Managing Dengue Risk Along the Laos–China Railway: An HEDRM Approach

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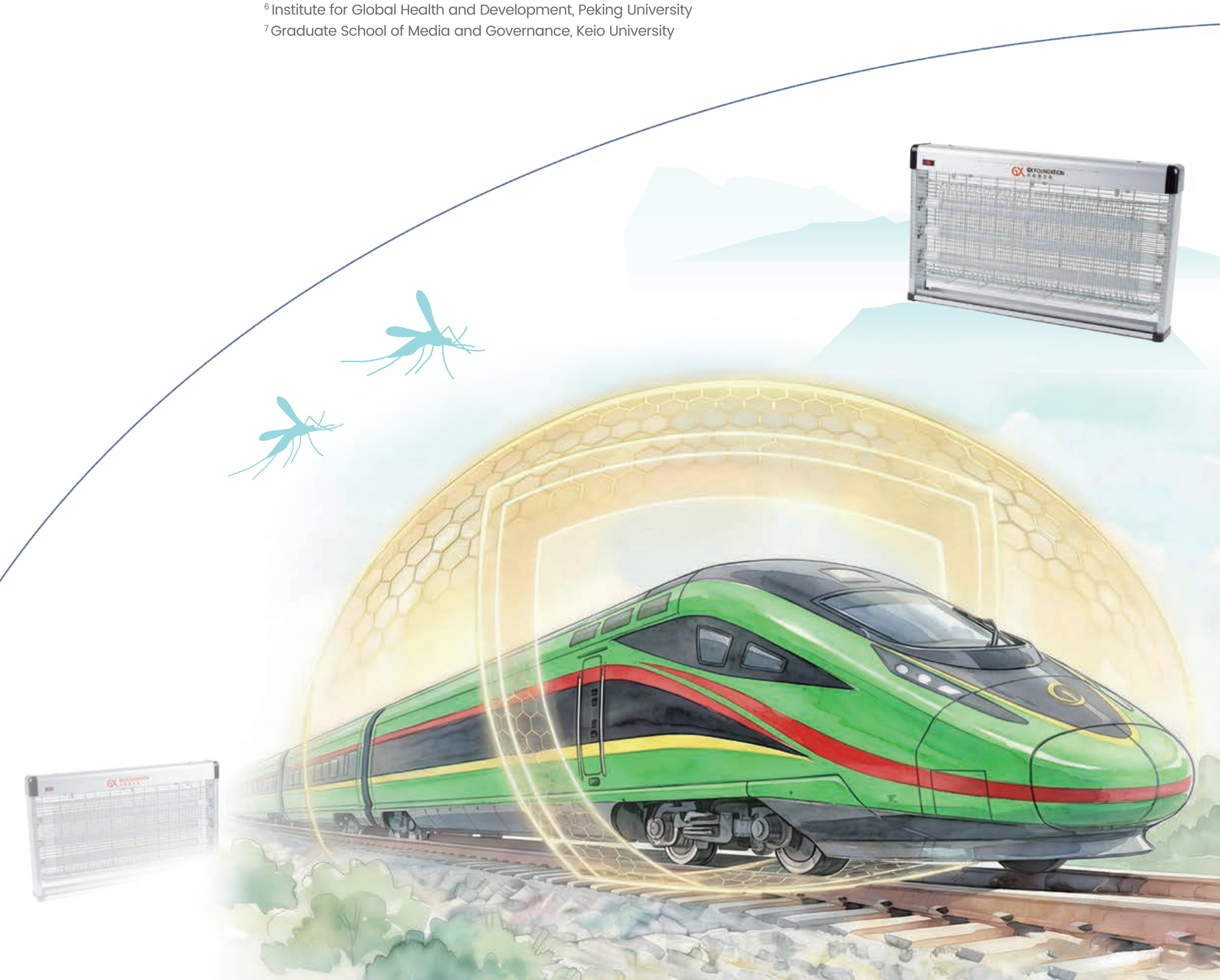

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01 Introduction

Vector-borne diseases (VBDs) are an escalating global health threat, with dengue among the fastest-expanding arboviral infections due to the widespread distribution of Aedes aegypti and Aedes albopictus mosquitoes, rapid urbanization, and climate variability (Bhatt et al., 2013; Chan et al., 2025; Messina et al., 2019). Human mobility is a major driver of dengue dynamics. Empirical and modeling studies show that movement along transport networks seeds introductions and synchronizes epidemics across connected populations, particularly in early outbreak phases (Stoddard et al., 2013; Wesolowski et al., 2015; Wilder-Smith & Gubler, 2008). In this context, safeguarding against dengue in an increasingly connected world has become a policy imperative, with renewed attention to transport corridors as critical interfaces for prevention and control (Chan et al., 2026; Chan, Sham, et al., 2020).

Health Emergency and Disaster Risk Management (HEDRM) offers an all-hazards, whole-of-system framework to reduce mortality, morbidity, and service disruption through integrated mitigation, preparedness, response, and recovery across sectors, consistent with the Sendai Framework for Disaster Risk Reduction 2015-2030, the International Health Regulations (2005), and the WHO's Global Vector Control Response 2017–2030 (Chan et al., 2017; Lo et al., 2017; WHO, 2019, 2021). Real-world experience demonstrates that well-implemented physical vector control and source reduction can suppress transmission at scale, as shown in Timor-Leste, underscoring the feasibility of integrated vector management in resource-limited settings (Chan et al., 2025). This study applies the HEDRM approach to the Laos-China Railway, a strategic, high-mobility, cross-border corridor, to operationalize cross-border surveillance and early warning, integrated vector management, risk communication, and contingency planning at railway nodes to protect workers, travellers, and adjacent communities from dengue and other VBDs. This work directly responds to the ISC-UNDRR-IRDR global research framework entitled "A Framework for Global Science in Support of Risk-informed Sustainable Development and Planetary Health" by operationalising its priorities for systemic risk reduction, transformative governance, and transdisciplinary collaboration along a strategic cross-border transport corridor (ISC-UNDRR-IRDR, 2021).

