ownership, plays a crucial role in a holistic rabies control ecosystem [10]. Community engagement is essential, with active involvement in vaccination drives and rabies reporting fostering a collective response to eradication efforts [12]. In addition to that, emerging technological innovations, such as the development of mobile apps for enhanced surveillance can offer promising avenues for improving detection and management of rabies [13]. Central to this One Health framework is the recognition that vaccinating dogs is not only the most efficient way to prevent rabies in humans but also a pivotal element of a broader, more cohesive strategy that bridges human health, animal welfare, and environmental considerations [14].

Expanding upon these initiatives, the integration of the One Health Approach into Asia's rabies control strategies can offer a pathway to not only address the current challenge but also to anticipate the future risks associated with rabies. The One Health Approach gained a lot of popularity in recent times due to its interdisciplinary nature in treating and controlling zoonotic and vector-borne diseases globally. The primary goals of this approach aims to boost human, animal, and environmental health, advance disease understanding and prediction, control diseases across species, and optimize resource use through multi-sector collaboration [15]. Through the implementation of the approach, Asian countries can improve surveillance, vaccination efforts, and public awareness of rabies prevention, crucially addressing the over 95% of cases stemming from dog bites with a multifaceted strategy [16].

Recognizing the multifaceted challenges rabies presents in Asia, from its widespread incidence and economic strain to the need for improved public health measures, the One Health approach emerges as a promising framework. The primary purpose of this scoping review is to evaluate and synthesize effectiveness of One Health interventions in managing rabies throughout various regions in Asia.

Methodology

The scoping review will adhere to the Arksey and O'Malley five-step framework [17], in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines [18]. The review will explore the scope and intricacies of the One Health interventions in addressing rabies across Asia, aiming to pinpoint key themes, evolving trends, and existing lacunae. The review was structured around five distinct phases as per the Arksey and O'Malley framework:

Formulating the Research Question

The scoping review is centred around the question: a) "How do One Health interventions impact the management and outcomes of rabies in different Asian contexts?", and What are the notable challenges and achievements in executing One Health strategies for rabies management in the region?"

Identifying the Relevant Literature

We conducted a comprehensive literature search on three major bibliographic databases – PubMed, Scopus, and Web of Science, using key descriptor terms such as "One Health", "Rabies", and "Asian Countries" within title and abstracts query tags. The search was not constrained by any publication dates, spanning from the inception of databases until 1 March 2024. Files obtained from the search were then uploaded to Nested Knowledge Platform for de-duplication of the records [19]. Detailed search strategy for each database were described **Appendix 1.**

Setting the Inclusion and Exclusion criteria

The selection criteria for inclusion in the review were centred around articles primarily addressing the research question, particularly those examining the One Health strategy in rabies management across Asia. Eligible publications included peer-reviewed research articles, mini-reviews, and case reports, written in English language. Studies not aligned with our research question, short articles like editorials, commentaries, abstract papers, conference proceedings, and perspectives were excluded. Articles without full texts were also omitted from the review.

Organizing and charting the data

Screening was conducted independently by two independent reviewers (PK and AS), with initial title/abstract screening were done to assess relevance to the review's objectives, followed by a full-text screening on the Nested Knowledge Platform. Any discrepancies that emerged during the review process were resolved through mutual agreement by a third senior reviewer (PS). Data on various parameters, including the first author's name, year of publication, country of publication, study objective, key findings, challenges identified, and additional insights, were gathered using a standardized extraction form.

Summarizing the Findings

In the summarization phase, we consolidated the key findings from the selected studies to focus on major insights and challenges relevant to the effectiveness of One Health interventions in rabies control across Asia.

Results

A systematic search was conducted across three bibliographic databases - PubMed (n=76), Scopus (n=203), and WOS (n=72), which yielded a total of 340 records. After removing duplicates, 217 records were selected for initial title/abstract screening in Nested knowledge screener, leading to the exclusion of 94 articles based on predefined inclusion and exclusion selection criteria. This further resulted in 115 reports being considered for full-text retrieval, from which exclusions were made due to reasons such as relevance to the review question and full-text availability. 17 studies were included for a scoping review. **Figure 1** illustrates the flow of study selection process in accordance with PRISMA-ScR guidelines.

The final review encompassed 17 studies, revealing a broad geographical spectrum

Of rabies research across Asia. Indonesia emerged as a significant contributor with four studies, followed by India and China with three each. Other countries like Vietnam, Sri Lanka, Thailand, and the Philippines were each represented by a single study, highlighting the transnational nature of rabies research in the region. Some of the studies selected were carried out in multiple Asian countries. These studies collectively underscore the essential integration of human, animal, and environmental health, advocating for multisectoral collaboration in rabies control strategies.

