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Global Perspectives on Rabies Prevention and Control: A Decade of World Rabies Day Themes and Progress toward Elimination (2016–2025)

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ABSTRACT

Rabies is a fatal zoonotic disease, responsible for approximately 59,000 human deaths annually; the majority occur in developing regions of Asia and Africa. This review explores worldwide efforts to prevent and control rabies during 2016–2025, using the evolving themes of World Rabies Day (WRD) as a framework. The research objective is to assess epidemiological trends, intervention strategies, challenges, and innovations related to the World Health Organization's target of zero human rabies deaths by 2030. The findings highlight a significant reduction in global rabies occurrence, with mass vaccination campaigns for dogs achieving 70% coverage in Guinea and a 95% decrease in human cases in Latin America. However, gaps in surveillance, vaccine shortages, and poor public education persist. Low-cost intradermal prophylaxis, monoclonal antibodies, and AI-driven surveillance systems are promising but remain constrained by socioeconomic inequalities and insufficient investment. Achieving "Zero by 30" requires stronger collaboration, equitable resource distribution, and sustained community mobilization. ***DOI: 10.61882/ibj.5398***

Keywords: One Health, Post-exposure prophylaxis, Rabies, Zoonoses

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1. INTRODUCTION

Rabies is a paradigmatic example of a viral zoonotic infection, caused most prominently by members of the genus *Lyssavirus*, and most commonly transmitted to humans by bites from infected dogs. Once clinical signs emerge, the disease transforms into acute encephalitis, which almost leads to death, underscoring its seriousness as a public health issue[1]. Despite the existence of effective preventive interventions like pre- and post-exposure vaccinations, rabies continues to pose a significant threat, leading to the deaths of an estimated 59,000 humans annually. This disease disproportionately affects susceptible groups in low- and middle-income nations in Africa and Asia[2]. Those aged below 15 years are especially vulnerable, comprising approximately 40% of cases because of their higher chance of close interaction with dogs[1]. The significant socioeconomic implications lead to an estimated annual economic cost of approximately $8.6 billion worldwide, which includes expenses for administering post-exposure prophylaxis (PEP) and productivity losses from premature mortality[3].

World Rabies Day (WRD) was launched in 2007 and is observed annually on September 28, the anniversary of Louis Pasteur's death and a celebration of his pioneering work with his colleagues in creating the first vaccine against rabies. Over time, this global event has become an important forum for advocacy, raising

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awareness and promoting preventive measures globally. The themes of WRD between 2016 and 2025 have systematically tackled key aspects of rabies control: "Rabies: Educate. Vaccinate. Eliminate." in 2016 and 2017, "Rabies: Share the message. Save a life" in 2018, "Rabies: Vaccinate to eliminate." in 2019, "End rabies: collaborate and vaccinate" in 2020, "Rabies: Facts, not Fear." in 2021, "Rabies: One Health, Zero Deaths" in 2022, "All for One, One Health for All" in 2023, "World Rabies Day: Act Now" in 2024, and "Act Now: You, Me, Community" in 2025[4,5]. These themes reflect a conscious shift from simple education- and vaccination-based approaches to more comprehensive sectoral collaboration and localized empowerment approaches, which align strongly with the World Health Organization (WHO)'s "Zero by 30" action plan launched in 2018 to eliminate dog-transmitted human rabies fatalities by 2030[6]. Recent studies have highlighted One Health tools[7] and end-stage challenges[8], complementing our thematic analysis of WRD-driven progress.

The present review synthesizes the global rabies landscape, incorporating epidemiological findings, results from interventions, and alignments with these thematic priorities to outline achievements, challenges, and future directions. This review also calls for multifaceted approaches necessary to achieve sustainable rabies elimination at a global level by synthesizing evidence from a range of geographical settings.