This special report is timely and warranted because dengue activity in Southeast Asia remains high. Laos experiences recurrent outbreaks, and transport corridors can amplify spread, yet practical, cross-sector examples of HEDRM embedded within railway operations are scarce. By documenting the HEDRM approach—including the humanitarian work conducted by the GX Foundation for the Laos-China Railway—we provide actionable evidence on how health and transport partners can jointly reduce vector-borne risks, safeguard staff and travellers, maintain continuity of operations, and strengthen system resilience along a strategic cross-border corridor.

The report is structured as follows. Section 2 outlines the HEDRM framework. Section 3 reviews dengue risk globally, regionally, and in Laos. Section 4 examines the role of transport infrastructure in infectious disease dynamics. Section 5 presents the Laos-China Railway context and stakeholder health risks. Section 6 details the dengue risk management project—its design, assessment methods, results, and lessons learnt—and provides recommendations for scaling and replication. Section 7 offers a brief conclusion.

02

Health Emergency and Disaster Risk Management

Health Emergency and Disaster Risk Management (HEDRM) is an interdisciplinary field that systematically addresses health risks across the disaster management continuum, including mitigation, preparedness, response, and recovery (Chan et al., 2017; Lo et al., 2017; WHO, 2019). Developed within the paradigm of the Sendai Framework for Disaster Risk Reduction 2015–2030, HEDRM integrates public health, emergency medicine, and disaster risk reduction to reduce mortality, morbidity, and health system disruption during emergencies and disasters (Chan & Lam, 2020; WHO, 2019).

The framework applies to a wide range of hazards under an all–hazards approach, including natural hazards, biological threats, and technological incidents (Chan, Gobat, et al., 2020; Chan et al., 2017; Chan et al., 2019). The research scope of HEDRM is broad and multi–faceted, encompassing epidemiological surveillance of disaster–related health outcomes, evaluation of health system resilience, analysis of community risk perception and behavioral responses, assessment of intervention effectiveness across the disaster cycle, and development of evidence–based training and workforce capacity–building strategies (Hung et al., 2021; WHO, 2021). By integrating diverse research domains, HEDRM seeks to generate actionable evidence that strengthens health systems, empowers communities, and informs policy–making to mitigate the health impacts of emergencies and disasters (Chan & Chan, 2020; WHO, 2019).

The Laos-China Railway is a high-mobility, transboundary corridor traversing dengue-endemic zones where intensified travel, construction sites, and peri-urban settlements can foster Aedes mosquito breeding and rapid spread of dengue and other arboviruses (e.g., chikungunya, Zika). The HEDRM approach is therefore crucial to integrate cross-border surveillance and early warning, targeted vector management and environmental source reduction, worker and community risk communication, and contingency plans for rapid response and recovery—thereby protecting passengers, staff, and nearby communities while maintaining railway operations. By aligning health and transport systems under shared protocols and capacities, HEDRM strengthens resilience, reduces morbidity and service disruption, and prevents localized outbreaks from propagating along the corridor.

03

Dengue Fever Risk in the World

3.1 *Elevated Risk Across Asia*

Dengue fever is one of the most significant and rapidly expanding vector-borne health threats worldwide, fuelled by climatic changes, population growth, and increasing urbanization (Chan et al., 2025; Chan et al., 2026; Chan, Sham, et al., 2020). Asia bears a disproportionate share of this global burden, with the South-east Asia and Western Pacific regions combined reporting over one million cases annually in recent years (IHME, 2025). These trends highlight the urgent need for coordinated public health strategies to address the growing impact of dengue in these heavily affected areas.

Dengue transmission is sustained by the Aedes aegypti and Aedes albopictus mosquitoes, which thrive in warm, humid, and densely populated urban environments. Climate change has intensified transmission by extending mosquito breeding seasons and enabling geographic expansion into areas previously considered low risk. The World Health Organization (WHO) has consistently classified dengue as a high global public-health risk, citing Asia as one of the most persistently affected regions due to endemic circulation of multiple dengue virus serotypes and frequent cross-border spread through travel and trade (WHO, 2024b, 2025b).

3.2 Elevated Risk in Southeast Asia

Southeast Asia (SEA) remains one of the most dengue-endemic subregions globally. Nearly all SEA countries experience year-round or highly seasonal dengue transmissions, with pronounced peaks during monsoon months. Rapid urban expansion, inadequate water and waste management infrastructure, and high population density create optimal breeding environments for Aedes mosquitoes (WHO, 2025a). The WHO estimates that over 1.3 billion people in the region reside in dengue-endemic areas, and several countries—including Indonesia, Thailand, Malaysia, Viet Nam, and Laos—routinely report large outbreaks (WHO, n.d.).

Moreover, all four dengue virus serotypes co-circulate in SEA, heightening the risk of secondary infections and severe disease. Climate variability has also disrupted historical seasonality, with outbreaks now occurring outside traditional rainy seasons (Sexton et al., 2025). Modelling studies indicate that, without sustained vector control and climate-adaptive surveillance, dengue incidences in parts of SEA will remain high in the coming decades (Colón-González et al., 2023).

3.3 Dengue Situation in Laos

Laos experiences recurrent and often severe dengue outbreaks, reflecting its tropical climate, developing urban infrastructure, and limited public-health resources relative to regional neighbours. Dengue transmission in Laos typically peaks between May and October; however, recent years have seen unusually high case numbers during both wet and dry seasons. In 2024, over 20,000 dengue cases and multiple fatalities were reported, following an even larger outbreak in 2023 (Sitthixay, 2025). In 2025, more than 9,000 cases were recorded in the first nine months alone, with the capital Vientiane accounting for nearly half of all reported infections (KPL Lao News Agency, 2025).

