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Future vaccine priorities in Cambodia: preparedness for emerging infectious diseases

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Cambodia has achieved substantial progress in immunisation over the past two decades, culminating in one of Southeast Asia's most successful COVID-19 vaccination campaigns. However, the epidemiological landscape is rapidly changing. Climate change, environmental degradation, urbanisation, increasing regional mobility, and intensified human–animal interactions are increasing the risk of emerging infectious diseases, placing Cambodia at the frontline of future epidemic and pandemic threats. Although national vaccine policy has traditionally focused on childhood immunisation, preparedness for emerging infectious diseases requires a broader strategy that integrates pathogen surveillance, genomic monitoring, regulatory readiness, rapid vaccine platforms, and One Health collaboration. Here, we highlight the need for Cambodia to transition from a vaccine delivery agenda toward a broader vaccine preparedness agenda. We propose a national framework centred around surveillance-informed vaccine prioritisation, strengthened laboratory and genomic capacity, resilient vaccine delivery systems, sustainable financing, and regional partnerships. Such an approach could enhance Cambodia's preparedness for pathogens including H5N1, dengue, Japanese encephalitis, rabies, and future Disease X scenarios, while strengthening its contribution to regional health security.

Keywords vaccine preparedness; emerging infectious diseases; immunisation policy; One Health; pathogen surveillance; Cambodia

Vaccination has transformed global public health by preventing millions of deaths each year and reducing the burden of numerous infectious diseases. Cambodia has made remarkable progress through its National Immunization Program, achieving high childhood vaccination coverage and demonstrating one of Southeast Asia's most successful COVID-19 vaccination campaigns. These achievements illustrate that sustained political commitment, effective health systems, and strong international partnerships can rapidly improve vaccine delivery even in resource-constrained settings [1-4].

However, the global infectious disease landscape is changing. Climate change, environmental degradation, expanding urbanisation, increased international travel and intensified human–animal interactions are creating favourable conditions for the emergence and spread of novel pathogens [5-7]. The COVID-19 pandemic demonstrated that future vaccine strategies must extend beyond routine immunisation programmes and incorporate preparedness for previously unknown epidemic and pandemic threats [1,4,8,9].

For Cambodia, vaccine preparedness is becoming an increasingly important component of national health security. Rather than focusing solely on expanding vaccination coverage, future strategies should integrate surveillance, rapid vaccine development, regulatory preparedness, and regional collaboration to strengthen resilience against emerging infectious diseases [4,7,9,10].

This viewpoint highlights the need for Cambodia to transition from a vaccine delivery agenda to a comprehensive vaccine preparedness strategy for emerging infectious diseases. Drawing on Cambodia's immunisation achievements, recent advances in vaccine science, and the evolving epidemiology of infectious diseases in Southeast Asia, we examine the changing priorities for national vaccine policy and identify opportunities to strengthen preparedness through integrated surveillance, rapid vaccine platforms, resilient health systems, and One Health collaboration. We propose that adopting a preparedness-oriented approach to vaccination would not only strengthen Cambodia's capacity to respond to emerging infectious diseases but also contribute to regional and global health security.

Future vaccine policy should move beyond routine childhood immunisation toward a comprehensive preparedness strategy that integrates pathogen surveillance, rapid vaccine platforms, regulatory readiness, and One Health collaboration.

CAMBODIA AT THE FRONTLINE OF EMERGING INFECTIOUS DISEASES

Cambodia lies within the Greater Mekong Subregion, one of the world's recognised hotspots for emerging infectious diseases. The country's tropical climate, rich biodiversity, extensive rice agriculture, and diverse livestock production create favourable ecological conditions for zoonotic disease emergence. Human populations frequently interact with domestic livestock, and wildlife, increasing opportunities for pathogen spillover [5–7].

Environmental changes further amplify these risks. Deforestation, changing land use, prolonged rainy seasons, and rising temperatures can alter vector ecology and increase opportunities for transmission of arthropod-borne pathogens. Intensive agricultural practices, including livestock farming and rice cultivation, may increase interaction among humans, domestic animals, and potential pathogen reservoirs [5,6]. At the same time, urbanisation and extending trade, increasing cross-border movement between Cambodia, Thailand, Vietnam, and Laos facilitate the spread of infectious pathogens across the region [5,11].

More than 70% of emerging infectious diseases originate from animals. Consequently, Cambodia's future vaccine preparedness must be closely linked to integrated surveillance across human and animal populations through a One Health approach [6,7,9].