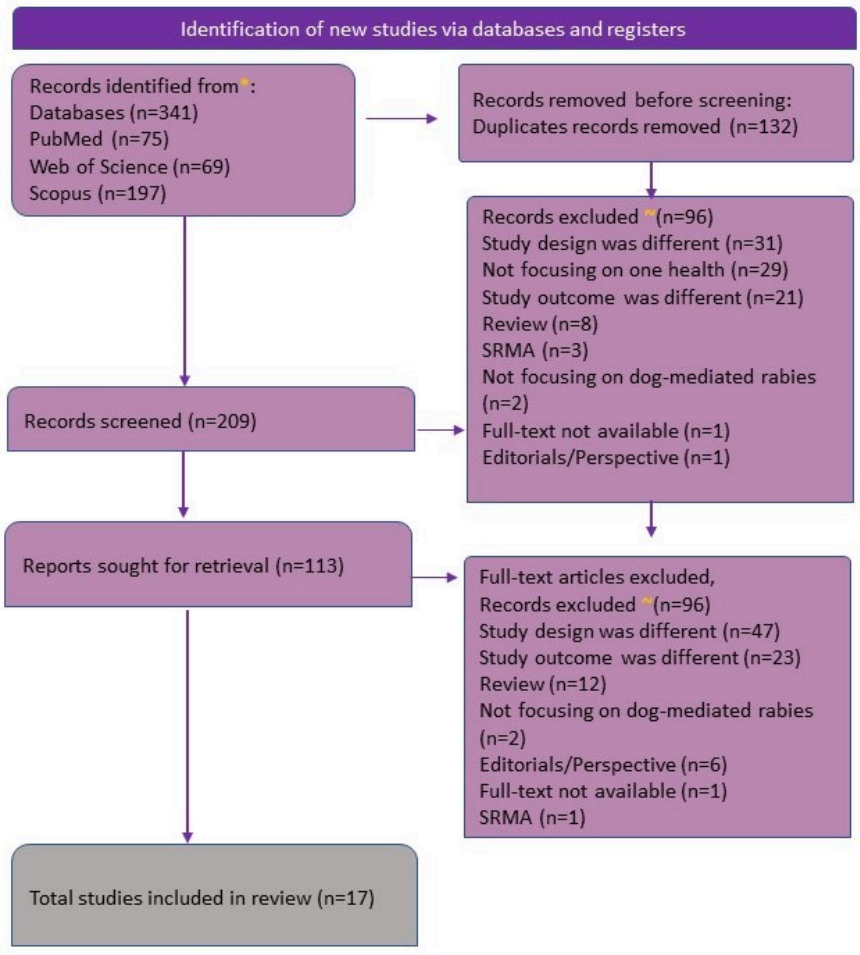

Figure 1: PRISMA-ScR flowchart depicting the study selection process.

One Health Interventions in Rabies control

Multiple one Health interventions were employed in the studies, **as illustrated in Table 1** below. Community engagement and cultural integration were the most frequently represented category with six studies (n=6), highlighting the crucial role of integrating community and cultural aspects into rabies prevention strategies to ensure their acceptability and effectiveness [20-25]. Technological innovations, closely followed by four studies (n=4) [5,21,26,27] show a significant trend towards leveraging technology to enhance the efficacy and scope of disease control measures in the continent. Strategic Planning and Interdisciplinary Cooperation were also found in four studies [26,28-30], emphasizing the necessity of well-coordinated strategies to combat rabies more effectively. Multisectoral collaboration was also a key focus, represented in two studies, showing the importance of collaborative efforts across various sectors, including health, veterinary, and community organizations [31-33], to manage and prevent rabies through a unified approach. Interestingly, one study examined the economic aspects of rabies control [32], highlighting the critical role of strategic funding and philanthropic support in enhancing the cost-effectiveness and sustainability of rabies prevention initiatives.

Community Engagement and Cultural Integration

The successful implementation of rabies control strategies often relies on the active involvement of local communities and the alignment with their cultural values. The Chiang Mai Model introduced in Thailand incorporates scientific rabies control methods with Buddhist principles, creating a culturally resonant approach. This model emphasized the need of multi-stakeholder collaboration, involving government bodies, Non-governmental organizations (NGOs), academic institutions, and religious bodies, to create a culturally sensitive and effective disease prevention framework [25]. One study also proposed a framework for rabies interventions that emphasized the importance of political, societal, and economic support. It advocated for a balanced approach that considers both the positive and negative consequences of interventions [21]. A study by Byrnes H. et al. suggested the implementation of a local state initiative – The Sikkim Anti-Rabies and Animal Health program (The SARAH program), aimed at controlling and eradicating rabies in the north-eastern Indian state [22]. A study conducted in Minahasa Regency of Indonesia centred on the effectiveness of rabies control through locally initiated strategies that required continuous local government commitment [23]. Another study on canine rabies elimination in Cebu, Philippines, emphasized the heavy dependence on patient out-of-pocket expenditures (OOPE) for funding vaccination campaigns and highlighted the urgency for government-led and inter-sectoral cooperation [24]. Moreover, in a study conducted in ASEAN countries, the author addressed the need for policy changes and capacity building to manage rabies epidemics effectively. It suggested an understanding of rabies ecologies and a regional approach to address disparities in vaccine availability and resource allocation [20]. Collectively, these studies demonstrate that successful rabies control requires not only scientific, medical and technological interventions but also robust community engagement, cultural sensitivity, and strong multisectoral collaboration to adapt strategies to local contexts and resources.