Several risk factors amplify dengue burden in Laos: high levels of under-reporting, limited laboratory diagnostic capacity, and environmental conditions that support mosquito proliferation. A study found strong associations between temperature, rainfall, and dengue incidence in Laos, indicating high vulnerability to climate-driven transmission shifts (Sugeno et al., 2023). Although community-based and WHO-supported vector control initiatives have shown localized success, national-level dengue control remains challenging, and outbreaks continue to impose significant health and economic strain.

CASE BOX I

Comparative Dengue Risk Profiles and Control Strategies in China, Singapore, and Laos

Laos, China and Singapore are neighbouring but very different countries in terms of levels of social and economic developments, political systems and organisational efficiency. China and Singapore demonstrate markedly different dengue risk profiles, influenced by variations in governance, disease surveillance systems, and urban infrastructure.

· China is not classified as fully dengue-endemic at the national level; however, there is an increasing risk of outbreaks in southern and coastal provinces such as Guangdong, Yunnan, and Hainan. Factors such as climate change and the northward expansion of Aedes albopictus have heightened the potential for local transmission following imported cases. China has experienced significant dengue outbreaks, with the most notable event occurring in 2014 and additional episodes in subsequent years. Nevertheless, robust centralized surveillance and rapid response systems have been effective in limiting sustained nationwide transmission (Li et al., 2024; Xie et al., 2025).

· Singapore, by contrast, is considered hyperendemic for dengue, yet the situation is highly controlled. Despite frequent outbreaks and cyclical surges, such as the record incidence observed in 2020, the case-fatality rate remains low due to strong healthcare access and effective disease management. The risk in Singapore is primarily driven by dense urban living and the persistent presence of mosquitoes. However, this risk is mitigated by robust vector control strategies, real-time surveillance technologies, high levels of public participation, and advanced early warning systems. Despite these efforts, population-level immunity is still insufficient, and dengue remains a recurrent public health concern (Singapore National Environment Agency, 2026 ; Ting et al., 2024).

In comparison, Laos experiences a higher relative burden of dengue and increased vulnerability, primarily due to less consistent outbreak control measures, greater sensitivity to climate variability, and more limited health system capacity when compared to both China and Singapore. Surveillance infrastructure and vector management programs in Laos are often constrained by resource limitations, which can result in delayed detection and response to outbreaks. Additionally, challenges such as limited healthcare accessibility, low public awareness of dengue and mosquito prevention, and a general lack of mosquito control tools among the population further exacerbate the country's vulnerability to sustained dengue transmission.

04

Transport Infrastructure and Infectious Disease

4.1 Role of Transport Infrastructure in Infectious Disease Transmission

Transport infrastructure plays a central role in shaping the spatial and temporal dynamics of infectious disease transmission by facilitating human mobility, trade, and connectivity between populations. Advances in transportation—whether by flight, rail, road, or inland waterways—reduce travel time and effectively compress geographic distance, enabling pathogens to spread more rapidly than would otherwise be possible (Tatem et al., 2006). Epidemiological research demonstrates that transport networks act as structural conduits for disease diffusion, particularly during early outbreak phases when population susceptibility is high, and surveillance is limited (Lessani et al., 2024). These dynamics have been observed historically in bacterial diseases such as cholera and plague, as well as in modern viral outbreaks including influenza, SARS (Severe acute respiratory syndrome), Ebola, and COVID—19 (coronavirus disease 2019) (Gonzalez et al., 2026; WHO, 2023).

CASE BOX II

Severe Acute Respiratory Syndrome (SARS) - How a Single Transport Hub Triggered Global Infectious Disease Spread

In February 2003, a physician from Guangdong (the index patient) stayed for just one night at the Metropole Hotel in Hong Kong, yet he infected at least 10 other guests on the same floor (Cherry & Krogstad, 2004). These individuals subsequently traveled through the Hong Kong International Airport to reach destinations including Singapore, Toronto, and Hanoi. What made the situation particularly alarming was an incident on a flight from Hong Kong to Beijing, where a single symptomatic passenger led to 22 out of 119 contacts (18%) becoming ill (Lai & Yu, 2010). The Singapore experience further underscored this dynamic: three female travelers who had stayed at the same hotel returned to Singapore and triggered a cascade of in-hospital transmissions that ultimately infected 109 people across five healthcare institutions (Wilder-Smith & Goh, 2008).

Crucially, this was not merely a story of individual transmission events but a demonstration of how transportation hubs amplify and accelerate pathogen spread. A systematic review by Browne et al. (2016) confirms that air transportation plays a decisive role in accelerating influenza and coronavirus propagation, with transmission occurring aboard aircraft, at destinations, and possibly within airports themselves. The review further highlighted the role of air travel in rapidly introducing viruses to new geographical areas—a pattern first vividly illustrated by the SARS outbreak (Browne et al., 2016).

Key lessons: Transport hubs can transform localized outbreaks into global health emergencies within days. Entry screening (e.g., infrared temperature checks) and quarantine infrastructure are essential to contain the spread at transport nodes.

4.2 Railways and Infectious Disease Transmission

Railway infrastructure has historically facilitated the accelerated spread of infectious diseases, particularly during the nineteenth and early twentieth centuries. The expansion of rail networks transformed localized outbreaks into regional or national epidemics by enabling rapid, high-volume movement of people between urban centres. During the later cholera pandemics of the 1800s, railways significantly reduced travel times across Europe, North America, and colonial Asia, facilitating hierarchical disease diffusion from major cities to smaller towns (Claeson & Waldman, 2026; Harvard University, n.d.). By the mid-nineteenth century, cholera outbreaks followed rail-linked urban hierarchies rather than simple geographic proximity, highlighting the growing epidemiological importance of transport connectivity (Pyle, 1969).

