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Review

Outbreak preparedness and response strategies in ASEAN member states: a scoping review

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ABSTRACT

Objectives: The 21st century has witnessed significant disease outbreaks with severe impact in Association of Southeast Asian Nations (ASEAN) countries, including SARS, H1N1, H5N1, and COVID-19. This review aimed to compile and analyze outbreak preparedness and response strategies, highlighting the success of coordinated multi-sectoral approaches and policy responses within the ASEAN region.

Methods: The protocol for this review was registered on the Open Science Framework and PROSPERO. A systematic analysis of publications from the 2002-2022 period was conducted following PRISMA guidelines on 4522 records retrieved from PubMed, CINAHL, Web of Science, and Scopus. The titles and abstracts were screened, and 229 articles were selected for full-text screening. Finally, 34 articles were included in this review.

Results: Four preparedness pillars were identified: governance and stewardship, disease detection, disease prevention, and health care management. The pillars were crucial in preparing for and responding to the COVID-19 pandemic. Coordinated responses among the ASEAN countries and local and international stakeholders were reported.

Conclusions: The findings emphasize that understanding the transmission dynamics of infectious diseases is paramount for effective disease prevention, surveillance, and timely response efforts to prevent the next pandemic. A well-coordinated multi-country and multi-agency policy response and understanding the different disease management models are crucial in addressing future outbreaks in the region. Future post-pandemic publications will shed more light on lessons learned and preparedness and response plans for future pandemics.

Introduction

The 21st century has witnessed a wave of severe infectious disease outbreaks, causing substantial morbidity and mortality across multiple countries [1]. Countries in the Association of Southeast Asian Nations (ASEAN) economic bloc, founded in 1967 and comprising 10 economies (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam), have also experienced severe disease outbreaks, including severe acute respiratory syndrome (SARS), pandemic influenza A (H1N1), avian influenza (H5N1), and Nipah virus [2].

The Southeast Asian (SEA) region is a diverse and rapidly evolving area projected to become the world's fourth-largest economy by 2030. Favorable demographics, robust economic growth, and facilitated trade and investment within ASEAN have elevated SEA region's global importance. However, external factors such as geopolitical stability, policy decisions, and disease outbreaks can impact these projections. Given the porous borders and close interconnection among ASEAN countries, focusing on heightening resilience and agility through the adoption of effective integrated disease control and prevention strategies is essential. A concerted effort involving multiple countries in anticipation of other types of pandemics in the future is crucial. Therefore, comprehending the various disease management models implemented in ASEAN countries and proactively integrating the knowledge into country-specific frameworks are essential to prepare for future outbreaks and pandemics.

Recently, ASEAN countries experienced firsthand the impact of COVID-19, highlighting the need to focus on post-pandemic resilience and agility and learn from past and current experiences. This can be achieved through the adoption of effective integrated prevention and response strategies in respective countries.

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In the early months of 2020, the World Health Organization (WHO) designated the novel COVID-19 outbreak as a global health emergency. Southeast Asia was among the first regions to be impacted, primarily because of its close geographical proximity and extensive connections in business travel, tourism, and supply chains with China. Notably, Singapore, Indonesia, the Philippines, and Malaysia recorded the highest number of COVID-19 infections, while Vietnam, Laos, Cambodia, and Brunei reported comparatively lower infection rates. In response to the early and widespread impact of COVID-19 in the region, Southeast Asian countries took steps to strengthen collaboration and coordination. Regional networks such as the ASEAN Centre for Public Health Emergencies and Emerging Diseases have been established to promote regional cooperation in virology research (https://jaif.asean.org/whats-new/asean-center-for-public-health-emergencies-and-emerging-diseases-acpheed/) and combat outbreaks through surveillance and communication.

This scoping review aims to collate, identify, and synthesize various outbreak preparedness and response strategies in 10 ASEAN member countries. The goal is to highlight successful, effective, and well-coordinated multi-sectoral strategies and policy responses, which are pivotal elements in addressing pandemic preparedness plans. Simultaneously, to avoid and prevent future setbacks, it is paramount to learn from weaknesses in certain initiatives and programs.

Methodology

Protocol and registration

The protocol of this scoping review was registered at the Open Science Framework (https://doi.org/10.17605/OSF.IO/N2CYJ) and PROSPERO (CRD42022307961).

Eligibility criteria

Articles reporting outbreak preparedness strategies in 10 ASEAN member countries (i.e., Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) from the year 2001 to 2022 were included. Those covering multiple countries beyond ASEAN were included if information for ASEAN countries could be extracted separately. Diseases covered in this review include H1N1 influenza, H5N1 influenza, SARS, the Middle East respiratory syndrome (MERS), COVID-19, dengue, malaria, and Nipah. Qualitative studies (such as interviews and document analyses) and quantitative surveys were included. Studies using a randomized controlled trial design were excluded, as they focused on specific interventions rather than nationwide outbreak response strategies. Articles before 2002 were excluded to focus on outbreak preparedness strategies in the past 20 years. Non-English articles were also excluded.

Information sources and search

Four databases (PubMed, CINAHL, Web of Science, and Scopus) were used to identify articles. The search strategy is available in Supplementary File 1. Additionally, the references of included articles were also screened for additional relevance.

Selection of sources of evidence

All references identified from the four databases were imported into Rayyan (https://www.rayyan.ai/). Each article was independently assessed by two researchers on the basis of the title and abstract. The team then met to discuss any discrepancies and agree on which articles required full-text review. Subsequently, the full texts of each retrieved article were independently assessed by another two researchers. Finally, the team convened to reach a consensus on the final articles to be included in the review.

Data extraction and charting

The research team developed a data extraction form and piloted it with 10 studies. The form includes study objectives, diseases covered, methods used, and implemented outbreak preparedness strategies.

Results

A total of 4522 records were identified from the databases and screened on the basis of titles and abstracts. Out of those, 229 full texts were retrieved, and eventually, 34 articles were included in this review. No additional articles were identified from websites and citation searching (Figure 1).

General description of included studies

Out of the 34 articles included in the analysis from the ASEAN countries, Singapore and Vietnam had the highest number of publications, each accounting for 35.3% (12 articles). Brunei had the lowest number of articles published, at 2% (one article). The publications covered several outbreak-prone diseases with various modes of transmission, including airborne, vector-borne, and zoonotic diseases. Among the airborne diseases, COVID-19 (35.3%), avian influenza (H5N1) (26.5%), SARS (14.7%), and pandemic influenza A (H1N1) (11.8%) were the most reported diseases. MERS accounted for 2.9% of the publications. Vector-borne diseases such as malaria, Nipah, Chikungunya fever, and Zika fever had the fewest publications, each at 2.9%. Interestingly, preparedness for Ebola virus disease, which is not endemic to ASEAN countries, was reported in 5.9% of the articles (Figure 2).

Best practices and outbreak preparedness/response strategies among the ASEAN member countries

Countries in the ASEAN region have developed and adopted diverse strategies to mitigate pandemic-prone diseases both within and beyond their territories. One effective tool in combating infectious disease threats is the publication and dissemination of national preparedness plans that are made available to health care personnel and the public. These plans are aimed at addressing specific and emerging threats. This scoping review identified four key pillars and associated best practices for mitigating disease outbreaks applied in the ASEAN region: governance and stewardship, disease detection, disease prevention, and health care management, all of which were crucial in pandemic preparedness and response (Table 1). While most countries prioritized specific needs and challenges, such as endemic and emerging infectious diseases such as dengue, Nipah, Chikungunya, Ebola, and malaria, pandemic-prone diseases such as COVID-19, influenza (H1N1 and H5N1), MERS, and SARS remain shared concerns in the region (Table 1).

