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Comparing Viet Nam's national climate strategy's effectiveness in mitigating infectious diseases against other OECD countries in South-East Asia

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Climate change is the greatest threat to human health; however, climate change is also impacting the spread of infectious diseases causing contemporaneous burdens on health systems worldwide. The aim of this research was to assess whether Organisation for Economic Co-operation and Development (OECD) South-East Asia (SEA) countries national climate strategies were effective in mitigating infectious diseases impacted by climate change, using Viet Nam as a key case study. To conduct benchmarking between OECD SEA countries, data from the Institute for Health Metrics and Evaluation (IHME), the Climate Watch, and copies of each countries' climate strategy were analysed using a SMART analysis. Further analysis was done with IHME data to benchmark the prevalence infectious disease group per 100,000 by country and income group, and health expenditure per capita by infectious disease incidence per 100,000 and DALY per 100,000 across OECD SEA countries. This research found that Viet Nam is doing relatively well in addressing infectious diseases through climate change policy mitigation efforts, both individually and in comparison, to OECD SEA countries. Viet Nam was found to have the highest prevalence of respiratory diseases and tuberculosis in comparison to other OECD SEA countries but is ranked comparatively well when looking at overall infectious disease DALY's and incidence rates compared to OECD SEA neighbours. Viet Nam's climate strategy clarifies the need to develop the healthcare network and infrastructure required to effectively manage epidemics. Increased health expenditure per capita and greater implementation of One Health frameworks in government strategies are recommended to improve Viet Nam's ability to mitigate climate susceptible infectious diseases.

Viet Nam has made significant progress in the last 12 months regarding climate change commitments. In July 2022 Viet Nam's Prime Minister approved Decision 896, the National Strategy on Climate Change to 2050[1]. This strategy announces the Viet Nam governments' objectives of reaching net zero emissions by 2050 and mitigating losses and damages resulting from climate change[1]. Further commitments were made to combating climate change in June of 2023 with Viet Nam and Australia signing a $105 million package to support Viet Nam's decarbonisation efforts[2].

The effects of climate change in Viet Nam are well documented and these recent commitments are timely to support Viet Nam's efforts in containing the damage resulting from climate change, including those on the environment and human health. Viet Nam is one of the most vulnerable countries to climate change due to its climate and long coastline[3,4]. Between 1999 and 2019, Viet Nam ranked the 6th most vulnerable country to climate change according to the Global Climate Risk Index 2020[5]. Since 2017, new records for rainfall, maximum temperatures, and floods are continuing to be made[5]. Long-term mapping trends of rainfall and temperature have identified that the main agricultural production areas of Viet Nam are in climate 'hotspots' and will experience dramatic negative impacts on productivity. Communities will be placed at risk from landslides and vector- and water-borne diseases[6]. Furthermore, since over 70% of Viet Nam's population live coastally, they are at increased risks from rising sea levels and possible future internal displacement[7].

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In recent years major reports have addressed the health effects of climate change in Viet Nam. The first Vulnerability and Adaptation assessment was conducted in Viet Nam in 2020 and identified that Viet Nam is highly sensitive to the health effects of climate change[5]. Of note, in particular, is the increasing exposure to climate change related hazards, with the score increasing from 3·5 to 4·4 (out of 5·0) between 2013 and 2017[5]. With these trends forecast to progress, Viet Nam's exposure risk to climate change is expected to place an extremely large burden on the health sector[8]. Indeed, some of the extra burdens on the healthcare sector from climate change related health problems have already been documented. A 1 °C increase in temperatures over 24 °C in Viet Nam results in a 2·4% increased risk of same-day hospital admission for infectious diseases, and a 1·3% increased risk of same-day hospital admissions for respiratory infections[9]. In the Mekong-Delta region, paediatric hospital admissions are significantly correlated with annual flood patterns,[10] and rising temperatures are significantly correlated with hospitalisations of young children up to five years of age[11]. Climate change will also increase the burden of dengue fever, diarrhoeal disease, and respiratory infections in Viet Nam due more favourable conditions for mosquitoes, increased proliferation of pathogens in food and water sources, and increases in pollutants and allergens in the air[5,12,13]. Further, climate change is increasing the risk and frequency of zoonosis due to rising temperatures and changing land conditions, which has resulted in a resurgence of existing infectious diseases such as Monkeypox[14,15].

To combat the burden of infectious diseases in Viet Nam, the government introduced the Law on Prevention and Control of Infectious Diseases in 2007. The law governs the prevention of infectious diseases and has policies in place to support facilitating prevention and mitigation efforts[16]. However, neither the law nor Viet Nam's National Climate Change Strategy or the new $105 million decarbonisation package explicitly identify the need to focus on infectious disease risks that are increasing due to climate change.