1.1. Epidemiology of rabies

Rabies continues to be endemic in over 150 nations, with domestic dogs being the main vector, accounting for a staggering 99% of human cases[9]. Asia and Africa continue to bear the highest burden (approximately 60% and 36% of global deaths, respectively), and children under 15 years represent ~40% of fatalities[10]. Recent comprehensive analyses have documented a sustained global decline in rabies incidence and mortality over the past three decades, with age-standardized rates decreasing significantly and projections estimating ~5,810 human cases by 2030[7,8]. These trends reflect the cumulative impact of intensified control efforts, though marked regional disparities persist. Regional disparities also highlight the intricacies of rabies epidemiology. In India, for example, the disease kills a person roughly every 30 minutes, with more than 90% of such deaths taking place in rural areas where access to medical interventions is extremely poor[11]. Sub-Saharan Africa suffers an estimated 21,000 annual fatalities, compounded by high dog population densities and widespread weaknesses in surveillance systems, leading to underreporting levels. The Americas, however, and especially Latin America, have made dramatic progress, with a 95% decline in human cases since the 1980s, though the emergence of bat-mediated transmissions introduces fresh epidemiological challenges[12]. Aside from canine sources, wildlife reservoirs—e.g., bats in the Western Hemisphere and jackals in some African areas—persist in maintaining transmission risks, while environmental dynamics such as climate change may compound these dynamics by reconfiguring animal habitats and migratory patterns[13,14].

2. GLOBAL STRATEGIES FOR RABIES CONTROL

2.1. Canine vaccination programs

The cornerstone of successful rabies control rests on extensive vaccination of dog populations, a measure shown to break transmission cycles when coverage is at least 70%[15]. In Bangladesh, the institution of a nationwide canine vaccination program resulted in a 50% decline in human rabies fatalities in recent years, illustrating the concrete effect of such activities in densely populated environments[16]. In Guinea in 2023, vaccination campaigns successfully immunized more than 10,000 dogs in 10 communities, reaching the critical 70% threshold for limiting outbreaks[17,18]. Latin America's persistence, with 80–90% vaccination rates in several countries, has resulted in fewer than 50 yearly human cases, representing a model of success in regional elimination[19]. In resource-poor regions such as South Asia and sub-Saharan Africa, however, coverage remains at 35-60% and 16-68%, respectively, beset by logistical challenges including difficult terrains, nomadic dog populations, and a lack of veterinary resources (Table 1)[20,21].

2.2. PEP for rabies

For those with potential exposure to rabies infection, PEP is a lifesaving measure, consisting of meticulous wound cleaning, rabies immune globulin (RIG) administration, and a series of vaccine doses, which is close to 100% effective if administered immediately[22]. The WHO's adoption of intradermal administration techniques has further improved affordability, achieving annual savings of around $70 million in India alone by 2020 through vaccine dosage reduction[23]. In spite of these efforts, broad access to RIG remains very low, with only 9% of countries across Africa and Asia receiving this critical component extensively due to prohibitive costs—between 15 and $70 per treatment—and chronic supply gaps[24]. New alternatives in development, such as monoclonal antibody cocktails, demonstrate great promise as alternatives to conventional RIG, with the potential to remove these limitations in the near term[3].

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Table 1. Canine vaccination coverage and human rabies incidence in selected regions (2016–2023)

Region	Vaccination coverage (%dogs)	Human rabies cases (annual)	Reference
Latin America	80–90	<50	[19]
South Asia	35-60	20,000–25,000	[25]
Sub-Saharan Africa	16–68	About 21,000	[20,21]

2.3. One health strategies

Embracing the One Health framework, which aligns and synergizes efforts between human, animal, and environmental health sectors, has become essential to comprehensive rabies control[26]. Joint frameworks led by the tripartite partners (WHO, the Food and Agriculture Organization of the United Nations [FAO], and World Organization for Animal Health and GARC have accelerated multisectoral action, including in Tanzania, where integrated initiatives covering dog vaccinations, PEP supply, and educational campaigns resulted in a 70% and 97% reduction of human rabies incidence following two consecutive vaccinations, respectively, in targeted pilot areas[27,28]. The themes of WRD have also highlighted this strategy, promoting harmonized policies that span veterinary and public health sectors, although ingrained challenges such as funding inequities and interagency coordination persist in hindering wider uptake in resource-poor settings[29].