Pillar 1 – Governance and stewardship

The governance and stewardship framework emphasized the importance of political will, leadership, and effective management of national outbreak preparedness plans in each ASEAN country (Table 1). Five best practices were identified for this pillar: surveillance and planning, multi-sectoral/organizational collaboration, capacity strengthening, resource mobilization, and financing and effective/intentional communication (Supplementary File 2). A high level of political will and commitment was critical for the effectiveness of this pillar. Comprehensive national preparedness plans were essential in driving strategies for outbreak preparedness across various diseases, including avian and human influenza (AHI), Ebola, dengue, COVID-19, and other emerging diseases (Table 1). All countries had national preparedness frameworks tailored to the specific public health risks of each nation, enhancing coordination and resource allocations during outbreaks [4,7,8,25]. Regional and

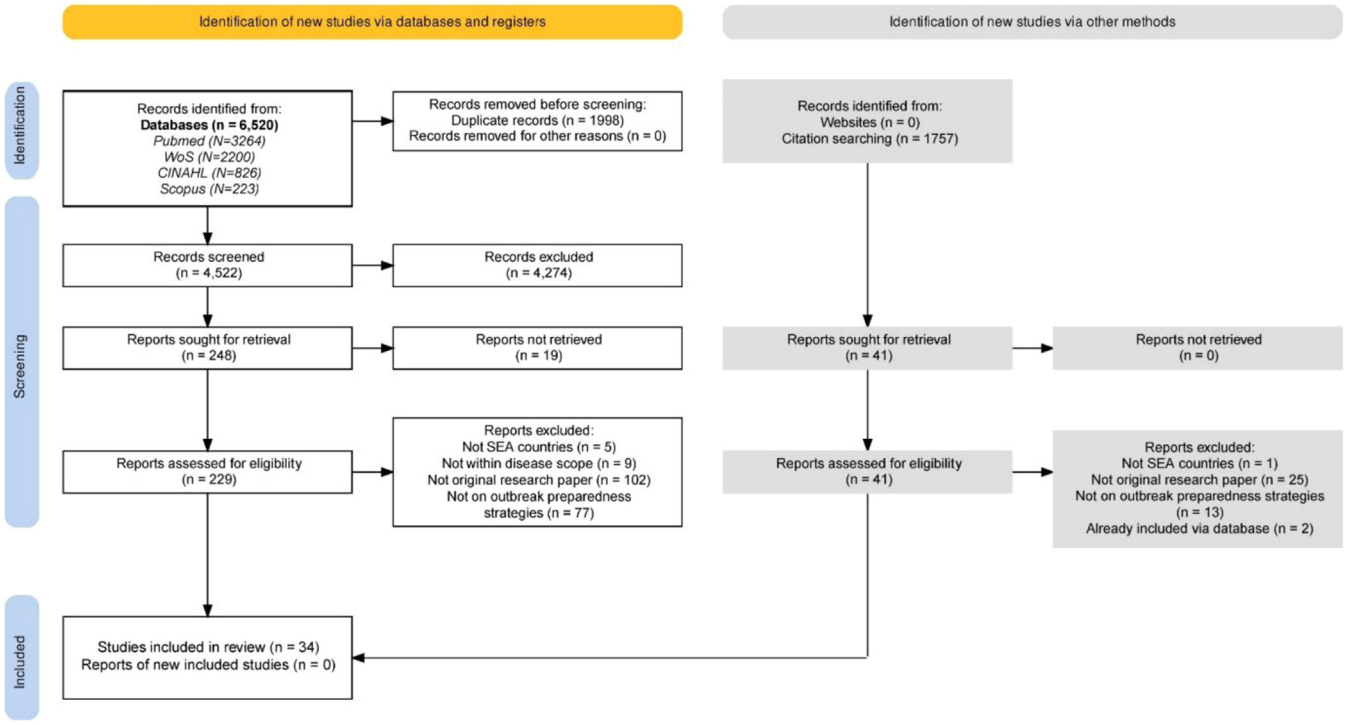

Figure 1. PRISMA flow diagram describing the selection of studies for this review.
PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SEA, Southeast Asian; WoS, Web of Science.

international collaborations were also sought to strengthen pandemic preparedness and response [4]. Multi-sectoral approaches, including interdepartmental, multi-ministry, and multi-agency collaboration, supported coordination and control efforts for outbreak diseases [4,7,8,13–17]. Pandemic preparedness committees were led by high-level country leadership and/or their representatives in all countries, with specialized coordination units established in some, including Indonesia, Thailand, Malaysia, and Laos [5,7,10]. While decisions and priority setting for preparedness and response were centrally managed (e.g., in Thailand), local authorities played crucial roles in countries such as Indonesia, the Philippines, and Vietnam [5,13]. In Thailand, pandemic preparedness is integrated into disaster preparedness and mitigation and is framed within the national disaster response plan [5]. Besides strong leadership, financing significantly influenced the level of preparedness and response. Discretionary budgets were allocated for local-level administration, such as during the AHI pandemic in Indonesia, Thailand, and Vietnam. However, this posed a challenge for Cambodia and Laos, where funding depended on external sources [5]. A network of public and private health care facilities was reported in all countries, despite varying health care systems, which were dependent on financial resources. Access to health care was improved with the availability of health insurance, with Thailand achieving universal health coverage, while Indonesia and Vietnam had multiple health care schemes, and social security schemes were still being developed for Laos [5]. Collaboration between different sectors was reported in most countries during various disease outbreaks, including intersectoral cooperation, which was notably applied in Malaysia during dengue outbreaks [7].

Pillar 2 – Disease detection

Disease detection strategies, focusing on enhancing laboratory capacity and surveillance efforts, were reported in all countries except Brunei (Table 1). Four best practices were identified for disease detection: case detection through focused surveillance, alert/early warning systems, data sharing, local and cross-border networking, outsourcing services, and sustained response and mitigation (Supplementary File 2). For avian influenza, surveillance networks and cooperation between countries were crucial for disease detection. National and sub-regional surveillance was important for the Mekong region, with a surveillance network coordinated through the Mekong Basin Disease Surveillance network (MBDS) in Cambodia, Laos, Thailand, and Vietnam [4,5]. Surveillance and rapid containment strategies for poultry were used for AHI in Cambodia, Laos, Thailand, and Vietnam [4]. Integrated surveillance systems combining clinical and entomological data tracking were used to monitor dengue cases and predict outbreaks through the Early Warning Outbreak Recognition System (EWORS), which was also used to detect leptospirosis [28]. Community-based surveillance networks were used for the detection of AHI (MBDS) in Laos, Myanmar, Thailand, and Vietnam [5,6]. Similarly, robust surveillance systems and enhanced laboratory capabilities were implemented, including the development of a molecular detection technique for Ebola virus disease in Indonesia [8,28]. Strong malaria surveillance systems enabled outbreak response in Malaysia and the Philippines, while Singapore increased monitoring and reporting of dengue cases, including setting up hotlines to handle and investigate mosquito breeding and dengue fever reports [12,16]. Singapore also placed substantial emphasis on using technology for infection control and e-health to detect disease patterns for SARS and facilitate early intervention [20–22]. For the detection of AHI, Thailand established the Field Epidemiology Training Program (FETP), FETP for Veterinarians (FETPV), and FETP for Wildlife Veterinarians to strengthen early detection and response to outbreaks [25]. Vietnam aimed to bolster disease detection by improving surveillance strategies and response capacity, while Cambodia and Laos implemented sentinel surveillance systems and regional surveillance plans (e.g., international data sharing through the MBDS) [4–6] (Table 1).