VACCINE PRIORITIES FOR CAMBODIA'S FUTURE HEALTH SECURITY

Although Cambodia has successfully controlled many traditional vaccine-preventable diseases, several emerging pathogens continue to threaten national health security. Future vaccine planning should therefore consider not only existing disease burdens but also pathogens with pandemic potential and changing epidemiological patterns [4,9].

Highly pathogenic avian influenza A (H5N1) remains one of the country's most important zoonotic threats [12]. Since the re-emergence of human H5N1 infections in Cambodia in 2023, 27 laboratory-confirmed cases, including 12 deaths, were reported as of 1 July 2025. During the first 6 months of 2025 alone, 11 cases and 6 deaths were reported [13]. More recently, a nine-month-old girl from Meanchey District, Phnom Penh, was diagnosed with H5N1 infection on 9 July 2026, representing Cambodia's fifth human case of 2026 [14]. Human infections have historically been associated with exposure to infected poultry, while continued viral evolution, mutation, and reassortment raise concerns about future adaptation for efficient human transmission [12,13,15]. The relatively high case-fatality ratio among reported human infections further highlights the importance of sustained surveillance and preparedness. Although pandemic influenza vaccine candidates have been developed and maintained through international preparedness programmes, Cambodia requires continued strengthening of its surveillance capacity and mechanisms for rapid access to vaccines and other countermeasures to respond effectively to potential outbreaks [12,13,15].

Dengue represents one of Cambodia's most important endemic arboviral diseases, producing recurrent outbreaks that place considerable pressure on healthcare services. The national dengue surveillance system reported 17,728 cases and 32 deaths by 22 July 2025, compared with 7,440 cases and 24 deaths during the same period in 2024, highlighting substantial year-to-year variability in transmission [16]. The circulation of multiple dengue virus serotypes, combined with changing mosquito ecology, climate variability, and population movement, contributes to ongoing transmission challenges [11]. Several dengue vaccines have been developed, but their indications and serostatus considerations differ. TAK-003 (Qdenga), a live-attenuated tetravalent vaccine, has demonstrated efficacy against symptomatic dengue in children and adolescents and is recommended by the World Health Organization (WHO) for children aged 6–16 years in settings with high dengue transmission intensity [17–19]. However, WHO does not currently recommend programmatic use of TAK-003 in low- to moderate-transmission settings because the benefit-risk profile, particularly with respect to DENV-3 and DENV-4 disease in seronegative individuals, remains an important consideration. This should be distinguished from CYD-TDV (Dengvaxia), for which vaccination of dengue-seronegative individuals has been associated with an increased risk of severe dengue and hospitalisation [20]. Therefore, any future dengue vaccination strategy in Cambodia should be guided by local transmission intensity, age-specific seroprevalence, previous dengue exposure, and vaccine-specific evidence rather than treating all dengue vaccines as equivalent [18].

Strengthening genomic surveillance, laboratory capacity, vaccine financing, cold-chain systems, and regional partnerships will improve Cambodia's ability to respond rapidly to emerging infectious diseases.

Japanese encephalitis (JE) continues to affect populations in rural agricultural areas where rice cultivation and pig farming create favourable conditions for virus maintenance and transmission. Historical sentinel surveillance in Cambodia estimated an incidence of 11.1 JE cases per 100,000 children younger than 15 years in 2007. During 2006–2008, 110 of 586 children presenting with meningoencephalitis at six sentinel hospitals were laboratory-confirmed as having JE (19%), with 95% of cases occurring among children aged ≤12 years [21]. Although these data predate the widespread introduction of national JE vaccination, they demonstrate a substantial historical disease burden and provide an important baseline for assessing the impact of vaccination. More recent nationally representative estimates of JE incidence and mortality are limited, highlighting the need for continued surveillance and updated burden assessments. Cambodia has incorporated JE vaccination into national immunisation strategies, and sustained high vaccine coverage remains essential for reducing disease burden. Continued surveillance, monitoring of vaccine effectiveness, and strengthening of regional vaccination approaches remain important priorities [22,23].

Rabies remains almost universally fatal after symptom onset but is entirely preventable through timely post-exposure prophylaxis and animal vaccination. In Cambodia, rabies continues to represent an important public health concern, with an estimated 20,000–40,000 people receiving rabies post-exposure prophylaxis annually, reflecting substantial ongoing exposure to potentially rabid animals [24]. Cambodia continues to face challenges related to free-roaming dogs, uneven dog vaccination coverage, delayed healthcare-seeking, and limited access to rabies biological products in remote areas [22,25,26]. Recent large-scale canine vaccination campaigns in Cambodia have demonstrated that high vaccination coverage can be achieved over a short period, supporting mass dog vaccination as a feasible and essential component of rabies elimination [27].