2.4. Community education and engagement

Strengthening communities through ac[illegible] engagement is central to sustainable rabies control, [illegible] evinced by the 2018 and 2025 WRD themes that emphasize message spreading and collec[illegible]ction[30]. In the Philippines, community-l[illegible]ccinati[illegible]n drives raised dog vaccination levels [illegible] 4[illegible]% t[illegible]75% in targeted areas, demonstrating the effectiveness of localized engag[illegible]ment[31]. [illegible]no[illegible]edg[illegible]attitudes, and practices surv[illegible]s have [illegible]hown broad ranges in awareness, wit[illegible]ccinati[illegible]n compliance varying from under 1% to m[illegible]an 90% among dog owners, sometimes due to misconceptions such as the use of traditional remedies[32]. Focused interventions, such as those in Egypt that improved satisfactory rabies prevention practices among mothers from 13.35% to 83.30%, highlight the reformative power of education[33]. Additionally, technological integrations, such as mobile applications for dog bite reporting, have enhanced surveillance capacities in urban Indian contexts, enabling quicker responses[34].

3. CHALLENGES IN RABIES ELIMINATION

3.1. Socioeconomic and logistical barriers

Entrenched socioeconomic determinants, such as poverty, poor healthcare infrastructure, and low public awareness, are daunting challenges to rabies elimination[35]. Vaccination coverage among dogs typically ranges between 16% and 68% in sub-Saharan Africa, due to limited financial resources and thinly spread veterinary networks[20,21]. Rural residents often make long journeys to receive PEP, increasing treatment delays[35]. Cultural practices, like allowing free-roaming dogs, also hinder control efforts in South Asia, requiring culturally appropriate measures[22]. Proper dog population management, with animal welfare in mind, is critical but often neglected under funding constraints.

3.2. Surveillance and data ga[illegible]

Strong surveillance is c[illegible]l to monitoring rabies trends and re[illegible]urce [illegible]o[illegible]ion[illegible]ely, but it is often weakened, in[illegible]en[illegible]ic re[illegible]ns by diagnostic shortcomi[illegible]nd reporting variabilities[36]. Under[illegible]o[illegible]r in[illegible]rica is a result of low laboratory c[illegible]city[illegible]nd fragmented health systems[37]. Pilot i[illegible]ves[illegible]n Haiti using integrated bite case [illegible]na[illegible]ent have improved detection rates, but large-sc[illegible] replication is hampered without heavy infrastructural investments[38]. The lack of harmonized global data standards continues to hinder cross-regional comparisons and strategic planning[39].

3.3. Emerging threats and variants

Though canine rabies is dominant, other wildlife reservoirs—bats in the Americas and jackals in Africa—perpetuate transmission cycles that evade traditional control strategies[40]. The emergence of variant lyssavirus strains poses further challenges to current vaccine constructs and surveillance strategies. Finally, ecosystem changes wrought by climate change could exacerbate the spread of rabies by affecting wildlife behaviors and distributions, requiring adaptive and predictive responses[41].

4. INNOVATIONS AND FUTURE DIRECTIONS

4.1. Novel vaccine technologies

Advancements in vaccine development are reshaping the rabies prevention landscape, with oral formulations proving effective for both domestic dogs and wildlife populations. In the United States, such campaigns targeting raccoons have reduced wildlife rabies by 80% in specific areas, offering a model for non-invasive immunization[42]. Recombinant vaccines using adenoviral vectors are being explored to augment

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potency while diminishing production expenses, potentially increasing accessibility in developing regions[43].

4.2. Digital and AI-based tools

The amalgamation of AI and digital technologies is transforming rabies response and control mechanisms. Predictive AI models in India have identified risk areas, allowing for focused interventions that reduced human cases by 20% in test locations[34]. The REACT App (The Rabies Exposure Assessment and Contact Tracing) and WVS (Worldwide Veterinary Service) platforms are some of the applications that enable real-time data collection and campaign coordination, especially in Southeast Asia, leading to increased operational efficiency (https://rabiestaskforce.com).