In the modern era, passenger rail systems, particularly high-frequency commuter and intercity rail, remain relevant to disease spread through prolonged close contact in enclosed environments. Although improved sanitation and public health measures limit large-scale epidemics, modeling studies indicate that rail corridors continue to shape the early trajectories of emerging infectious diseases by concentrating movement along predictable routes (Gardner, 2017; Hajdu et al., 2025).

CASE BOX III European high-speed rail system and COVID-19 spread

High-speed rail networks (e.g., Eurostar, TGV, ICE) connect dense urban centres with frequent, high-capacity services, creating rapid pathways for infectious agents to move between cities in some instances, countries. Mobility-network research shows these corridors can accelerate spatial spread by linking contact networks across regions (Balcan et al., 2009). During COVID-19, steep reductions in intercity and international rail travel—together with lockdowns and border controls—correlated with slower geographic diffusion of cases (Kraemer et al., 2020; Pullano et al., 2020). At the carriage and station level, transmission risk depended on trip duration, passenger density, ventilation/air exchange, and passenger behaviors; modeling and outbreak reports indicate airborne exposure is plausible under poor ventilation and high occupancy (Goscé & Johansson, 2018). European operators implemented layered measures—service adjustments, mandatory masking, enhanced HVAC operation and filtration, intensified cleaning, testing/quarantine for cross-border travellers, and demand management via timetabling and real-time crowding information—balancing reduced seeding risk with preserving essential mobility.

Key lesson: Rail corridors are multifunctional health-risk vectors. Beyond airborne pathogens, railways can influence vector-borne disease dynamics (e.g., dengue) by moving infected people who seed new transmission foci, and enabling transport of vectors (e.g., mosquitoes) in vehicles or goods. This underscores the critical importance of the topic of railways and infectious disease transmission for integrated transport and public-health policy.

4.3 Highways, Motorways, and Contemporary Mobility

Highway and motorway networks are dominant drivers of infectious disease spread in contemporary settings, especially for respiratory pathogens. Road infrastructure supports daily commuting, regional travel, and long-distance freight movement, producing dense and recurrent mobility patterns that amplify opportunities for transmission. During the COVID-19 pandemic, multiple studies demonstrated strong correlations between reductions in road mobility and subsequent declines in case growth rates, with time-lagged effects reflecting incubation periods (Badr et al., 2020; Zhang et al., 2022).

Unlike railways—which tend to produce point-source outbreaks—highways and motorways enable more dispersed yet sustained flows of movement across large territories, thereby contributing to the geographic seeding of infections. Highway connectivity has been shown to facilitate rural-urban transmission, the spread of infection from metropolitan "superspreading" zones, and cross-border disease diffusion in regions with porous land boundaries (Han et al., 2025; Iyaniwura et al., 2023). These findings have informed modern public-health interventions such as targeted travel restrictions, mobility-aware lockdowns, and corridor-specific surveillance strategies.

4.4 *Vector-Borne Disease Risk with Human Travels*

VBDs are infections caused by parasites, viruses, or bacteria transmitted to humans through the bites of infected vectors such as mosquitoes, ticks, or flies (EFSA, 2026; WHO, 2024c). They have a high risk of transmission facilitated by human travel. Imported VBDs refer to those cases where an infected individual or vector is brought into a new geographic area through travel or trade, carrying the pathogen from an endemic region. In contrast, autochthonous VBDs are those for which the disease transmission occurs locally within an area, without recent travel history outside of the region. This local transmission depends on the presence of competent vectors, susceptible host, and suitable environmental conditions for the pathogen to spread.

The global risk of both imported and autochthonous VBDs has increased significantly due to factors such as globalization, rapid international travel, and expanding trade networks, allowing vectors and pathogens to move beyond traditional boundaries (CARPHA, 2017). Climate change and urbanization have expanded the habitats and breeding grounds for vectors like Aedes mosquitoes, thereby extending their geographic range and seasonal activity. Additionally, delays in detecting and reporting imported cases can facilitate the establishment of local transmission in new areas, creating emerging public health threats worldwide.

Recently reported imported VBDs include dengue, chikungunya, and Zika virus infections detected in travelers returning from endemic regions to Europe and North America. Autochthonous outbreaks of these diseases have also occurred in areas like southern Europe, where competent mosquito vectors such as Aedes albopictus are established (Cattaneo et al., 2025). For instance, Italy, France, and Spain have reported local transmissions of dengue and chikungunya in recent years, triggered by imported cases in combination with suitable environmental conditions (ECDC, 2025).

Specifically for dengue, recent imported cases have been documented globally in travelers returning from Asia, the Americas, and the Pacific. Autochthonous dengue transmission was confirmed in 2025 in places such as southern France and Italy. In the Pacific region, countries like Fiji, French Polynesia, and Samoa have experienced localized dengue outbreaks—underscoring the persistent risk of both imported and local dengue transmissions (ReliefWeb, 2025).

Given the significant role that points of entry, such as airports and seaports, play in the introduction of infected individuals and vectors, vector control efforts at these locations are critical. Similarly, transportation infrastructure such as motorways, railways, and canals—through which humans and freight regularly move—can facilitate the spread of vectors and pathogens. Implementing surveillance and vector control measures at these key nodes helps to prevent the establishment and spread of VBDs, thereby protecting public health and limiting outbreaks.