Pillar 3 – Disease prevention

Community involvement was a key strategy for disease prevention in all ASEAN countries (Table 1). Disease prevention was achieved through

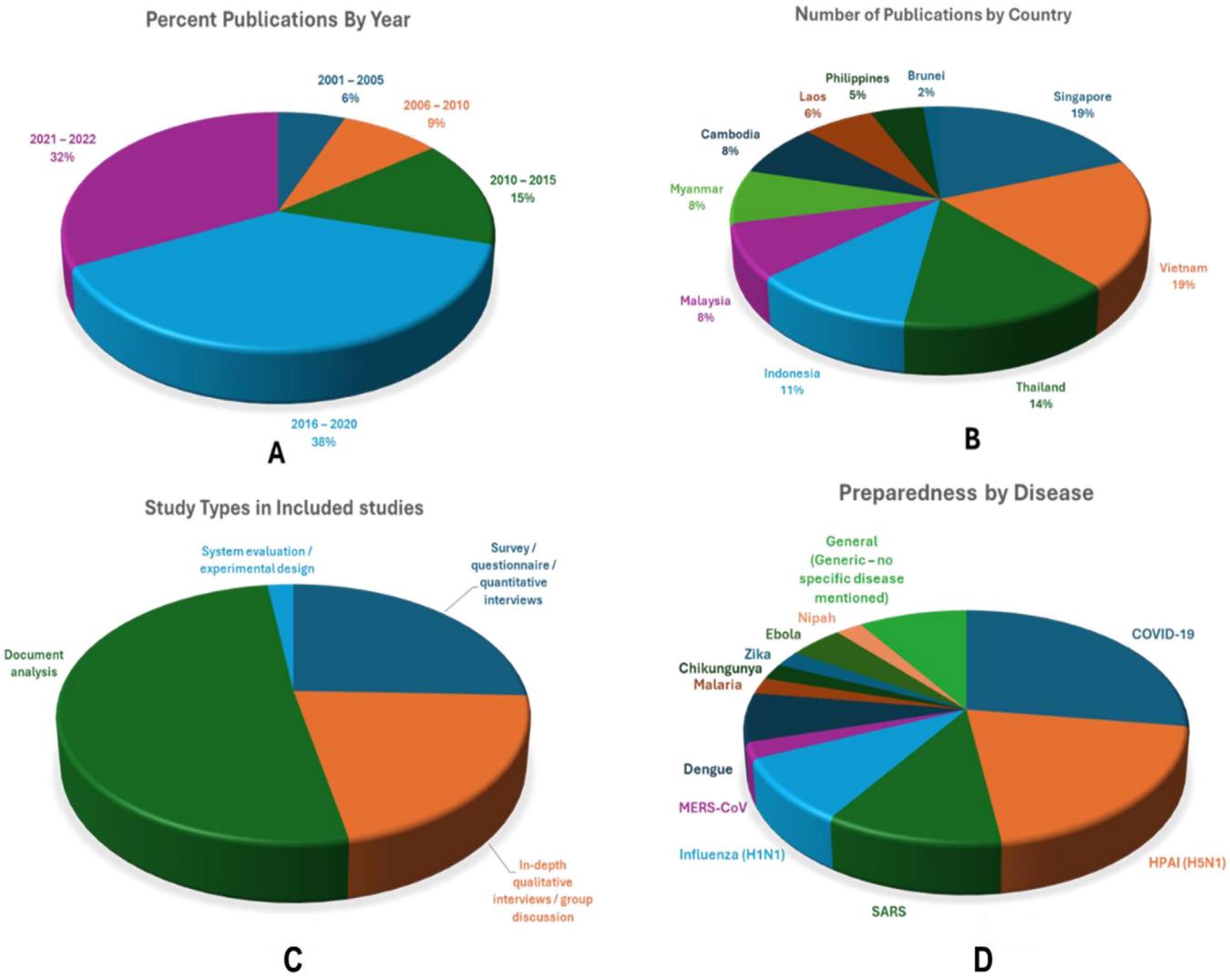

Figure 2. Characteristics of the included studies. Number of studies included in the review by (a) publication year; (b) country; (c) study type; (d) disease type. HPAI, highly pathogenic avian influenza; MERS-CoV, Middle East respiratory syndrome coronavirus; SARS, severe acute respiratory syndrome.

six best practices: vaccination and preventive therapy, confirmation of test results, case management and vector control, border control and travel restrictions, risk communication and community involvement, and innovation (Supplementary File 2). Poultry vaccinations were introduced to prevent AHI in Indonesia and Vietnam, while research toward developing pandemic vaccine production capacity was the focus in Indonesia, Thailand, and Vietnam [5]. Stockpiling of personal protective equipment and antiviral drugs were part of disease preparedness and prevention plans for AHI in Indonesia and Thailand [5]. Active collaboration between animal and human health sectors to conduct disease surveillance and prevent the spread of AHI was a focus of Indonesia, Thailand, and Vietnam [5]. Simulation exercises conducted by WHO and MBDS for prevention of AHI in Cambodia, Indonesia, Laos, Thailand, and Vietnam aimed to enhance disease prevention, with improvements in public communication (health education) in Cambodia [4,5]. Indonesia invested in strengthening laboratory investigations to prepare for pandemics, including surveillance and rapid containment of laboratory samples with influenza-like symptoms. Additionally, the country focused on active public engagement through education about disease prevention and the importance of early detection of AHI [4,5]. Stockpiling of antiviral drugs for human influenza and implementation of preventive vaccination, including simulation exercises for AHI and pandemic preparedness, were part of the disease prevention best practices for Indonesia [4,10,11]. In Malaysia, improved surveillance and early outbreak detection were implemented through electronic reporting, laboratory networking, information exchange, and standardized data collection, processing, and feedback for dengue and malaria [7,12]. Similarly, successful vector control for the prevention of dengue was reported in Indonesia, while integrated vector management with active community participation was implemented for malaria and dengue in Malaysia, the Philippines, and Vietnam [7,9,10,12]. In the Philippines, insecticide resistance was monitored, and active community participation in vector control activities, particularly indoor residual spraying, was reported [12]. Extensive Ebola awareness campaigns, including at airports, and information sharing with at-risk travelers were conducted in Indonesia, Myanmar, and Thailand [8]. Singapore conducted extensive community campaigns for dengue awareness and prevention, involving communities, government agencies, and organization in comprehensive efforts to search for and destroy mosquito breeding grounds to prevent the spread of dengue [16]. For the prevention of Zika, social media was used to raise awareness, share information, and monitor social conversations in real time [24]. During the SARS outbreak, electronic wristbands were used to enforce quarantine, and tracking within hospitals was implemented to monitor and control the outbreak [20]. Temperature checks were also conducted before entering buildings [20,22,23].

Table 1
Summary of the best practices in outbreak preparedness among ASEAN countries.

Country	Outbreak response pillars			
	Governance and stewardship	Disease detection	Disease prevention	Health care management
Brunei			*COVID-19:* • Implemented social distancing and has successfully controlled the pandemic during the early phase of outbreak [3].	
Cambodia	*Avian and human influenza:* • Integrated pandemic preparedness within its national disaster response framework, enhancing coordination and resource allocation during outbreaks [4]. • Developed both national pandemic preparedness and AHI response plans, which were part of a broader strategy for disaster preparedness [4].	*COVID-19:* • Implemented rapid tests [3]. *Avian and human influenza:* • Active cooperation through the surveillance network in the Mekong basin through the MBDS [4]. • Strengthening surveillance and rapid containment strategies for poultry-related transmission of AHI [4]. • Strengthened health system functions specifically regarding laboratory capacity [4]. *Sub-regional disease surveillance:* • Active cooperation through the surveillance network in the Mekong basin through the MBDS [5,6]. • Integrated an event-based reporting tool into the MBDS electronic reporting system, which enables community participation in notifying unusual occurrences and improves the timeliness of data reporting [5,6].	*COVID-19:* • Implemented social distancing and has successfully controlled the pandemic during the early phase of outbreak [3]. *Avian and human influenza:* • Improvement in public communication strategies (e.g., health education) to disseminate information and guidelines effectively during outbreaks [4]. • Conducted simulation exercises for AHI and pandemic preparedness [4].	
Indonesia	*Avian and human influenza:* • Developed comprehensive national preparedness plans for dealing with pandemic influenza and other infectious diseases [4]. *Dengue:* • Leadership and better inter-sectoral cooperation in outbreak response [7]. • Formed special dengue units for enhanced dengue clinical management [7]. *Ebola:* • Developed a specific, written Ebola virus disease preparedness plan, disseminated via the Ministry of Health website [8]. • Had a mechanism for releasing funds for potential Ebola virus disease importation or outbreak [8]. • Incident management structure with defined roles and responsibilities was detailed in the Ebola preparedness plans [8]. • Integrated rapid response teams into public health event responses [8].	*COVID-19:* • Implemented rapid tests for limited and targeted people [3]. *Avian and human influenza:* • Implemented robust surveillance systems and enhanced laboratory capabilities to detect and monitor disease outbreaks, which played a crucial role in the early identification and containment of cases [4,9]. *Dengue:* • Implemented integrated surveillance systems that combine clinical and entomological data to track dengue cases and predict outbreaks [7]. • Adopted the electronic syndromic surveillance system, Early Warning Outbreak Recognition System (EWORS), which detected a large dengue hemorrhagic fever outbreak in 2003 [13]. Leptospirosis: • EWORS detected a leptospirosis outbreak (a combination of fever and jaundice) in Jakarta in 2006 [13]. *Ebola:* • Had a functional biosafety level 3 facility and could rapidly upgrade to biosafety level 2+ [14]. • Developed a molecular technique for Ebola virus disease diagnosis and identified suspected cases in the past year [8].	*COVID-19:* • Enforced mass movement restrictions and social distancing protocols under the larger-scale social distancing policy, Pembatasan Sosial Berskala Besar [3]. *Avian and human influenza:* • Actively engaged in public communication and awareness campaigns to inform and educate the public about preventive measures and the importance of early detection and treatment [4]. • Conducted simulation exercises for AHI and pandemic preparedness [4]. • Implemented preventive vaccination of poultry [10,11]. • Practiced stockpiling of antiviral drugs for humans [10]. *Dengue:* • Successful vector control interventions [7]. *Ebola:* • High capacity for public awareness and social mobilization about Ebola virus disease [8]. • High awareness at airports and had functional mechanisms for sharing information about at-risk travelers [8].	*Ebola:* • Designated at least one national reference hospital for managing Ebola virus disease [8]. • Conducted extensive training within hospitals using a cascade training approach or mobile training teams [8]. • Demonstrated operational readiness to isolate and manage suspected or confirmed Ebola cases with prepared isolation rooms, trained staff, necessary supplies, and systems for clinical and human waste management [8].