4.3. Policy and funding initiatives

WHO's Zero by 30 plan provides a roadmap for elimination through investment in vaccination and PEP, but faces an annual funding gap of $8.6 billion, of which 54% is productivity loss due to premature death, 37% is treatment for humans bitten by dogs suspected to be rabid, and merely 2% is utilized for dog vaccination and population management[1]. Regional strategies, such as the Pan-American Health Organization's plan, have proven feasible in the Americas and may be replicated elsewhere with customized modifications[44]. Filling these funding gaps through global commitments is crucial for equitable success.

5. DISCUSSION AND ANALYSIS

The theme pathway of WRD during the decade distills a maturation of global rabies approaches, from early focuses on education and vaccination (2016–2019) to building collaboration through One Health principles (2020–2022) and, finally, to insistent demands for community-focused action (2023–2025)[30]. Model results from canine vaccination in Latin America and Bangladesh validate the strategy's strength, but the conspicuously lower coverage in Africa betrays deep-seated inequities requiring rectification through prioritized resource allocation[17,19-21]. Innovations in PEP, such as intradermal techniques and monoclonal alternatives, have eased economic strains, but continued supply shortfalls require optimized manufacturing and distribution chains[45]. The One Health framework has delivered synergies, as seen in Tanzania, although inconsistency in implementation underscores the need for standardization of coordination protocols[32]. Community actions, aligned with recent themes, have increased participation and awareness, undermining obstacles such as cultural myths through context-tailored education[46,47]. The pathway of WRD themes from 2016 to 2025 represents a strategic shift from education and vaccination to One Health collaboration and community empowerment. Figure 1 illustrates the thematic maturation of WRD and its alignment with core control strategies.

Rabies, a neglected tropical disease, is underreported, hiding its true burden and hindering targeted interventions[36,39]. Changing threats from wildlife and environmental changes necessitate vigilant and responsive surveillance[13]. Technological advances offer hopeful directions, but their implementation in low-resource settings requires inclusive scaling. To reach the Zero by 30 target, increased investments in infrastructure, education, and equity are critical. Suggested relevant future themes include: 2026—"Innovate for Equity: Bridging Rabies Gaps"; 2027—"Global Solidarity: United Against Rabies"; 2028—"Sustainable Surveillance: Data to Eliminate"; 2029—"Empower Communities: Local Solutions for Zero Deaths"; and 2030—"Victory by 30: Celebrating Rabies-Free Future." These proposals seek to maintain momentum through targeted innovation, unity, and long-term sustainability.

6. CONCLUSION

Rabies persists as an entirely preventable yet relentlessly oppressive global health concern, disproportionately affecting marginalized populations. The decade summarized by WRD themes from 2016 to 2025 has driven substantial gains through improved education, intense vaccination campaigns, One Health integrations, and empowered community engagement, cumulatively yielding incidence decreases across many areas. Although successes in Latin America and certain Asian settings through canine vaccination and PEP highlight achievable trajectories, persistent disparities within Africa and Asia—characterized by access restrictions, surveillance gaps, and funding vacuums—present considerable challenges to universal elimination. Innovative solutions in vaccine technology and digital analytics promise transformative prospects, provided that there is equitable distribution and long-term financial commitment. Ultimately, the vision of zero human rabies fatalities by 2030 rests on strengthened interdisciplinary collaborations, policy synchronization, and unwavering international commitment. Guided by the lessons of the last ten years and energized by forward-looking themes, united efforts can eliminate this ancient plague, protecting all societies equally.