Seasonal influenza, respiratory syncytial virus (RSV), mpox, and future zoonotic pathogens should also be incorporated into national preparedness planning. In Cambodia, influenza surveillance has documented substantial seasonal circulation and influenza-associated severe acute respiratory infections, particularly among young children and other vulnerable populations, although nationally representative estimates of annual influenza-associated morbidity and mortality remain limited [28–30]. These surveillance gaps highlight the need for continued laboratory-based influenza surveillance and improved disease-burden estimates to inform vaccination policy. RSV vaccines and maternal immunisation strategies represent important recent developments that may expand prevention options for severe respiratory disease among infants and high-risk populations [28]. However, Cambodia-specific epidemiological and vaccine-effectiveness data for RSV remain limited, supporting the need for strengthened respiratory virus surveillance and disease-burden estimation before broader vaccine policy decisions are made [31]. Similarly, the emergence and inter-

national spread of mpox have highlighted the importance of maintaining surveillance, laboratory confirmation, and preparedness mechanisms, including timely access to vaccines for populations at high risk [32]. For Cambodia, following the documented Clade IIb mpox outbreak in 2023–2024 [33], continued surveillance of both imported and locally acquired infections will be important to inform and strengthen future vaccine preparedness.

Rather than addressing each pathogen independently, Cambodia should prioritise flexible vaccine preparedness systems capable of responding rapidly to both known and emerging infectious threats (Figure 1). This approach enables national preparedness investments in surveillance, laboratory capacity, regulatory systems, vaccine procurement, and delivery platforms to serve multiple pathogens rather than relying on pathogen-specific preparedness. Such an approach aligns with global preparedness frameworks that emphasise adaptable vaccine platforms, rapid research and development, scalable manufacturing and procurement mechanisms, and equitable access during outbreaks [4,7,9,10].

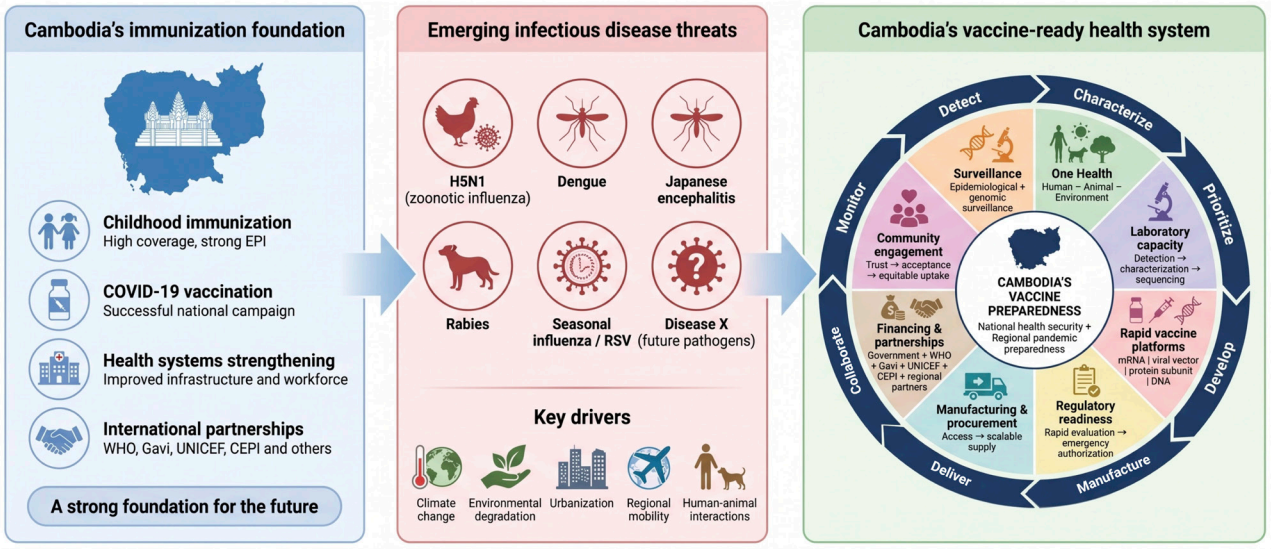


Figure 1. Conceptual framework for strengthening vaccine preparedness in Cambodia. Created in BioRender..

NEW VACCINE TECHNOLOGIES ARE CHANGING PREPAREDNESS

Recent advances in vaccine science have fundamentally changed how rapidly vaccines can be developed during outbreaks. The COVID-19 pandemic demonstrated that platform-based vaccine technologies can substantially reduce development timelines while maintaining high levels of efficacy and protection against emerging pathogens [10,34–36].