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Table 1 (*continued*)

Country	Outbreak response pillars			
	Governance and stewardship	Disease detection	Disease prevention	Health care management
Laos	*Avian and human influenza:* • Engaged in regional and international collaborations to enhance pandemic preparedness and response capabilities [4].	*COVID-19:* • Implemented rapid tests [3]. *Avian and human influenza:* • Strengthened surveillance systems for rapid detection and response to outbreaks, including establishing community-based surveillance networks (e.g., MBDS) [4]. *Sub-regional disease surveillance:* • Active cooperation through the surveillance network in the Mekong basin through the MBDS [5,6].	*COVID-19:* • Implemented social distancing and has successfully controlled the pandemic during the early phase of outbreak [3]. *Avian and human influenza:* • Conducted simulation exercises for AHI and pandemic preparedness [4].	
Malaysia	*Dengue:* • Leadership and better inter-sectoral cooperation in outbreak response [7]. • Formed special dengue units for enhanced dengue clinical management [7].	*Dengue:* • Improved surveillance (through electronic reporting [e-dengue], laboratory networks for mutual support and information exchange, standardized data collection, processing and feedback, strengthened monitoring and evaluation activities, enhanced capacity building) [7]. • Improved early outbreak detection (through the use of pre-tested alarm signals and a standardized outbreak definition) to initiate a staged outbreak response (initial, early, and late responses) applying pre-defined procedures [7]. *Malaria:* • Strong malaria surveillance systems that enable rapid response to outbreaks [12].	*COVID-19:* • Imposed national lockdown and has successfully controlled the pandemic during the early phase of outbreak [3]. *Dengue:* • Successful vector control interventions [7]. *Malaria:* • Used integrated vector management, combining various tools and strategies for effective vector control [12]. • Active participation of communities in vector control activities [12]. • Conducted bioassay and susceptibility tests to monitor insecticide resistance [12].	*Dengue:* • Improved clinical management (due to better clinical training and obligatory analysis of dengue deaths) [7]. • Coping strategies during dengue outbreak to manage the surge of patients (use of trolleys and foldable beds, transfer of staff from non-dengue wards when necessary, or staff had additional or prolonged shifts) [7].
Myanmar	*Ebola:* • Had a mechanism for releasing funds for potential Ebola virus disease importation or outbreak [8]. • Incident management structure with defined roles and responsibilities was detailed in the Ebola preparedness plans [8]. • Had an emergency operating center managed by the Ministry of Health's disaster management department [8]. • Integrated rapid response teams into public health event responses [8].	*COVID-19:* • Implemented rapid tests [3]. *Sub-regional disease surveillance:* • Strengthened surveillance systems for rapid detection and response to outbreaks, including establishing community-based surveillance networks (e.g., MBDS) [5,6]. *Seasonal influenza:* • Improved in surveillance system [9]. • Improved in laboratory testing capacity [9].	*COVID-19:* • Implemented social distancing and has successfully controlled the pandemic during the early phase of outbreak [3]. *Ebola:* • High capacity for public awareness and social mobilization about Ebola virus disease [8]. • High awareness at airports and had functional mechanisms for sharing information about at-risk travelers [8].	
Philippines	*COVID-19:* • Few special task forces, led by respective national government agencies, were formed during the COVID-19 outbreak to enforce government pandemic policies [13]. • Additional financial support was provided through the Bayanihan 2 Act, while Proclamation 1021 extended the state of calamity in the Philippines until September 2021 [13].	*COVID-19:* • Implemented rapid tests [3]. • Improved existing health information systems and introduced new ones to track COVID-19 cases [13]. • Efforts were made to integrate surveillance data from various sources, including hospitals, laboratories, and local government units [13]. • Adopted StaySafe.ph, an app led by academia and the private sector, as the official contact tracing app during the COVID-19 outbreak [13]. • Expansion of testing capacities was prioritized, with the establishment of numerous testing centers nationwide [13]. *Malaria:* • Strong malaria surveillance systems that enable rapid response to outbreaks [12].	*COVID-19:* • Implemented various versions of community lockdowns and travel bans, with varying stringency, from strict to lenient, during different phases of the COVID-19 pandemic [3,13]. • Isolation facilities were set up to manage confirmed and suspected cases, reducing the burden on hospitals [13]. • Initiated a mass vaccination campaign as vaccines became available, prioritizing health care workers, older adults, and vulnerable populations [13]. *Malaria:* • Used integrated vector management, combining various tools and strategies for effective vector control [12]. • Active participation of communities in vector control activities, particularly in indoor residual spraying campaigns [12]. • Conducted bioassay and susceptibility tests to monitor insecticide resistance [12].	

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Table 1 (*continued*)