05

Laos-China Railway

5.1 General Context of the Laos-China Railway

The Laos-China Railway is a 1,035 km electrified line connecting Kunming (Yunnan, China) and Vientiane (Laos). Along the Lao section, approximately 198 kilometers of track traverse 76 tunnels, highlighting the engineering complexity of the route. The project was executed through a bilateral joint venture, the Laos–China Railway Company, ensuring shared governance and operational responsibility. It is a flagship Belt and Road Initiative project that aims to enhance regional connectivity and economic integration between the People's Republic of China and the Lao People's Democratic Republic. As a landlocked country, Laos faces higher transport costs and a reliance on cross-border infrastructure for trade and access to services, making corridors such as the Laos-China Railway strategically important for economic integration, service delivery, and broader social development. The railway traverses mountainous terrain, requiring extensive tunnelling and bridge construction, and connects key Lao provinces, including Luang Namtha, Oudomxay, Luang Prabang, and Vientiane, thereby linking previously isolated regions to domestic and international markets. Figure 1 shows a map of the Laos-China Railway.

Figure 1. Map of Laos-China Railway and its major railway stations

Note: The stations on the Laos-China Railway shown in bold are major stations where tickets can be purchased.

5.2 *Health Risks Faced by Major Stakeholders of the Railway*

As a major stakeholder in the construction and operation of the Laos-China Railway, the health of railway workers is a crucial dimension of public health intervention. The International Organization for Migration (IOM) published a Health Impact Assessment (HIA) for the railway project (IOM, 2025), identifying key health risks faced by construction workers, including infectious diseases such as malaria, dengue, and HIV/ AIDS, occupational health hazards, and the potential for amplified health risks along migration corridors associated with large-scale infrastructure projects. According to the recommendations of this assessment, the IOM launched periodic health screenings, safety training, and educational programmes at worker camps. Importantly, the railway facilitated rapid and regular transportation of medical teams and supplies to remote or high-traffic node points. This improved worker health monitoring and enabled a timely response to emerging illnesses, especially during peaks of construction and in the early operational phase.

Additionally, the IOM collaborated with the Lao Ministry of Health in launching mobile outreach campaigns targeting communities along the rail corridor where migrants settled or concentrated (IOM, 2018). These involved infectious disease prevention campaigns, mobile clinics, and, more recently, coordination on COVID-19 monitoring and risk communication for both Lao and non-Lao railway users, bolstered by rail-enabled logistical efficiency. The IOM's experience highlighted the importance of integrating migration health with transport infrastructure, particularly for response preparedness and routine surveillance.

06

HEDRM Project to Manage Dengue Risk Along the Laos-China Railway

6.1 Project Brief

Recognizing the dengue risk along the Laos-China Railway corridor, the GX Foundation (GX) has, since 2020, partnered with the Laos-China Railway to develop and implement an HEDRM program for VBD control. The program aims to strengthen protection of passengers and railway staff against the cross-border transmission of dengue fever on the Laos-China Railway.

The Laos-China Railway is a key cross-border transport artery linking China and Laos. It extends from Kunming to Mohan for 613 km, and from Boten to Vientiane for 422 km, comprising 29 stations. As of March 2026, the railway has reached a significant milestone, carrying more than 70 million passenger trips since its opening.

6.2 GX Foundation's Dengue Control Programme

GX has partnered with the Laos-China Railway to implement a targeted vector-control package focused on stations and associated facilities along the corridor. To reduce mosquito exposure in high-traffic areas, GX donated and oversaw the deployment of 871 mosquito-killing lamps across 29 stations—511 in the China section (Kunming–Mohan) and 360 in the Laos section (Boten–Vientiane). Placement prioritized locations with elevated bite risk and passenger density, including ticket offices, waiting halls, fare gates, toilets, baby-care rooms, and platforms, as well as staff offices and rest areas. Table 1 summarizes deployment at 10 key stations (five in China and five in Laos), detailing totals per station and distribution across internal zones (washrooms, staff rest and operations rooms, and passenger and security areas) and external facilities (staff accommodation complexes, canteens, and maintenance areas).

In Laos, the railway corridor serves as the operational backbone of GX's dengue control programme, which integrates vector control, community protection, and health education. Through memoranda of understanding with the Laos–China Railway Company, GX has complemented lamp deployment with sticky traps and rapid test kits, supported entomological monitoring, and delivered community outreach to promote source reduction and timely care-seeking.

The Laos-China Railway also enables broader health-service delivery that reinforces dengue risk management. By improving access to remote populations, shortening travel time for patients and specialist teams, and ensuring reliable transport of equipment and supplies, the line supports GX's outreach clinics, cataract campaigns, and vector-control interventions, while offering logistical advantages for rapid disaster response.

TABLE 1 Number of Lamps Installed at the Ten Main Stations on the Laos-China Railway in 2024

	China section					Laos section				
Station	Kunming South	Yuxi	Puer	Xishuang banna	Mohan	Boten	Muang Xai	Luang Prabang	Vang Vieng	Vientiane
Total number of lamps installed	**8**	**12**	**47**	**66**	**115**	**47**	**29**	**38**	**36**	**27**
Within the station	**8**	**0**	**22**	**30**	**62**	**34**	**23**	**24**	**13**	**27**
Washrooms			4	3	4	10	7	6	5	6
Staff Rest Areas			2	6	5	1				
Staff/Ops Rooms			8	10	25	14	5	10	6	4
Passenger/ Security Zones	8		8	9	28	3	3	3	2	12
Others				2		6	8	5		5
Outside the station	**0**	**12**	**25**	**36**	**53**	**13**	**6**	**14**	**23**	**0**
Staff Accommodation Complex			10	16	34	1	1	5	12	
Staff Canteen						8	2	3	5	
Integrated Maintenance Work Area		12	15	20	19					
Others						4	3	6	6	

Note: The table was produced by courtesy of GX Foundation.