Messenger RNA (mRNA) vaccine technology represents a crucial advance in modern vaccinology. mRNA vaccine technology enables rapid vaccine development and adaptation when new pathogen sequences become available, offering a flexible platform for emerging and re-emerging infectious diseases. The success of mRNA COVID-19 vaccines has further accelerated research into their applications against influenza, RSV, and other emerging pathogens [34,35].

Viral vector, protein subunit, and DNA vaccine platforms similarly provide adaptable approaches that may support rapid vaccine development during future outbreaks [9,10,36]. For resource-constrained countries such as Cambodia, access to these technologies through international partnerships and global vaccine initiatives could help substantially shorten response times during future health emergencies [4,9,10,36].

These platform technologies represent an important shift from pathogen-specific vaccine development toward adaptable vaccine development and manufacturing systems capable of responding to previously unknown infectious diseases. This concept aligns closely with the WHO Disease X framework, which encourages countries to build preparedness systems capable of addressing unknown future pathogens rather than focusing only on currently recognised diseases [9].

In parallel, genomic surveillance, digital health systems, and pathogen sequencing provide opportunities for earlier outbreak detection and more targeted vaccine deployment. Strengthening these capabilities will improve Cambodia's ability to identify emerging pathogens, monitor pathogen evolution, and implement timely public health interventions [6–9].

BUILDING A VACCINE-READY HEALTH SYSTEM

Future vaccine preparedness depends not only on vaccine availability but also on resilient health systems capable of delivering vaccines rapidly, safely, and equitably. Cambodia's COVID-19 response demonstrated the importance of coordinated government leadership, international partnerships, community engagement, and adaptive vaccine delivery systems during public health emergencies [1,3].

Several priorities deserve particular attention (Figure 1). First, genomic surveillance should be expanded to improve early detection of emerging pathogens in both humans and animals. Second, laboratory infrastructure and regulatory capacity require continuous investment to support pathogen identification, vaccine evaluation, and emergency response. Third, maintaining reliable cold-chain systems and digital immunisation information systems will facilitate rapid vaccine deployment during future outbreaks [4,6,7,9,10].

Long-term financial sustainability also remains essential. Continued collaboration with international organisations, including WHO, and initiatives such as Gavi, the United Nations International Children's Emergency Fund, and Coalition for Epidemic Preparedness Innovations, will support vaccine access while strengthening national preparedness capacities [4,9,10].

Equally important is maintaining public confidence in vaccination. Experiences during the COVID-19 pandemic demonstrated that vaccine acceptance is influenced by communication, trust, accessibility, and social factors.[36] Addressing vaccine hesitancy through community engagement and evidence-based communication will remain essential for successful future vaccination programmes [3,36–38].

FROM ROUTINE IMMUNISATION TO PANDEMIC PREPAREDNESS

Cambodia has demonstrated that effective immunisation programmes can achieve exceptionally high vaccine coverage through strong political commitment, coordinated public health action, and international collaboration. The country's COVID-19 vaccination programme provides valuable experience for strengthening preparedness and responding rapidly to future public health emergencies [1–3].

Nevertheless, emerging infectious diseases increasingly require preparedness strategies that extend beyond routine childhood vaccination. Climate change, zoonotic spillover, regional mobility, and viral evolution will continue to generate new infectious threats that cannot be addressed using conventional immunisation programmes alone [5,6,9].

Future vaccine policy should therefore adopt a preparedness-oriented approach that combines surveillance, rapid vaccine technologies, resilient health systems, and One Health collaboration. Strengthening these capacities will improve Cambodia's ability to respond to known pathogens such as H5N1, dengue, JE, rabies, and seasonal influenza while enhancing preparedness for future Disease X scenarios [7,9,17,39,40].

By investing in vaccine readiness today, Cambodia can strengthen both national health security and its contribution to regional pandemic preparedness. A future-oriented vaccine strategy will require sustained investment, international cooperation, and integration of scientific innovation with robust public health systems [4,7,9,10].

CONCLUSIONS

Cambodia has demonstrated that strong immunisation systems and effective public health leadership can achieve high vaccine coverage and rapid deployment during health emergencies. As the

risk of emerging infectious diseases continues to grow, the country should build on these achievements by transitioning from a vaccine delivery agenda toward a comprehensive vaccine preparedness strategy that integrates surveillance, genomic and laboratory capacity, regulatory readiness, sustainable financing, and One Health collaboration. By strengthening these capacities, Cambodia can enhance its resilience against future epidemics and pandemics while contributing to broader regional health security.

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