Technological Innovations in Rabies Control

The integration of cutting-edge technologies has significantly transformed rabies surveillance and management strategies across various regions and can prove to be a game-changer in the next few years. In Bali, Indonesia, the development of a mobile application marks an advancement in modernizing rabies surveillance with the integration of technology. The application streamlines the recording of dog vaccination data and enhances access to veterinary services, providing timely vaccination reminders [27]. Another study demonstrated the use of portable MinION technology in Goa, India, to quickly sequence the rabies virus which provided detailed information about the virus's genetic variations and transmission, helping to improve control strategies [5]. This novel approach has also offered insights into the virus's genetic diversity and transmission dynamics, enabling more targeted and effective control strategies. Furthermore, a study in China used a WeChat-based rabies prevention program, using wide reach of social media platforms to educate the public on rabies management and prevention [34]. Another China-based research focused on the need for reliable vaccine technology and improved animal governance [21]. These technological innovations mark a significant transition towards more effective and accurate rabies management and prevention, both in Asia and worldwide.

Strategic Planning and Interdisciplinary Cooperation in Rabies Control

Four studies on this theme highlighted the importance of well-coordinated strategies and collaboration across various sectors in combating rabies effectively. This study by Chen Q. et al. focused on China's efforts to eliminate dog-mediated rabies by 2030 through a well-coordinated national strategy, emphasizing the importance of integrating of one health considerations [28]. A similar study by Miranda J.L. et al. highlighted the necessity of a sustainable One Health approach in rabies control across Asia and Africa, advocating for enhanced multisectoral collaboration and intercountry cooperation [35]. The study in Indonesia investigated a rabies outbreak, recommending One Health emergency response strategies for more effective control, focusing on improved coordination and integration across different health management sectors [30]. To conclude, a study analyzed rabies control dynamics in Asia, particularly focusing on Thailand’s success in reducing human rabies deaths by 90%, stressing the importance of integrated health strategies and interdisciplinary cooperation [26]. Together, these studies illustrate the critical need for strategic planning and interdisciplinary collaboration in the successful management and eventual eradication of rabies.

Multisectoral Collaboration for Effective Rabies Management

33

The critical role of multisectoral collaboration in the effective management of rabies is highlighted through the findings of two distinct studies. A study in Vietnam showcased the Integrated Bite Case Management program, demonstrating how effective rabies surveillance and control can be enhanced through cooperation between veterinary and medical professionals under a One Health approach []. On the other hand, Indonesian research highlighted the effectiveness of rabies control efforts when community initiatives are supported by government-led strategies, illustrating the crucial role of ongoing support across various sectors [31]. These studies show the essential nature of multisectoral collaboration, leading to substantial progress in rabies control.