Country	Outbreak response pillars			
	Governance and stewardship	Disease detection	Disease prevention	Health care management
Singapore	*COVID-19:* • Established an interdepartmental and cross-organizational working group preplanning system (Multi-Ministry Task Force) that can be swiftly activated in response to a public health crisis and operates in a whole-of-government manner [13–15]. • Ministry of Health was committed to covering all expenses for suspected or confirmed patients with COVID-19 [15]. *Dengue:* • Collaboration between various government agencies, including the Ministry of Health and the National Environment Agency, to coordinate dengue control efforts [16].	*COVID-19:* • Increased the laboratory capacity and conducted extensive testing to identify and isolate cases [14,15,17–19]. • Implemented strict surveillance and established robust contact tracing systems using technology, such as the TraceTogether app, to track potential exposure [14,15,17,18,20]. *Dengue:* • Increased monitoring and reporting of dengue cases to detect outbreaks early [16]. • Set up dengue hotlines to handle and investigate mosquito breeding and dengue fever reports [16]. *SARS:* • Emphasized the use of technology for infection control and e-health to detect patterns and intervene early [21]. • Adopted a wide-ranging definition for suspicious cases, which led to numerous individuals being quarantined or monitored via phone surveillance, regardless of whether they actually contracted SARS [20,22].	*COVID-19:* • Implemented strict local and community lockdown by instructing their people to work from home [3,15,17–19]. • Implemented stringent border control measures early on, including travel bans and mandatory quarantine for travelers [14,15,17,18]. • Enhanced screening procedures were implemented in airports and then extended to schools, workplaces, public buildings, and health care settings, including temperature checks and health declarations [14,15,17–19]. • Enforced strict quarantine protocols for confirmed cases and close contacts [14,15,17–19]. • Shared precise and up-to-date information on COVID-19 with the public through mass media and digital platforms [19]. • Rolled out SafeEntry, a national digital check-in system that recorded individuals' identification numbers and contact details whenever they visited public places such as malls, schools, and public transport [21]. *Dengue:* • Involvement of community groups and organizations in dengue prevention efforts to ensure local participation and support [16]. • Increased cleaning frequency of open roadside drains and applied larvicides in hard-to-reach areas [16]. • Enhanced inspection regime for scupper drains and public drains to prevent water stagnation [16]. • Application of larvicides to treat water sources that cannot be emptied [16]. • Conducted extensive campaigns to raise awareness about dengue prevention, including the importance of eliminating mosquito breeding sites and using repellents [16]. • Conducted a comprehensive search and destruction of mosquito breeding grounds with the help of volunteers and government agencies—"carpet combing" exercise [16]. *SARS:* • Used electronic wristbands to enforce quarantines and radio-frequency identification tracking within hospitals to monitor and control the outbreak [20]. • People had to have their temperature taken before entering public buildings and offices, and thermal scanners were introduced later [20,22]. • Enforced travel bans, thermal screening, and health declarations at the entries (including airport and ferry terminals) [22,23]. *Zika:* • Used social media (i.e., Facebook) to raise public awareness and share information about Zika and to monitor social conversations in real time [24].	*COVID-19:* • Ensured the health care system (hospital facilities, availability of intensive care unit beds, ventilators, medical staff, and personal protective equipment) was equipped to handle a surge in cases, including increasing hospital capacity and securing medical supplies [14,17,19]. • Used dedicated facilities for isolation to prevent the spread within the community [14,15,17,18]. • Activated a network of more than 800 Public Health Preparedness Clinics (PHPCs) to prevent the overburdening of hospitals [15,17,18]. *SARS:* • Focused on hiring additional infectious disease (ID) staff and training them in infection control activities [21]. • Planned for a dedicated ID hospital equipped with necessary capabilities and improved the capabilities of "sister" institutions [21].

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Table 1 (*continued*)

Country	Outbreak response pillars			
	Governance and stewardship	Disease detection	Disease prevention	Health care management
Thailand	*Avian and human influenza:* • Integrated pandemic preparedness into their national disaster response framework [4]. • Endorsed the National Strategic Plan for Emerging Infectious Diseases (2013-2016), incorporating One Health as a core principle and involved collaboration among multi-disciplinary professionals, including those trained in FETP [25]. • Collaboration between national actors and international development partners facilitated the adoption of One Health to improve containment of emerging infectious diseases [25]. • The Thailand One Health Network, endorsed by the One Health Declaration in 2011, was established to coordinate authorities within Thailand and support regional efforts [25]. *Ebola:* • Developed a specific, written Ebola virus disease preparedness plan, disseminated via the Ministry of Health website [8]. • Had a mechanism for releasing funds for potential Ebola virus disease importation or outbreak [8]. • Incident management structure with defined roles and responsibilities was detailed in the Ebola preparedness plans [8]. • Had an emergency operating center managed by the Ministry of Health's disaster management department [8]. • Integrated rapid response teams into public health event responses [8]. • Developed a cost-effective training approach, with extensive training at the central level and instructions to the sub-national level [8].	*COVID-19:* • Implemented rapid tests [3]. *Avian and human influenza:* • Engaged in international cooperation for technical assistance and resource sharing through the MBDS network [4]. • Implemented extensive surveillance systems for early detection of outbreaks [4,9]. • Programs such as the FETP, FETP for Veterinarians (FETPV), and FETP for Wildlife Veterinarians were established to strengthen early detection and response to outbreaks [25]. • In 2012, a project proposed by FETP and its allies (FAO, USAID, US-CDC, and THOHUN) was launched and aimed to strengthen One Health epidemiological teams at the provincial and district levels, involving participants from various health sectors and engaged in field projects [25]. *Sub-regional disease surveillance:* • Strengthened surveillance systems for rapid detection and response to outbreaks, including establishing community-based surveillance networks (e.g., MBDS) [6]. *Ebola:* • Fully satisfied the effectiveness criteria of an early warning system and capacity to identify potential incubating travelers for medical follow-up [8]. • Had a functional biosafety level 3 facility and could rapidly upgrade to biosafety level 2+ [14]. • Developed a molecular technique for Ebola virus disease diagnosis and identified suspected cases in the past year [8].	*COVID-19:* • Implemented local lockdown and have successfully reduced the number of COVID-19 cases [3]. *Avian and human influenza:* • Conducted simulation exercises for AHI and pandemic preparedness [4]. • Antiviral stockpiling for humans [10]. *Ebola:* • Extensive campaigns for raising public awareness and social mobilization regarding Ebola virus disease [8]. • High awareness at airports and had functional mechanisms for sharing information about at-risk travelers [8].	*Ebola:* • Introduced a system of bonuses or hazard pay for health and non-health professionals in high-risk assignments, or compensation in case of infection or death [8]. • Designated at least one national reference hospital for managing Ebola virus disease [8]. • Conducted extensive training within hospitals using a cascade training approach or mobile training teams [8]. • Demonstrated operational readiness to isolate and manage suspected or confirmed Ebola cases with prepared isolation rooms, trained staff, necessary supplies, and systems for clinical and human waste management [8].
Vietnam	*Avian and human influenza:* • Established rapid response teams to contain outbreaks swiftly [4]. *Dengue:* • Formed special dengue units for enhanced dengue clinical management [7]. *COVID-19:* • Government introduced multiple economic stimulus packages to revive the economy and support individuals, numerous businesses, household enterprises, and cooperatives struggling because of the COVID-19 pandemic [26]. • Ministry of Health formed a National Steering Committee along with 45 Rapid Response Teams for outbreak prevention and control [26]. • Rapid decisions were made to increase the production of medical equipment and halt the export of anti-COVID-19 drugs to strengthen the health system's capacity [26].	*COVID-19:* • Implemented rapid tests [3]. • Manufactured the virus detection test kits (reverse transcription–polymerase chain reaction and real-time reverse transcription–polymerase chain reaction) for COVID-19 testing [26]. • Enhanced laboratory capacity to conduct extensive testing [26]. *Avian and human influenza:* • Implemented extensive surveillance systems for early detection of outbreaks [4]. • Engaged in international cooperation for technical assistance and resource sharing through the MBDS network [4]. • Strengthened their laboratory investigation capacity to prepare for the potential pandemic [4]. *Sub-regional disease surveillance:* • Strengthened surveillance systems for rapid detection and response to outbreaks, including establishing community-based surveillance networks (e.g., MBDS) [5,6]. *Dengue:* • Developed a comprehensive dengue surveillance system with regular monitoring and reporting [7].	*COVID-19:* • Implemented nationwide strict social distancing and has successfully controlled the pandemic during the early phase of outbreak [3,26]. • Used automatic and sanitizer dispensers, mobile disinfection chambers, robots, and drones for disinfection during COVID-19 outbreak [27]. • Imposed border closure and travel bans during the early phase of COVID-19 [26]. • Imposed mandatory quarantine for all international arrivals [26]. • Established various communication channels (e.g., text messages, music videos and short films) to widely distribute information on COVID-19 prevention through mass media channels and social networks [26]. *Avian and human influenza:* • Conducted simulation exercises for AHI preparedness at national, provincial, and district level, and at airports and borders [4]. • Vaccination of poultry and antiviral stockpiling for humans [10]. *Dengue:* • Successful vector control interventions [7].	*COVID-19:* • Implemented rapid tests [3]. *Avian and human influenza:* • Had a plan for surge capacity of health care workers and hospitals (extra beds) during the pandemic [4]. • Mobilized health care systems and security forces to respond promptly [26]. • Launched online-based system for medical examination and treatment of COVID-19 infections [26]. *Dengue:* • Coping strategies during dengue outbreak to manage the surge of patients (two patients in one bed, staff had additional or prolonged shifts during the dengue outbreak) [7].