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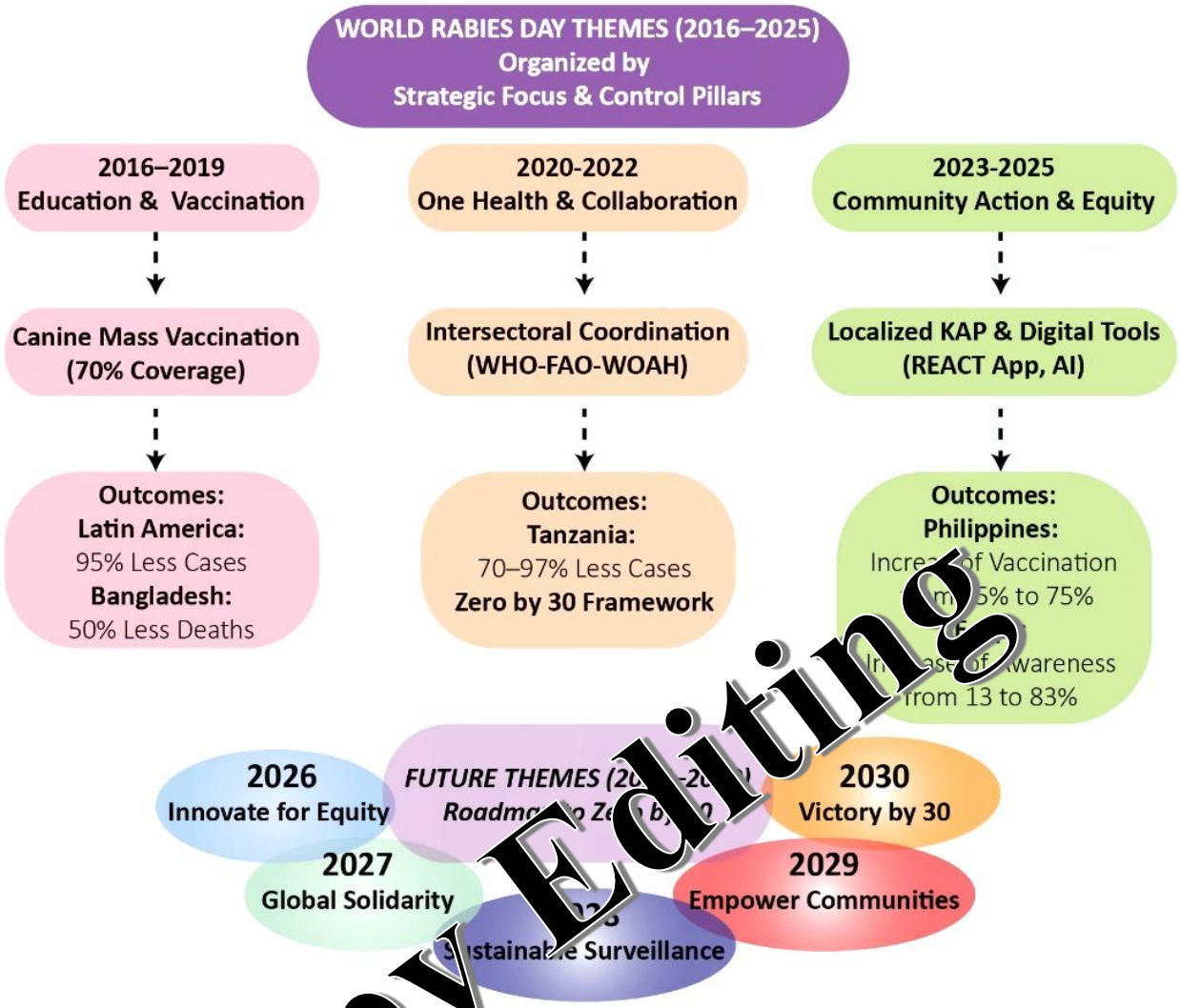

Fig. 1. Evolution of WRD themes (2016–2025) and alignment with rabies control pillars. Each phase is associated with key control pillars and real-world outcomes. Proposed themes for 2026-2030 give a forward-looking roadmap to achieve the WHO "Zero by 30" goal. Data were synthesized from WHO, CDC, and regional reports (see References [4,5,19,21,29,33,35]).

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Artificial intelligence (AI) tools were used only for language editing and improving the readability of the manuscript. All scientific content, interpretations, and conclusions were developed and verified by the authors.

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All authors reviewed the results and approved the final version of the manuscript.

Authors' contributions
AA: visualization; AA and AG: writing-review and editing; AA, MA, and AG: conceptualization, methodology, investigation, writing–original draft preparation.

Data availability
All relevant data can be found within the manuscript.

Competing interests
The authors declare that they have no competing interests.

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