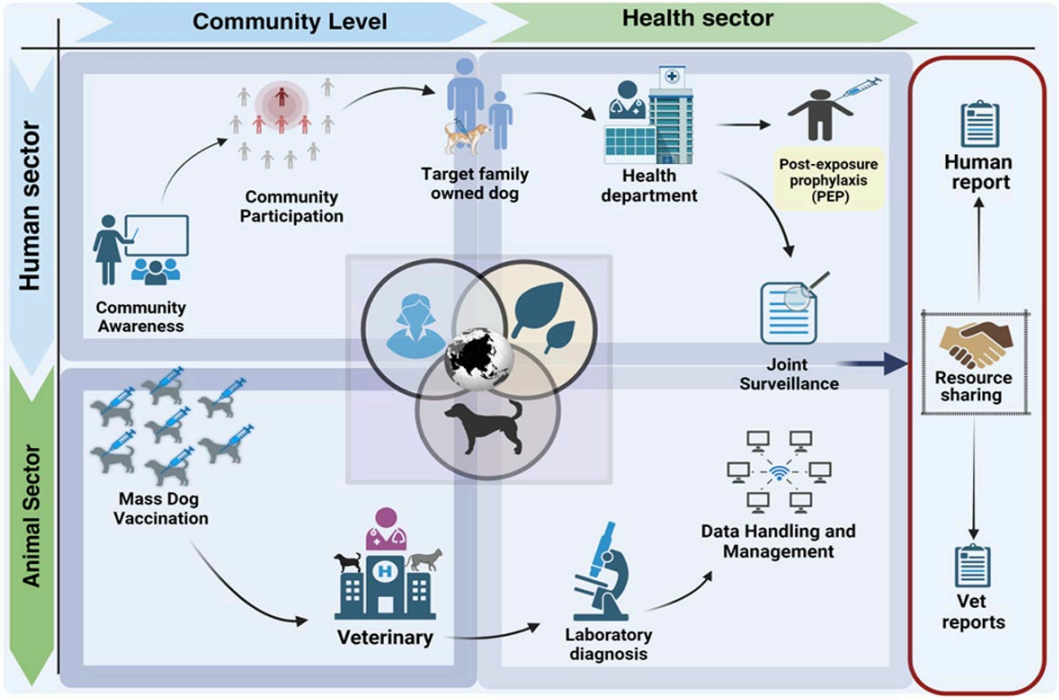

Figure 2 shows the Multisectoral Rabies Management Approach. This figure depicts the collaboration among community, health, and animal sectors for rabies control, highlighting technology's role in surveillance and data integration within a One Health framework.

The Role of Funding and Philanthropy in Rabies Control Initiatives

Building upon the critical role of funding in rabies control, a study Fitzpatrick C.M. et al. shed light on critical aspects of rabies elimination efforts. The study provided a detailed analysis of the cost-effectiveness of various approaches, emphasizing the significant impact of strategic funding and philanthropic efforts in making canine vaccination programs sustainable [32]. Miranda L.M. et al. also observed the reliance on patient out-of-pocket expenditures for funding rabies vaccination campaigns in the Philippines, highlighting the substantial burden on individuals and the need for more sustainable funding solutions [24]. The included studies emphasize the multifaceted nature of effective rabies control, where technological innovations, community engagement, strategic funding, and multisectoral collaboration all played vital roles in creating sustainable and effective strategies to combat this zoonotic disease.

Table 1 shows summary of studies Integrating One Health in Rabies Control, featuring comprehensive reviews of various approaches and findings, highlighting insights, key findings, limitations, and the impact on One Health strategies in rabies management.

Author, Year	Country	Objective	Key Findings	Challenges Identified	Additional Insights

Ross et al., 2023[33]	Vietnam	Integrated Bite Case Management (IBCM)	-78-fold increase in rabies case detection post-VARSP. Low rabies mortality after dog bites. -Adoption of electronic IBCM system expected to further enhance surveillance accuracy.	Reliance on passive surveillance, under-detection due to healthcare-seeking behaviours.	Pilot IBCM model in Phu Tho showed significant surveillance improvement.
Aptriana et al., 2023[31]	Indonesia	One Health approach in rabies control	- Effective rabies case reduction through locally initiated and top-down approaches. -Sustainable program requires local government commitment.	Sustainability issues, need for continuous local government support.	Highlighted the effectiveness of the One Health approach.
Subrata et al., 2022[27]	Indonesia	Mobile app for rabies surveillance	-Development of RaCon app prototype for enhanced surveillance. -App integrates public and animal health data for a comprehensive overview.	N/A	Emphasized integration of public and animal health sectors.
Gibson et al., 2022[9]	India	MinION technology for rabies sequencing	-Identification of three rabies virus lineages. Noted diversification in Goa samples. -Insights into virus spread patterns facilitate targeted control measures.	N/A	Stressed the importance of coordinated vaccination efforts beyond Goa's borders.
Chen et al., 2021[28]	China	Rabies control program assessment	-Identified strengths in surveillance and gaps in dog vaccination coverage. -Emphasized the need for a coordinated national strategy for rabies elimination.	Low dog vaccination coverage, limited lab confirmation capabilities.	Advocated for enhanced regulation, coordination, and a One Health working group.
Barbara et al., 2014[40]	Sri Lanka	Framework for rabies interventions	-Proposed framework emphasizing political, societal, and financial support. -Advocates for a balanced approach considering both positive and negative consequences of interventions.	Lack of multifaceted support in endemic countries, potential for oversimplification.	Recommended a One Health approach integrating multiple disciplines.
Byrnes et al., 2017[22]	Sikkim, India	SARAH program for rabies eradication	-SARAH program serves as a replicable model for other regions. - Highlighted the necessity of an integrated One Health approach for effective eradication.	Challenges in vaccination coverage estimates, resource constraints.	SARAH program serves as a model for rural rabies control.
Fitzpatrick et al., 2016[41]	Tamil Nadu, India	Cost-effectiveness of rabies control strategies	- Canine vaccination highly cost-effective. -DALYs significantly reduced through focused vaccination efforts.	N/A	Established a One Health coordination committee in Tamil Nadu.