AHI, avian and human influenza; ASEAN, Association of Southeast Asian Nations; FAO, Food and Agriculture Organization; FETP, Field Epidemiology Training Program; MBDS, Mekong Basin Disease Surveillance network; SARS, severe acute respiratory syndrome; THOHUN, Thailand One Health University Network; USAID, United States Agency for International Development; US-CDC, United States Centers for Disease Control and Prevention.

Pillar 4 – Health care management

Countries in the ASEAN region varied in health care capabilities, with some possessing well-resourced systems, while others faced limitations (Table 1). Strengthened health systems and extensive training for health care personnel were key to managing health systems across all ASEAN countries (Supplementary File 2). Mobile training teams provided extensive training within hospitals, and a national reference hospital was designated for managing Ebola virus disease in Indonesia, equipped with isolation rooms, trained staff, necessary supplies, and systems for clinical and human waste management [8]. Similarly, for Ebola preparedness, Thailand conducted extensive hospital training and introduced a system of bonuses or hazard pay for health and non-health staff in high-risk assignments, including compensation in case of infection [8]. In Malaysia, improved clinical training and obligatory analysis of dengue deaths, along with coping strategies during dengue outbreaks due to a surge of patients, were implemented [7]. In Vietnam, preparations were made for an increased capacity of health care workers in response to AHI and dengue [7].

Regional response to COVID-19 early-phase outbreak

Although the data were from publications during the early phase of the COVID-19 pandemic, the four key pillars and best strategies described earlier for various disease outbreaks were applied. The ASEAN nations joined forces to combat the COVID-19 pandemic through collaborative efforts. National senior officers convened in March and April 2020 to exchange insights on prevention, screening, and treatment strategies. The need for enhanced international cooperation to address health threats associated with COVID-19 was emphasized, seeking technical knowledge and financial support from experts in the United States, South Korea, Japan, and China.

ASEAN ministerial meetings addressed the economic challenges posed by the pandemic, focusing on efficiently managing the ASEAN market for trade and investment, bolstering regional coordination, and leveraging digital technologies, particularly for micro, small, and medium enterprises. Countries were urged to enhance resilience in supply chains through initiatives such as the Master Plan on ASEAN Connectivity (MPAC) 2025, aiming to fortify economic cooperation and withstand internal and external shocks. The ASEAN Foreign Ministers' meeting stressed the importance of avoiding actions that could lead to inflationary pressures or jeopardize food security, emphasizing the need to ensure the smooth flow of goods and services by overcoming non-tariff barriers and refraining from unnecessary measures [3].

National responses to COVID-19 early-phase outbreak

As each ASEAN member state confirmed its initial COVID-19 case, they swiftly implemented national prevention and control strategies to curb the outbreak. Rapid disease detection was implemented in all ASEAN countries. Disease prevention measures, including social distancing, successfully controlled the pandemic in its early phase in all countries. However, local lockdowns and enhanced screening procedures were implemented in schools, airports, buildings, and workplaces [14,15,17,18]. Work-from-home policies were adopted in most countries, and Singapore rolled out a digital check-in system to record individuals' contact details and location [20]. The Philippines improved existing health information systems and introduced new ones to track COVID-19 cases [13].

It was observed that the techniques for disease prevention applied in outbreaks before the pandemic were used and/or improved upon during the COVID-19 pandemic in the various ASEAN countries. Strict quarantine protocols were enforced, including travel bans, and stringent border controls, particularly in Singapore, with social distancing and lockdown measures implemented in all countries [3,14,15,17–19]. Mass vaccination campaigns were conducted in the Philippines, prioritizing health workers, older adults, and vulnerable populations as vaccines became available [13]. Movement restrictions and social distancing were crucial in the early phase of the pandemic and were enforced in all countries [3].

Singapore effectively contained the 2003 SARS outbreak through a "wide net" policy approach, identifying and quarantining suspicious cases to prevent the virus's spread. This approach, later deemed crucial, was also applied during the COVID-19 pandemic, with varying levels of strictness in quarantines based on infection risk. Contact tracing was aided by digital technologies, including contact tracing apps and a national digital check-in system at public locations, which facilitated targeted testing and hot spot identification. Additionally, electronic monitoring devices were used to ensure quarantine compliance [14–24].

Indonesia focused on mass testing and implemented social distancing measures, although challenges in testing capacity and health care infrastructure persisted [29]. The Philippines imposed strict lockdowns and travel restrictions while ramping up testing and contact tracing efforts [13]. Malaysia implemented Movement Control Orders and enhanced testing capabilities, coupled with strict enforcement of quarantine measures [3].

Vietnam swiftly implemented proactive measures, including border closures, extensive contact tracing, sanitization, and quarantine protocols, which helped keep infection rates relatively low [3]. The Vietnamese government also launched several economic stimulus packages to revive the economy and assist people, numerous enterprises, household businesses, and cooperatives facing difficulties due to the COVID-19 pandemic [27,30]. Cambodia and Laos implemented border closures and strict quarantine measures, while Brunei focused on early detection, contact tracing, and quarantine measures to prevent community transmission [3].

Thailand implemented strict border controls, mandatory quarantine for incoming travelers, and extensive testing and contact tracing efforts [3]. Myanmar faced challenges in health care infrastructure and access to testing but implemented public health campaigns and social distancing measures to curb the spread of the virus [3]. Overall, ASEAN countries used a combination of testing, contact tracing, quarantine measures, and public health campaigns to mitigate the impact of the COVID-19 pandemic (Table 1).

Discussion

Outbreak and response strategies: past experience and best practices in ASEAN countries

With experience from past disease outbreaks such as SARS, MERS, and other emerging infectious diseases, and given the proximity to various emerging and re-emerging infectious disease threats, ASEAN countries have developed strategies that have assisted in mitigating these threats. Singapore's experience with SARS, which led to prompt identification and isolation of cases, helped develop strategies that contributed to the successful management of COVID-19 [23]. All ASEAN countries demonstrated a high level of political will through their national influenza preparedness and response policies, although governance arrangements differed between countries [8,10,11]. Surveillance and rapid containment, including investments in health surveillance, laboratory capacity, monitoring, and evaluation, and public health communication were emphasized during the previous influenza, H5N1, and highly pathogenic avian influenza outbreaks, leading to strengthened capacities in these areas during the COVID-19 pandemic response. Thailand, which had registered cases of AHI, SARS, and MERS in the past, was able to build on its experiences to strengthen infection control systems and hospital preparedness and response plans, accelerate early detection and laboratory diagnosis, and establish effective isolation protocols [31,32]. Risk communication, information sharing, training of

Table 2
Summary of the challenges/limitations in outbreak preparedness among ASEAN countries.