6.3 *Medical Humanitarian Response Co-benefits along the Laos-China Railway*

Building on Section 6.1's assessment of the railway's dual role—heightening cross-border health risks while enabling faster, farther-reaching health operations—humanitarian actors leveraged the Laos-China Railway as a logistical corridor to extend medical services, emergency response, and public health interventions to previously underserved populations (KPL Lao News Agency, 2025; WHO, 2024a). Framed within the HEDRM framework, this corridor enables both routine risk reduction and surge response: the same network that can accelerate disease spread also provides the physical platform for prevention, surveillance, and rapid logistics.

Within this HEDRM approach, GX's dengue control programme may serve as a core, corridor-based risk-reduction model. By integrating targeted vector control with community protection and health education along the railway, the programme reduces baseline transmission risk and strengthens preparedness for seasonal and cross-border dengue threats.

In the Lancang-Mekong River Basin Area, major typhoons and flooding often markedly elevate the risk of mosquito-borne diseases, notably dengue, by creating extensive standing-water breeding sites, disrupting sanitation and shelter systems, and displacing populations into overcrowded settings with limited vector-control capacity (Gudo et al., 2016; Shaikh et al., 2023). Applying the same corridor model to acute shocks, GX launched a four-month emergency response (Project X) in Luang Namtha following the flooding caused by Typhoon Yagi in 2024 (Figure 2), under the leadership of provincial and national health authorities (Figure 3). The operation delivered VBD control kits and laboratory equipment to restore timely case detection and management, reduce transmission, and mitigate the likelihood of secondary outbreaks during recovery. This targeted VBD response aligns with established disaster-health practice by prioritising immediate transmission risk reduction, strengthening surveillance and diagnostics, and protecting vulnerable communities while longer-term recovery proceeds. Notably, no dengue cases were recorded during the post-flood monitoring period.

Figure 2. Flood-Affected Communities in Luang Namtha, Laos in 2024
Note: The photos were used by courtesy of GX Foundation.

The Laos-China Railway functioned as a critical operational linkage for Project X, enabling rapid movement of supplies and personnel and facilitating coordination with provincial authorities. Donations of laboratory equipment to Namtha District Hospital and Luang Namtha Provincial Hospital expanded diagnostic coverage from approximately 20 to 78 villages, illustrating how the corridor can translate HEDRM principles into measurable service reach. Together, GX's routine dengue control activities and its post-typhoon response demonstrate an integrated, corridor-based HEDRM model that manages ongoing VBD risk while providing scalable capacity for disaster response.

Figure 3. GX Donating Epidemic Prevention Supplies to Flood-Affected Communities
Note: The photos were used by courtesy of GX Foundation.

6.4 *Project Monitoring and Evaluation*

To assess implementation fidelity and early user experience, GX conducted monitoring of mosquito-lamp deployment and collected feedback on the perceived effectiveness of lamps and VBD educational materials. The assessment focused on how, where, and how well the lamps were being used within station environments, and on staff and passenger perceptions within the first year of operation.

Responses were analysed descriptively to inform operational adjustments (e.g., confirming priority zones for lamp placement and maintenance routines) and to guide subsequent HEDRM activities along the corridor. Findings complement Section 6.2 by linking routine dengue risk reduction with corridor-based surge capacity for flood-related outbreaks.

On-site assessment:

- **Timing and coverage:** On-site monitoring was carried out within three months of installation completion in both the China and Laos sections in 2024 (Figure 4).
- **Station selection:** In consultation with the Laos–China Railway, six stations were selected based on passenger throughput, number of lamps installed, and exposure to cross-border passenger and cargo flows. Selected stations in China were Pu'er, Mohan, and Xishuangbanna; in Laos, Boten, Vientiane, and Luang Prabang.
- **Verification and observation:** Teams visited all locations specified in the installation plans to verify placement, confirm functionality, and observe use patterns in high-risk areas (e.g., ticketing halls, platforms, washrooms, staff areas).
- **User interviews:** Sixty on-site intercept interviews were conducted to gather qualitative feedback. Of respondents, 48.3% were passengers, and 51.7% were station operational staff and railway management.


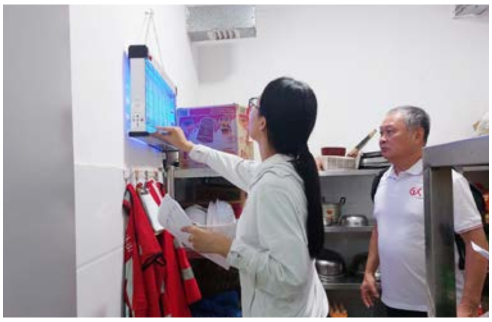

Figure 4. On-site mosquito lamps inspection
Note: The photos were used by courtesy of GX Foundation.

User satisfaction surveys:

· **Modality and respondents:** To complement on-site findings, two rounds of WeChat-based surveys were conducted with railway staff in 2024, yielding a total of 1,243 responses.

· **Timing:** The first round occurred six months after installation; the second took place 12 months after installation.

· **Focus:** Surveys captured staff perceptions of lamp effectiveness and the usefulness of accompanying VBD educational materials.

6.5 *Key Results and Early Outcomes*

Consistent with the HEDRM project outlined in Sections 6.1–6.2, the corridor-based intervention achieved high implementation fidelity and early gains in operational preparedness for VBD prevention along the Laos-China Railway.

Installation was completed on schedule between May and July 2024, strengthening environmental vector control in high-mobility settings. More than 95% of the lamps were installed according to technical specifications, while a small number were retained as reserve stock to replace damaged units or those affected during transportation. Most lamps were installed at the recommended height of 1.5 metres to maximize effectiveness, although a limited number could not be optimally positioned due to infrastructural constraints such as the absence of power sockets.