Karamoy et al., 2023[23]	Minahasa Regency, Indonesia	One Health approach in rabies control	-Effective implementation with room for improvement in coordination and education. -Identified need for enhanced community education and involvement in vaccination efforts.	Insufficient dog data surveillance, suboptimal vaccination rates.	Stressed the importance of community involvement and education in vaccination efforts.
Petsophonsaku et al., 2023[25]	Thailand	The Chiang Mai Model for rabies control	-Long-term welfare benefits, reduction in free-roaming dogs. -Model demonstrates effective integration of scientific and cultural approaches.	N/A	Integrated scientific strategies with Buddhist principles for humane rabies control.
Du et al., 2023[34]	China	WeChat-based rabies prevention program	-High user satisfaction, especially among urban users. -Program's digital approach broadens public health education reach.	N/A	Highlighted the role of digital platforms in public health education.
Miranda et al., 2014[24]	Cebu, Philippines	Canine rabies elimination campaigns	-Significant reliance on patient out-of-pocket expenditures for campaign funding. -Highlights the importance of government and inter-sectoral cooperation.	Non-compliance with PEP series, limited understanding of rabies dynamics.	Emphasized government-led and inter-sectoral cooperative strategies.
Miranda et al., 2023[29]	Asia and Africa	Rabies situation and control measures	-Over 99% of human rabies deaths occur in Asia and Africa. -Canine-mediated rabies potentially eliminable with current tools. Focus on prevention and awareness critical.	N/A	Advocated for a sustainable One Health approach and intercountry cooperation.
Zuhriyah et al., 2020[30]	Dompu, Indonesia	Rabies outbreak analysis and response	-1,315 rabid animal bites and 9 human fatalities reported. -One Health emergency response strategies recommended for effective control.	Lack of dedicated One Health institutions, limited stakeholder coordination.	Highlighted cost-effectiveness and practicality of One Health in managing zoonotic diseases.
Balogh et al., 2023[20]	ASEAN countries	Rabies epidemic analysis and control strategies	-Advocated for policy changes, capacity building, and oral rabies vaccines for dogs. -Need for a regional approach addressing unique rabies ecologies.	Disparities in vaccine availability, financial and resource constraints in rural areas.	Suggested a nuanced understanding of rabies ecologies and regional variances in control methodologies.
Barber et al., 2023[21]	China	Rabies situation analysis	-Highlighted the need for a One Health approach and the challenges in vaccine reliability and animal governance. -Need for a comprehensive strategy addressing regional disparities.	Regional disparities, limited resources for rural vaccination clinics.	Called for a strategic shift to address the complex factors influencing rabies control.

Ghai et al., 2020[26]	Asia	Rabies control dynamics	-Thailand's success in reducing human rabies deaths by 90%, challenges in achieving dog vaccination coverage. -Emphasized the importance of integrated health strategies.	N/A	Stressed the interconnectedness of health sectors and the importance of interdisciplinary cooperation.

Table 1 shows summary of studies Integrating One Health in Rabies Control, featuring comprehensive reviews of various approaches and findings, highlighting insights, key findings, limitations, and the impact on One Health strategies in rabies management.

Discussion

This scoping review is the first to describe and evaluate the various interventions employed in the battle against rabies, outlining how each distinctly supports comprehensive disease management and prevention strategies in Asia, a region critically affected by the ongoing risk of rabies [1]. Asian countries Vietnam is on track to eliminate human rabies cases by 2025, and China aims to achieve this target by 2030. The Philippines and Malaysia are also focusing on educating children about pets and bite prevention [36]. Our review has uncovered that technological innovations such as mobile applications for surveillance and the use of portable MinION sequencing technologies have markedly improved the monitoring and analysis of the rabies virus. These technologies enable precise tracking and understanding of transmission patterns, which is crucial for tailoring response strategies to specific regional dynamics [37]. Additionally, the review highlights the critical importance of community engagement and cultural integration. Successful models like the Chiang Mai Model in Thailand demonstrate how incorporating local cultural practices and encouraging community participation can significantly enhance the effectiveness of rabies control programs. Aligning strategies with local beliefs not only fosters greater public cooperation but also ensures the sustainability of health interventions [38].

Moreover, our findings reveal that strategic planning and interdisciplinary cooperation are essential for the efficient management of rabies. National and regional strategies that integrate human, animal, and environmental health sectors under a One Health framework show promise in managing and eventually eradicating rabies[36]. Multisectoral collaboration, involving public health officials, veterinarians, and community organizations, is also highlighted as a crucial component for effective disease control, ensuring that efforts are coordinated and comprehensive. On the financial front, the review draws attention to the need for sustainable funding models. The reliance on out-of-pocket expenditures for post-exposure prophylaxis in some regions underscores the necessity for strategic funding solutions that can support widespread vaccination campaigns and alleviate the economic burden on communities. These insights point toward the need for a robust, integrated approach that leverages technological advancements, enhances community engagement, and utilizes strategic funding to effectively combat rabies in Asia.