Country	Challenges limitations
Brunei	NA
Cambodia	*Avian and human influenza:* • Limited availability of health facilities and a low density of hospital beds and health care workers, which hinder effective outbreak response [4]. • Reliance on out-of-pocket payments and external funding, leading to financial constraints in pandemic preparedness and response efforts [4]. • Limited access to health care services, with significant portions of the population using private sector providers, including drug stores and private clinics, as their first source of care [4]. • Variability in the implementation and operational procedures of pandemic preparedness plans, reflecting differences in governance structures and resource allocation at the central and local levels [4]. • Limited stockpiles of the antivirals due to low level of economic development [4]. • Simulation exercises focused only on early containment but not on pandemic preparedness in later phases [4]. • Had relatively low health system resource densities and were regionally underserved for antiviral drugs (specifically, oseltamivir), health workers, mechanical ventilators, and hospital beds [38]. • High levels of inequalities in health system resource distribution [38].
Indonesia	*Avian and human influenza:* • Limited financial and human resources posed significant challenges to the effective implementation of pandemic preparedness plans [4]. • Coordination between different levels of government and various health agencies was sometimes problematic, leading to delays and inefficiencies in response efforts [4]. • The health care infrastructure in some regions was inadequate for managing the surge in patients during outbreaks, highlighting the need for improvements in health care facilities [4]. • Sociocultural barriers: sociocultural factors, including public resistance to certain preventive measures and misconceptions about the diseases, hampered the effectiveness of response efforts. • Ensuring the sustainability of preparedness and response efforts, particularly during periods without immediate outbreaks, was a challenge [4]. • Simulation exercises focused only on early containment but not on pandemic preparedness in later phases [4]. *COVID-19:* • Lacked a robust early warning system to detect and respond to the initial spread of the virus, resulting in a delayed reaction to the outbreak [29]. • The government's non-transparent attitude due to incomplete and unintegrated data [29]. • There were gaps in communication and public information dissemination, resulting in confusion and mixed messages about preventive measures and health protocols among the public [29]. • Lack of sufficient testing capacity and infrastructure, which hampered the ability to accurately track and manage the spread of COVID-19 [29]. • Lack of coordination between various levels of government and health authorities, leading to inconsistent implementation of policies and regulations [29]. • There were issues with the allocation and distribution of resources, including financial aid and medical supplies, which affected the overall response to the pandemic [29]. • Health care system faced significant challenges due to insufficient medical supplies, equipment, and health care facilities to handle the surge in COVID-19 cases [29]. *Dengue:* • Faced challenges in coordinating efforts across different regions and levels of government [7]. • Limited financial and human resources for widespread mosquito control and public health interventions [7]. • Inconsistent data collection and reporting, which hampers the effectiveness of surveillance and response [7]. *HPAI:* • Low uptake of vaccination by farmers due to short production cycles in broiler farms and cost concerns [11]. • Efficacy of vaccines is variable, especially in broiler chickens, requiring multiple doses [11]. • Effective vaccination requires adequate biosecurity, which is lacking in small-scale farms [11]. • Small-scale and backyard farms (sectors 3 and 4) struggle with proper implementation [11]. • Enhanced collaboration between government, companies, and farmers is needed for effective HPAI mitigation [11]. *Ebola:* • Faced difficulties in releasing funds dedicated to preparedness activities [8]. • Insufficient focus on raising awareness about Ebola virus disease among clinicians [8]. • The hospitals had primarily developed a system for separating suspected Ebola virus disease patients from others, but triage procedures were poorly planned [8]. • There were gaps in risk communication, and support was requested for further strengthening of this [8].
Laos	*Avian and human influenza:* • Limited financial and human resources, which affect the overall capacity to respond effectively to pandemics [4]. • Inadequate health infrastructure, including insufficient numbers of health facilities and equipment, particularly in rural areas [4]. • Need for ongoing training and capacity building for health care workers to ensure preparedness and effective response during outbreaks [4]. • Challenges in coordinating and integrating efforts across different sectors and levels of government, which can hinder efficient response efforts [4]. • Simulation exercises focused only on early containment but not on pandemic preparedness in later phases [4]. • Had relatively low health system resource densities and were regionally underserved for antiviral drugs (specifically, oseltamivir), health workers, mechanical ventilators, and hospital beds [38]. • High levels of inequalities in health system resource distribution [38]. • Still used paper-based reporting systems in certain areas, which caused inconsistent and out-of-range date in reported data [5]. • Inconsistency in timeliness of report, response, and public communication for the outbreak [5].

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Table 2 (*continued*)

Country	Challenges limitations
Malaysia	*Dengue:* • Issues of routine vector surveillance and control: lack of community involvement and promotional activities, difficulty in interpretation of entomological indices [7]. *COVID-19:* • Fragmented health systems: fragmentation in health systems led to inconsistent responses and coordination challenges. Different regions and sectors often had varying protocols and resources, hindering a unified approach [40]. • Resource shortage: many health systems faced significant shortages of essential resources, including personal protective equipment, ventilators, intensive care unit beds, and health care personnel. This constrained the capacity to manage surges in COVID-19 cases [40]. • Inadequate public health infrastructure: gaps in public health infrastructure, particularly in low-resource settings, limited the ability to implement and sustain effective preventive measures, testing, and treatment [40]. • Inequities in health care access: socioeconomic disparities and inequities in health care access were highlighted and exacerbated by the pandemic. Vulnerable populations often faced greater barriers to receiving timely and adequate care [40]. • Data management issues: inefficient data management and lack of interoperability between health information systems impeded the accurate tracking of cases, resource allocation, and evidence-based decision-making [40]. • Preventive measure implementation: inconsistent implementation of preventive measures, such as quarantine, isolation, and social distancing, along with limited public adherence, affected the overall effectiveness of control efforts [40]. *Human influenza:* • Limited sentinel sites: the number of sentinel surveillance sites may not be sufficient to provide a comprehensive picture of influenza activity across the entire country. This limitation affects the representativeness of the data [39]. • Geographical gaps: some regions, particularly rural and remote areas, may not be adequately covered by the surveillance system, leading to potential under-reporting of influenza cases [39]. • Laboratory capacity: while there is a network of laboratories, resource constraints can limit their capacity to conduct widespread and timely testing during peak influenza seasons [39]. • Funding and staffing: inadequate funding and staffing can hinder the expansion and maintenance of the surveillance system, and the implementation of public health interventions [39]. • Data quality and timeliness: challenges in ensuring the quality and timeliness of data reporting from sentinel sites can impact the effectiveness of the surveillance system [39]. • Integration with other health data systems: there may be limitations in integrating influenza surveillance data with other health information systems, which can affect comprehensive analysis and response planning [39]. *Malaria:* • Difficulties in reaching remote areas and ensuring continuous supply of vector control tools [12].
Myanmar	*Avian and human influenza:* • Issues with completeness of data reported, leading to potential gaps in outbreak information [5]. • Inconsistency in timeliness of report, response, and public communication for the outbreak [5]. *Ebola:* • Faced difficulties in releasing funds dedicated to preparedness activities [8]. • No national system of immediate reporting; relied on sentinel public hospitals and tally sheets [8]. • The hospitals had primarily developed a system for separating suspected Ebola virus disease patients from others, but triage procedures were poorly planned [8]. • Had limited clinical expertise for managing Ebola virus disease cases [8]. • There were gaps in risk communication, and support was requested for further strengthening of this [8].
Philippines	*COVID-19:* • Lack of adequate preparation or financial assistance for poor communities, causing panic among residents [3]. • Inadequate health care infrastructure and limited medical supplies posed significant challenges [13]. • Health care workforce was overwhelmed, and there was a shortage of trained personnel for surveillance and contact tracing [13]. • Coordination among various government agencies and between national and local governments was often problematic, causing issues with the implementation and enforcement of quarantine measures [13]. *Malaria:* • Inconsistent use of larval control [12]. • Entomological surveillance was limited to semi-annual or annual monitoring in the sporadic and malaria-prone transmission provinces [12].
Singapore	*COVID-19:* • The use of contact tracing apps and other comprehensive measures that involve monitoring public movements through closed-circuit television (CCTV), bank, and phone data has raised privacy concerns [18]. *SARS:* • The outbreak led to economic concerns, especially due to travel bans and penalties against foreigners. The measures taken, although necessary, had significant social implications, creating both physical and mental barriers within the society [22].