On-site monitoring indicated widespread and sustained use of lamps across stations, offices, and staff quarters. Teams observed that most lamps were switched on and operational, with visible reductions in indoor mosquitoes at assessment sites. Initial barriers related to placement or power access were identified and addressed, supporting the continuity of preventive measures in high-traffic transport environments.

Acceptability among railway staff was high. Staff working in offices and residing in staff quarters expressed strong appreciation for the lamps as a protective measure that supports well-being and occupational health. Two rounds of WeChat surveys with staff showed stable perceived effectiveness over time: 69.76% of respondents at six months and 68.62% at 12 months reported the lamps were effective. While the proportion reporting fewer mosquito bites declined from 73.84% shortly after installation to 43.10% at 12 months, respondents continued to view the lamps as a valuable preventive tool in both work and living settings.

Results from risk communication and public education were mixed. Among surveyed staff, awareness of dengue transmission and preventive measures improved markedly; over 90% found GX's education posters useful and were willing to share them with family and friends, and more than half reported increased knowledge and intention to adopt preventive behaviours. However, passenger interviews indicated limited visibility and recall of posters within stations, suggesting that communication strategies should be adapted for transient audiences—for example, by prioritising highly trafficked locations and integrating audio or digital formats where feasible.

Overall, the combination of engineering controls and risk communication proved feasible and acceptable along a major transport corridor, enhancing day-to-day dengue risk reduction. Lessons on device placement, power access, and audience targeting provide a practical basis for scale-up and for integration with surge actions during flood events, reinforcing the railway's role as both a conduit of risk and a platform for rapid, targeted health protection.

6.6 Achievements and Learnings

This pilot project represents a successful HEDRM-oriented intervention to address public health risks associated with transport infrastructure in a dengue-endemic setting. By systematically reducing mosquito populations along the Laos–China Railway, the project effectively lowered the risk of dengue transmission in railway stations and staff living and working environments. Notably, no dengue infection among railway staff was reported during the 12 months following the intervention. In parallel, public awareness of dengue transmission and prevention increased, supporting longer-term risk reduction through improved knowledge and protective behaviours.

The project demonstrated the feasibility and added value of achieving health co-benefits through cross-sector collaboration, a core principle of the HEDRM framework. By leveraging GX's expertise in public health and community engagement alongside the railway operator's extensive logistics network, infrastructure access, and workforce presence, the partnership jointly implemented VBD prevention and control measures across key railway stations and staff areas. Integrating public health interventions into routine transport operations not only enhanced the health and safety of railway communities but also contributed to the sustainability and resilience of large-scale infrastructure projects operating in endemic regions.

Beyond local impact, the project generated broader system-level benefits by providing a replicable model for NGO–enterprise collaboration in disaster risk and health management. The intervention model was shared within the international NGO community in Laos and drew recognition from international stakeholders, including United Nations agencies. On 30 May 2025, the Chinese Embassy in Laos facilitated a visit by United Nations missions to the Laos–China Railway to observe the project's implementation. Project outcomes were also documented as case studies and disseminated to participants at the 8th Global Platform for Disaster Risk Reduction (GP2025) in Geneva, organized by the United Nations Office for Disaster Risk Reduction, contributing to global learning on integrating health into infrastructure systems.

The project also offers important insights into the evaluation of vector control interventions within an HEDRM context. It highlights the need to move beyond a narrow focus on entomological or environmental indicators and to incorporate user satisfaction and perceived effectiveness as key outcome measures. As the ultimate objective of vector control is to reduce health risks and daily disruptions caused by disease vectors, self-reported outcomes—such as perceived reductions in mosquito bites and improved comfort in living and working environments—provide

valuable evidence of whether interventions meet community needs. High levels of user satisfaction are closely linked to compliance and long-term sustainability, as individuals are more likely to maintain preventive practices when interventions are perceived as convenient, effective, and acceptable. Feedback from users also informed programme learning and offered practical perspectives for improving efficiency in future implementations.

In addition to health outcomes, the project strengthened collaboration between the GX Foundation and the Laos–China Railway, reinforcing people-to-people connections and demonstrating the positive role of Chinese enterprises and staff in public health efforts in Laos. This partnership created enabling conditions for future collaboration under GX-supported initiatives, including patient recruitment for cataract programmes and coordinated flood emergency response in Luang Namtha – Project X. These spillover benefits further underscore how integrating health risk management into infrastructure projects can generate sustained social, institutional, and emergency response gains aligned with the HEDRM framework.

Limitations should be noted. The assessment relied on purposive station selection and self-reported perceptions, which may not fully represent all stations or user groups. Results should be interpreted as indicative of early implementation performance and user experience rather than definitive impact estimates.

07

Discussion and Conclusions

This special report demonstrates that applying an HEDRM approach to the Laos-China Railway can effectively reduce VBD risks in a high-mobility, cross-border corridor. The project achieved rapid, large-scale deployment of mosquito-killing lamps at priority stations and staff facilities, documented visible entomological impact, received strong user endorsement, and reported no staff dengue infections in the 12 months post-intervention. Coupled with strengthened surveillance linkages, humanitarian outreach, and multi-agency emergency drills, the corridor now functions as an operational platform for integrated prevention, early detection, and rapid response to dengue and other VBD threats.

Beyond its immediate health outcomes, this project offers a direct and actionable contribution to the ISC-UNDRR-IRDR global research framework. It addresses Priority 1—understanding systemic, cascading, and complex risk—by illustrating how a transport corridor simultaneously amplifies dengue transmission through human mobility while serving as a logistical platform for post-disaster response. The project further advances Priority 3—enabling transformative governance and action—and Priority 9—fostering transdisciplinary approaches and multi-stakeholder collaboration—by applying co-designed strategies for disaster risk reduction and climate resilience at the community level. Collectively, this program offers a practical, replicable, and measurable model for aligning infrastructure-based health interventions with the vision of risk-informed sustainable development and planetary health advanced by UN agencies and international organisations.