The findings from this scoping review provide critical insights for policymakers, public health officials, and other stakeholders involved in rabies control. Governments should aim to bolster technological infrastructure to support advanced surveillance systems like mobile apps and genomic sequencing, critical for early detection and rapid response to rabies outbreaks. Enhancing community engagement through culturally sensitive education initiatives and integrating rabies prevention into school curriculums can increase community participation and effectiveness. Formal mechanisms should be established to facilitate intersectoral cooperation among human, animal, and environmental health agencies, including joint training and shared data systems. Comprehensive rabies control policies must include mandatory pet vaccinations, regulation of animal populations, and stricter wildlife trade controls, supported by sufficient funding for effective implementation. Improving access to affordable post-exposure prophylaxis (PEP), particularly in underserved areas, and supporting innovative financial models like public-private partnerships can sustain rabies control initiatives. Advocating for a One Health approach that encompasses cross-disciplinary research and integrated disease management strategies will enhance the training of health professionals and the overall effectiveness of rabies prevention efforts across Asia [39].

Despite the comprehensive nature of this review, several limitations need to be acknowledged. Firstly, the focus on studies specific to Asia may not encapsulate the full spectrum of global efforts and innovations in rabies control. Such a regional focus could overlook pivotal studies from other regions that offer valuable insights into One Health interventions. Secondly, the potential for publication bias must be considered, as studies with positive outcomes are more likely to be published, which could skew perceptions of the effectiveness of the One Health approach. Additionally, the variability in study designs and methodologies among the reviewed articles complicates efforts to standardize outcomes, impacting the comparability of results. Moreover, excluding publications in languages other than English may omit significant research contributions from Asia.

The generalizability of the findings is another concern, as the effectiveness of community engagement and multisectoral collaborations observed in the reviewed studies may not be directly transferable to other socio-cultural settings due to differing cultural norms and public health infrastructures. Furthermore, this review did not account for the evolving nature of the rabies virus and its epidemiology, which could influence the long-term success of current interventions.

Future research should investigate the scalability of successful interventions, the adaptability of the One Health approach to other zoonotic diseases, and the implementation of integrated surveillance systems. In an increasingly interconnected world, the insights gained from Asia's approach to combating rabies could inform broader global health strategies, ensuring preparedness and effective response to this and other zoonotic challenges. This review lays a foundational groundwork for future studies and offers actionable insights for policymakers and public health officials to advance towards a rabies-free world.

Conclusion

This scoping review has provided a comprehensive overview of the One Health interventions implemented in Asia to control and manage rabies. The findings highlight the importance of a multifaceted approach involving technological innovations, community engagement, strategic planning, multisectoral collaboration, and sustainable funding models. Through the application of advanced surveillance technologies and genomic sequencing, significant strides have been made in monitoring and understanding the transmission patterns of the rabies virus. These technological advancements facilitate timely and tailored responses that are critical for effective rabies control. The review also emphasizes the crucial role of community engagement and cultural integration in rabies prevention strategies. Successful models such as the Chiang Mai Model in Thailand demonstrate the effectiveness of aligning rabies control initiatives with local cultural practices and values, which enhances public cooperation and the sustainability of these interventions. Additionally, the integration of human, animal, and environmental health sectors under a unified One Health framework has shown promise in addressing the complexities of rabies management comprehensively.

Despite these advancements, the review identifies several limitations, including regional focus, publication bias, and variability in study methodologies, which may affect the generalizability of the findings. Future research should focus on expanding the applicability of successful interventions and exploring the adaptability of the One Health approach to other zoonotic diseases. As we move forward, it is crucial for policymakers and public health officials to consider these insights and continue to foster robust collaborations and integrated strategies. Doing so will not only advance rabies control in Asia but also contribute to global efforts in combating this deadly disease. This review serves as a vital stepping stone towards achieving a rabies-free world.

Supporting information

None

Ethical Considerations

None

Acknowledgments

None

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author contribution statement

All authors attest they meet the ICMJE criteria for authorship and gave final approvalforsubmission.

Data availability statement

Data included in article/supp. material/referenced in article.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Jane Ling MY, Halim A, Ahmad D, Ramly N, Hassan MR, Syed Abdul Rahim SS, et al. Rabies in Southeast Asia: a systematic review of its incidence, risk factors and mortality. BMJ Open. *2023;13(5):e066587 [Crossref][PubMed][Google Scholar]*

2. Goel K, Sen A, Satapathy P, Kumar P, Aggarwal AK, Sah R, et al. Emergence of rabies among vaccinated humans in India: a public health concern. Lancet Reg Health Southeast Asia. *2023;9 [Crossref][PubMed][Google Scholar]*

3. Velasco-Villa A, Mauldin MR, Shi M, Escobar LE, Gallardo-Romero NF, Damon I, et al. The history of rabies in the Western Hemisphere. Antiviral Res. *2017;146:221-32 [Crossref][PubMed][Google Scholar]*