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Table 2 (*continued*)

Country	Challenges limitations
Thailand	*Avian and human influenza:* • Need for better coordination among various health agencies and stakeholders [4]. • Insufficient number of trained health care professionals to manage large-scale outbreaks [4]. • Limited resources impacting the scale and scope of health interventions [4]. • Inadequate health care infrastructure to support widespread health emergencies [4]. • Simulation exercises focused only on early containment but not on pandemic preparedness in later phases [4]. • Inequitable distribution of health system resources across regions [38]. *Ebola:* • The hospitals had primarily developed a system for separating suspected Ebola virus disease patients from others, but triage procedures were poorly planned [8]. *HPAI:* • Inadequacy between initial disease control policies and specific poultry farming practices [41]. • Native chicken farmers prioritized the protection of valuable animals and sustained cockfighting activities, which contradicted HPAI control policies that were mainly aimed at eradicating infection through culling and restricting animal transport [41]. • There is a reluctance to report outbreaks to authorities due to fear of culling and loss of livelihoods. This can hinder effective surveillance and control measures [41]. • Distrust in government authorities and skepticism about the benefits of formal surveillance systems contribute to under-reporting and non-compliance with recommended practices [41]. • Chicken farmers' traditional knowledge and informal networks play a crucial role in disease surveillance. They often rely on their own observations and community advice rather than formal veterinary services [41].
Vietnam	*Avian and human influenza:* • Faced challenges with limited health care resources to address widespread health emergencies [4]. • Inadequate health care infrastructure to support extensive outbreak management [4]. • Difficulties in reaching and providing care to remote and rural populations [4]. • Limited funding for comprehensive outbreak preparedness and response activities [4]. • Simulation exercises focused only on early containment but not on pandemic preparedness in later phases [4]. • Inequitable distribution of health system resources across regions [38]. • Inconsistency in timeliness of report, response, and public communication for the outbreak [5]. • Limited engagement between public surveillance and local private entities [34]. • Did not release the correct poultry health and animal disease suspicion passive information to avoid market disturbance [37]. • Although marketplaces may be shut down in response to suspected avian influenza cases, marketing practices and networks might still function in a modified way, potentially contributing to the spread of the avian influenza virus [30]. *Dengue:* • Difficulties in coordinating responses between national and local authorities, particularly on the routine surveillance and control measures [7]. • No outbreak declarations were issued, which hampered the prediction and early detection of dengue outbreaks [7].

ASEAN, Association of Southeast Asian Nations; HPAI, highly pathogenic avian influenza; SARS, severe acute respiratory syndrome.

health workers, and collaboration between organizations were reported as key factors in managing infections [33]. Collaboration, networking, and risk communication were strengthened in the region during the COVID-19 pandemic. The existing platforms established from previous infectious disease outbreaks culminated in best practices summarized in the four pillars of governance and stewardship, disease detection, disease prevention, and health care management in ASEAN countries. Governance was crucial in management and financial support, ensuring that the health sector had the necessary resources to combat the diseases.

Lessons from ASEAN countries on detection and early response or containment of emerging infectious diseases

ASEAN member countries have strived to implement International Health Regulations (IHR) core capacities in their individual countries and the region. These include early detection of disease and culling infected birds during the H5N1 pandemic, which helped minimize the spread of the outbreak, although it led to the loss of flocks and income for affected communities. Addressing the social impact within the community was essential for achieving participation and adherence to disease prevention protocols, and for reporting infected or suspected cases [34–36]. Risk communication through various media channels, including television, radio, and social media platforms, ensured that communities received necessary up-to-date information on a mass scale. Similarly, assessing employee health risks and ensuring continuity of essential functions and infrastructure allowed for business continuity during the pandemic. The existence of national and sub-regional surveillance networks, including at ports of entry, ensured information sharing between countries, essential for combating zoonotic infections and providing early warning systems to health care personnel and the public within the respective countries and across borders [25,37].

Strengths, limitations, and the impact of previous outbreaks on COVID-19 preparedness and response

Variations in health care systems, economic strength, and health care infrastructure within the ASEAN region influenced the extent of preparedness and response that each country could achieve. Limitations in terms of the health care systems, infrastructure, and financial resources were reported for Cambodia [4,38], Laos [4,38], Myanmar [5,8], the Philippines [12,13], and Vietnam [4,5,7,38]. Inefficiencies due to challenges in coordination between various sectors and health agencies were reported in Indonesia [4], Thailand [4], and Malaysia [39]. The lack of a robust early warning system resulted in delays in response to the COVID-19 outbreak in Indonesia [29]. Similarly, fragmented health systems led to an inconsistent response in Malaysia [40]. The lack of community involvement affected routine vector surveillance and control for dengue, while geographical gaps, particularly in rural areas, led to under-reporting and data inconsistencies for Malaysia [39]. Privacy concerns were raised in Singapore given comprehensive measures that involved monitoring public movements through closed-circuit television (CCTV), bank, and phone data [18] (Table 2).

Some severe infectious disease outbreaks, including SARS (2003), H1N1 (2009), avian influenza, and MERS, affected ASEAN countries

before COVID-19. Consequently, when COVID-19 emerged, the ASEAN region adapted quickly to prevention measures relative to other parts of the world. ASEAN countries had experience in addressing threats from highly infectious respiratory infections and were preparing for similar threats from various pandemic-prone diseases within and outside the region [10,42]. Singapore's firsthand experience with SARS in 2003 was evident in its preparedness and response to COVID-19, leading to successful outcomes. Similarly, experiences with SARS, MERS, and AHI assisted in the response to COVID-19 in Thailand, Malaysia, the Philippines, and Vietnam in different ways. The effectiveness of the response in each country mirrored past respiratory disease outbreak responses, with infrastructure and policies established during prior outbreaks being applied and improved upon during the COVID-19 pandemic.

During the COVID-19 pandemic, ASEAN members took coordinated actions to respond to pandemic challenges, such as the Hanoi Plan of Action on Strengthening ASEAN Economic Cooperation and Supply Chain Connectivity in Response to the COVID-19 Pandemic. Members collaborated on the flow of essential goods and enhanced the resilience of supply chains and sourcing in the region. To support recovery and resilience building, ASEAN launched the COVID-19 ASEAN Response Fund and cooperated with external partners on the ASEAN Centre for Public Health Emergencies and Emerging Diseases to enhance regional health security and sustain ASEAN preparedness and resilience in the face of public health emergencies (weforum.org). Implementing control strategies and measures in ASEAN was successful because of these previous experiences, coordination, and collaboration [43,44]. This experience meant that channels of communication and risk management strategies were available and could be tailored to manage the COVID-19 pandemic response situation. ASEAN countries were united in fighting COVID-19, mounting coordinated efforts to respond to challenges.

Despite these positive outcomes, some limitations of this review include the limited number of publications from some countries, which could have affected the interpretation of the results. Because of heterogeneity in study design, articles were not assessed for quality. Additionally, the limited availability of articles from any of the ASEAN countries specifically targeting quality and/or effectiveness of the response in various countries meant that this information was not critically presented in this article.

Another key limitation of this review is that the COVID-19 articles reviewed primarily cover the early phase of the pandemic, focusing on the initial response strategies and interventions. However, the pandemic has evolved significantly since then, and many effective initiatives and strategies were likely implemented as researchers, public health experts, and clinicians gained a deeper understanding of the disease by 2021-2022. These later developments may not be fully captured in this review, as many studies and reports from this period were not yet published or accessible at the time of writing. Future research should aim to fill this gap by analyzing and documenting the lessons learned during the later stages of the pandemic, especially those that contributed to long-term resilience and improved pandemic response. This would provide a more comprehensive understanding of the strategies that were most effective in managing COVID-19 as the situation evolved. The four pillars outlined in this review and the associated best practices show how ASEAN countries are working toward building strong health systems. Each outbreak managed in the region provides lessons that can enhance and strengthen IHR core capacities not only in the region but across the globe.

Conclusion

This scoping review identified best practices and synthesized outbreak preparedness and response strategies across 10 ASEAN countries. The four pillars—governance and stewardship, disease detection, disease protection, and health care management—were crucial in successfully combating various infectious disease outbreaks. Regional networking, multi-sectoral collaboration, the planning and implementation of national preparedness and response strategies, and learning from past outbreaks have all contributed to improved preparedness and response strategies, as evidenced by the COVID-19 pandemic response. However, limited health care resources and infrastructure, financial constraints, and geographical and communication gaps remain challenges in several countries in the region. The studies included for COVID-19 were reported during the early phase of the pandemic and thus may not fully represent the response from the countries. Understanding the transmission dynamics of infectious diseases is essential for effective disease prevention, surveillance, and response efforts to prevent the next pandemic. Recent outbreaks of COVID-19, H5N1, SARS, MERS, and Zika underscore ASEAN's vulnerability to the emergence and re-emergence of infectious diseases. ASEAN member countries should capitalize on established regional networks.

Declarations of competing interest

The authors have no competing interest to declare.

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Author contributions

FMN conceived the review. All authors conducted the data extraction. FMN, NJY, and CHT undertook the data analysis. FMN and NJY drafted the manuscript. This version was edited, reviewed, and approved by all authors.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijregi.2024.100430.

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