This work yields clear, actionable implications for policy and practice. First, transport–health partnerships can embed vector control and risk communication into routine railway operations without disrupting services, advancing resilience and continuity of critical infrastructure. Second, corridor-aligned surveillance—digitally connected to national systems—enables near-real-time situational awareness and faster outbreak investigation, particularly at international nodes like the Mohan–Boten port. Third, humanitarian programming can leverage rail logistics to extend equitable access to prevention, diagnostics, and care, while joint disaster drills translate plans into operational readiness. Finally, integrating climate- and mobility-informed risk forecasting into routine corridor operations will enable anticipatory vector control, targeted resource allocation, and sustained impact.

The significance of this work extends beyond the immediate context of the Laos-China Railway. It offers a practical, replicable HEDRM model for biological hazards in transport corridors that advances the Sendai Framework priorities, supports International Health Regulations core capacities, and aligns with the WHO's Global Vector Control Response. By demonstrating cross-sector governance, co-financed operations and maintenance, and community-centered engagement, the initiative provides a template for scaling along the Laos-China corridor and adapting to other regional rail and road networks.

Key next steps of projects include expanding coverage to the remaining stations and high-risk worker housing; institutionalizing bi-national early warning and information-sharing protocols; strengthening multilingual risk communication for travellers and staff; integrating climate- and seasonality-informed vector management; establishing routine maintenance and device replacement cycles; and enhancing monitoring with standardized entomological indices, epidemiological endpoints, and cost-effectiveness analyses. Taken together, these actions will consolidate health co-benefits, protect livelihoods, and help ensure that economic connectivity is matched by resilient, people-centered public health protection across the region. Looking ahead—and subject to partner priorities and resources—potential areas for further work include selective scale-up to high-risk locations, bi-national early-warning and information-sharing protocols, strengthened multilingual risk communication for travelers and staff, and streamlined maintenance and monitoring frameworks that incorporate climate- and seasonality-aware vector management with standardized entomological and epidemiological indicators. Together, these measures would help consolidate health co-benefits and ensure that growing economic connectivity is matched by resilient, people-centred public health protection.

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Major Organizations

Integrated Research on Disaster Risk (IRDR)

Website: *https://www.irdrinternational.org*

Integrated Research on Disaster Risk (IRDR) is an international scientific program co-sponsored by the International Science Council (ISC) and the United Nations Office for Disaster Risk Reduction (UNDRR), and supported by China Association of Science and Technology (CAST). IRDR aims to usher in an inclusive, safe and sustainable world by promoting a better understanding of disaster risk and the effective use of risk science in decision-making. IRDR contributes to the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 through "A Framework for Global Science in Support of Risk-informed Sustainable Development and Planetary Health" toward 2030 and beyond.

GX Foundation

Website: *https://gxfoundation.hk*

GX Foundation is a non-governmental charitable organisation established in Hong Kong, China, in 2018. It aims to provide medical and public health humanitarian assistance to Belt and Road countries, embodying the spirit of "sharing" and "people-to-people connectivity".

GX's work spans Asia, Africa, Central America, and the South Pacific. Its flagship "Cataract Blindness Elimination Programme" aims to completely eliminate the backlog of cataract blindness cases in project countries, providing free cataract surgeries in Laos, Cambodia, Djibouti, Senegal, and Mauritania.

Additionally, GX is actively engaged in vector-borne disease prevention and control, including in Timor-Leste, Honduras, Laos, Cambodia, Djibouti, Senegal, Mauritania, Vanuatu and Fiji, as well as in several large infrastructure projects within various countries. Other global focus areas are the "Direct Potable Water Project" in Timor-Leste, along with building community disaster resilience and preparedness, as well as humanitarian talent development in project countries.

Collaborating Centre for Oxford University and CUHK for Disaster and Medical Humanitarian Response (CCOUC), The Chinese University of Hong Kong

Website: *http://www.ccouc.ox.ac.uk*

The Collaborating Centre for Oxford University and CUHK for Disaster and Medical Humanitarian Response (CCOUC) was founded in 2011 through a partnership between the University of Oxford and The Chinese University of Hong Kong. Based in Hong Kong, CCOUC operates as a non-profit research institute focused on disaster and humanitarian response, particularly in the Asia-Pacific region. Its core activities include multidisciplinary research, education, and community knowledge transfer related to disaster preparedness and medical humanitarian relief. CCOUC works to minimize adverse health impacts from disasters among vulnerable populations, using evidence-based approaches to inform policies and training. Since 2016, CCOUC has been formally designated as an International Centre of Excellence (ICoE) within the Integrated Research on Disaster Risk (IRDR) network. Through its research, training, and knowledge transfer activities, CCOUC aims to advance best practices and build regional and global capacity in disaster and medical humanitarian response.

Center of Global Health (CGH), The Chinese University of Hong Kong

The Centre for Global Health (CGH) is an integral part of the JC School of Public Health and Primary Care at The Chinese University of Hong Kong (CUHK). Under the leadership of Professor Emily Chan, CGH is dedicated to advancing public health knowledge and improving health outcomes both regionally and globally. The centre focuses on multi-disciplinary research, public health education, and the translation of research findings into policy and practice. CGH addresses pressing health challenges such as disaster preparedness, pandemic response, and health equity, leveraging its strategic location in Hong Kong to foster regional and international collaborations. By engaging experts across diverse fields, CGH works to strengthen the capacity of health systems and inform evidence-based interventions. The centre's commitment to innovation and community impact puts it at the forefront of global health leadership in Asia and beyond.

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