4. Fehlner-Gardiner C. Rabies control in North America - past, present and future. Rev Sci Tech. *2018;37(2):421-37 [Crossref][PubMed][Google Scholar]*

5. Gibson AD, Yale G, Corfmat J, Appupillai M, Gigante CM, Lopes M, et al. Elimination of human rabies in Goa, India through an integrated One Health approach. Nat Commun. *2022;13(1):2788 [Crossref][PubMed][Google Scholar]*

6. Acharya KP, Acharya N, Phuyal S, Upadhyaya M, Lasee S. One-health approach: A best possible way to control rabies. One Health. *2020;10:100161 [Crossref][PubMed][Google Scholar]*

7. The potential effect of improved provision of rabies post-exposure prophylaxis in Gavi-eligible countries: a modelling study. Lancet Infect Dis. 2019;19(1):102-11. *[Crossref][PubMed][Google Scholar]*

8. Organization WH. Rabies | Key Facts 2024 [updated 20 September 2023. Available from: https://www. *who.int/news-room/fact-sheets/detail/rabies; 2024. Accessed May 10, 2024 [Crossref][PubMed][Google Scholar]*

9. Gibson AD, Yale G, Corfmat J, Appupillai M, Gigante CM, Lopes M, et al. Elimination of human rabies in Goa, India through an integrated One Health approach. Nat Commun. *2022;13(1):2788 [Crossref][PubMed][Google Scholar]*

10. Radhakrishnan S, Vanak AT, Nouvellet P, Donnelly CA. Rabies as a Public Health Concern in India-A Historical Perspective. Trop Med Infect Dis. *2020;5(4) [Crossref][PubMed][Google Scholar]*

11. Goel K, Sen A, Satapathy P, Kumar P, Aggarwal AK, Sah R, et al. Human rabies control in the era of post-COVID-19: a call for action. J Travel Med. *2023 [Crossref][PubMed][Google Scholar]*

12. Taylor LH, Wallace RM, Balaram D, Lindenmayer JM, Eckery DC, Mutonono-Watkiss B, et al. The Role of Dog Population Management in Rabies Elimination-A Review of Current Approaches and Future Opportunities. Front Vet Sci. *2017;4:109 [Crossref][PubMed][Google Scholar]*

13. Fooks AR, Johnson N, Freuling CM, Wakeley PR, Banyard AC, McElhinney LM, et al. Emerging technologies for the detection of rabies virus: challenges and hopes in the 21st century. PLoS Negl Trop Dis. *2009;3(9):e530 [Crossref][PubMed][Google Scholar]*

14. Barroga TRM, Basitan IS, Lobete TM, Bernales RP, Gordoncillo MJN, Lopez EL, et al. Community Awareness on Rabies Prevention and Control in Bicol, Philippines: Pre- and Post-Project Implementation. Trop Med Infect Dis. *2018;3(1) [Crossref][PubMed][Google Scholar]*

15. Agarwal K, Srivastava S, Singh V, Rohilla R, Zaman K, Rukadikar A, et al. One health concept and its applications in clinical practice: a comprehensive review. The Evidence. *2023;2(1) [Crossref][PubMed][Google Scholar]*

16. Mazigo HD, Okumu FO, Kweka EJ, Mnyone LL. Retrospective analysis of suspected rabies cases reported at bugando referral hospital, mwanza, Tanzania. J Glob Infect Dis. *2010;2(3):216-20 [Crossref][PubMed][Google Scholar]*

17. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. *2005;8(1):19-32 [Crossref][PubMed][Google Scholar]*

18. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. *2018;169(7):467-73 [Crossref][PubMed][Google Scholar]*

19. Cowie K, Rahmatullah A, Hardy N, Holub K, Kallmes K. Web-Based Software Tools for Systematic Literature Review in Medicine: Systematic Search and Feature Analysis. JMIR Med Inform. *2022;10(5):e33219 [Crossref][PubMed][Google Scholar]*

20. Balogh Kd, Oh Y, Gordoncillo MJ, Phuentshok Y, Brum E, Schoonman L, et al. FAO, WOAH and WHO Working Together in the Asia Pacific Region to Eliminate Dog-mediated Human Rabies by 2030. CABI Books. *2023:11–24 [Crossref][PubMed][Google Scholar]*

21. Barber S, Hathaway MJ. Rabies in China: The Role of Rabies Ecologies and Pet Activism. CABI Books. *2023:199–206 [Crossref][PubMed][Google Scholar]*

22. Byrnes H, Britton A, Bhutia T. Eliminating Dog-Mediated Rabies in Sikkim, India: A 10-Year Pathway to Success for the SARAH Program. Front Vet Sci. *2017;4:28 [Crossref][PubMed][Google Scholar]*

23. Karamoy A, Kalesaran A, Mantjoro E. The Implementation and Challenges of One Health Approach for Rabies Control in Minahasa Regency, Indonesia. Int J Infect Dis. *2022;116:S108 [Crossref][PubMed][Google Scholar]*

24. Miranda LM, Miranda ME, Hatch B, Deray R, Shwiff S, Roces MC, et al. Towards Canine Rabies Elimination in Cebu, Philippines: Assessment of Health Economic Data. Transbound Emerg Dis. *2017;64(1):121-9 [Crossref][PubMed][Google Scholar]*

25. Petsophonsakul W, Inoue S. One Health Approach to Control Canine Rabies in Thailand: The Chiang Mai Model. CABI Books. *2023:34–46 [Crossref][PubMed][Google Scholar]*

26. Ghai S, Hemachudha T. Evaluating human rabies control in Asia: using 'One Health' principles to assess control programmes for rabies. Rev Sci Tech. *2018;37(2):617-27 [Crossref][PubMed][Google Scholar]*

27. Subrata IM, Harjana NPA, Agustina KK, Purnama SG, Kardiwinata MP. Designing a rabies control mobile application for a community-based rabies surveillance system during the COVID-19 pandemic in Bali, Indonesia. Vet World. *2022;15(5):1237-45 [Crossref][PubMed][Google Scholar]*

28. Chen Q, Ma X, Rainey JJ, Li Y, Mu D, Tao X, et al. Findings from the initial Stepwise Approach to Rabies Elimination (SARE) Assessment in China, 2019. PLoS Negl Trop Dis. *2021;15(3):e0009274 [Crossref][PubMed][Google Scholar]*

29. Miranda MEG, Miranda NLJ. Rabies Prevention in Asia: Institutionalizing Implementation Capacities. In: Ertl HCJ, editor. *Rabies and Rabies Vaccines. Cham: Springer International Publishing; 2020. p. 103-16 [Crossref][PubMed][Google Scholar]*

30. Zuhriyah L, Fatmawati M, Priyanto N, Djajati N, Arifin Z, Kastianti I, et al. One health strategies for rabies outbreak control in dompu, west nusa tenggara, indonesia: recommendations for emergency response. Int J Appl Pharm. *2020:97-100 [Crossref][PubMed][Google Scholar]*

31. Aptriana CD, Sudarnika E, Basri C. Nationally and locally-initiated One Health approach in controlling rabies in West Kalimantan, Indonesia. Vet World. *2022;15(12):2953-61 [Crossref] [PubMed][Google Scholar]*

32. Fitzpatrick MC, Shah HA, Pandey A, Bilinski AM, Kakkar M, Clark AD, et al. One Health approach to cost-effective rabies control in India. Proc Natl Acad Sci U S A. *2016;113(51):14574-81 [Crossref][PubMed][Google Scholar]*

33. Ross YB, Vo CD, Bonaparte S, Phan MQ, Nguyen DT, Nguyen TX, et al. Measuring the impact of an integrated bite case management program on the detection of canine rabies cases in Vietnam. Front Public Health. *2023;11:1150228 [Crossref][PubMed][Google Scholar]*

34. Du Z, Huang W, Zhang Y, Zhang P, Liu Z, Chen Q, et al. Assessment of the content, usability, and benefits of the WeChat-based programme for dog bite victims in China: A prospective observation study. Medicine. *2020;99(50):e23657 [Crossref][PubMed][Google Scholar]*

35. Jose Miranda NL, Gutierrez Miranda ME. Emerging Opportunities for Enhanced Regional One Health Approach in the Prevention, Control and Elimination of Rabies and Other Zoonoses in South-east Asia. CABI Books. *2023:25–33 [Crossref][PubMed][Google Scholar]*

36. Ingelheim B. STOP Rabies: moving towards elimination. 2024. *[Crossref][PubMed][Google Scholar]*

37. World Organization for Animal Health. Rabies. Available from: https://rr-asia. *woah.org/en/projects/rabies; 2024. Accessed May 10, 2024 [Crossref][PubMed][Google Scholar]*

38. Strategic framework for elimination of human rabies transmitted by dogs in the South-East Asia Region [press release]. 2016. . *[Crossref][PubMed][Google Scholar]*

39. Acharya KP, Subedi D, Wilson RT. Rabies control in South Asia requires a One Health approach. One Health. *2021;12:100215 [Crossref][PubMed][Google Scholar]*

40. Häsler B, Hiby E, Gilbert W, Obeyesekere N, Bennani H, Rushton J. A one health framework for the evaluation of rabies control programmes: a case study from Colombo City, Sri Lanka. PLoS Negl Trop Dis. *2014;8(10):e3270 [Crossref][PubMed][Google Scholar]*

41. Fitzpatrick MC, Shah HA, Pandey A, Bilinski AM, Kakkar M, Clark AD, et al. One Health approach to cost-effective rabies control in India. Proceedings of the National Academy of Sciences. *2016;113(51):14574-81 [Crossref][PubMed][Google Scholar]*

Disclaimer / Publisher's Note