Tackling health challenges by considering and addressing environmental, infectious, and zoonotic diseases, animal health, and public health aspects is key to a 'One Health' approach[17]. Whilst Viet Nam has separate policies and frameworks to address climate change,[1] animal health,[18] and human health,[19] an integrated and coordinated approach to One Health is less well developed. Across the Organisation for Economic Co-operation and Development (OECD) South-East Asia (SEA) region, it is evident that there is no consistent approach towards climate change mitigation and adaption plans, nor in tackling the impact climate change will have on infectious diseases. Countries are individually responsible for creating their climate change plans and priorities, and reporting on their Paris Agreement contributions and commitments, however, a lack of alignment between SEA region countries could prove counterproductive when issues, such as climate change and infectious disease control, are cross-national.

In this paper, we analyse how current national climate strategies support infectious disease mitigation efforts and compare Viet Nam's approach to other OECD SEA countries. Our aim was to identify future policy avenues and potential joint initiatives.

Methods

Data collection

In this study, we analysed the national climate change strategy for each country in the OECD SEA region[20]. We assessed and compared the potential for each countries' climate strategy to mitigate the impact of climate change on infectious diseases.

We downloaded each countries' climate strategy from a reputable source, such as the countries' government website or official climate reporting websites such as the United Nations Framework Convention on Climate Change (UNFCCC)[21]. Viet Nam's national climate change strategy is currently only available in Vietnamese at the time of analysis[22].

Each national climate change strategy was systematically analysed, and specific details were captured in a data collection form to ensure consistency of data. Details captured for comparison include country of strategy, title of strategy, strategy years effective, and mentions of disease. Key search terms to find mentions of disease in the climate strategies can be found in Table 3 in the "Appendix".

We chose key search terms in order to capture the infectious diseases that are most prevalent in the South-East Asia region,[23] and most likely to be used in a national climate change strategy. When searching key terms produced a result in a national climate change strategy, the exact paragraph of the report was captured, along with the corresponding section and page number. Additional information was also captured in the data collection form such as income group,[24] and whether the country was a signatory to the Paris Agreement[25].

A separate analysis of each countries' climate change strategy was conducted to identify the core priorities or targets of each country. The use of 'priorities' or 'targets' terminology depended on the structure or preference of term in each strategy, but the same fundamental information was captured. All priorities/targets were recorded in an Excel worksheet. We searched for the terms "disease", "health", "infectious", and "communicable" to ascertain whether any strategies alluded to the impact of climate change on infectious diseases as a core priority/target. If any priorities/targets matched a key search term, this was captured against the specific line item and recorded for future use.

To analyse the progress of each country in mitigating the effects of climate change in their respective countries and the contribution of each country towards the Paris Agreement commitments, specific data was collected from the Climate Watch website[26]. As signatories to the Paris Agreement, all countries included in this study report on their current and future emissions reductions efforts and implementation strategies[27]. We chose to incorporate this additional analysis of climate change efforts because significant progress in mitigating the effects of climate change has inherent benefits for the health of the country's population and will therefore be an indicator as to whether each country's climate change efforts are contributing towards mitigating infectious diseases. Data collected from the Climate Watch included whether each country had submitted their first nationally determined contribution (NDC) and a new or updated NDC, whether countries had a long-term

climate strategy and if so, what the long-term strategy was, whether county's NDC mentions loss and damage from climate change, and whether the NDC addresses Sustainable Development Goal (SDG) targets 3·3 and 3b. SDG targets 3·3 and 3b were specifically chosen as SDG 3·3 is specific to infectious diseases and SDG 3b concerns the research and development of medicines and vaccines for communicable diseases[28].

In order to compare whether the focus on infectious disease under each country's climate change strategy is aligned to the actual burden of infectious disease in each country, we collected data from the Institute for Health Metrics and Evaluation (IHME)[29]. Using the IHME Global Burden of Disease (GBD) Compare tool, each countries infectious disease burden was assessed by collecting the prevalence per 100,000, incidence per 100,000, and DALY per 100,000 for each infectious disease group. The search strategy used for the IHME GBD Compare tool is detailed in Table 4 in the "Appendix".

Data analysis

To display the general characteristics and standpoints of each country, we constructed Table 1 to compare each country's climate change strategies, and their commitments under the Paris Agreement, and under their NDC's. This table allowed for easy visualisation and comparison of the current contributions each country has made, the years effective for their commitments, and contributions towards SDGs 3·3 and 3b.

The SMART goal framework in Table 2 was used to compare more specific results in a uniform and measurable manner[30].

To create an overall score for each country, their score against each SMART element was calculated and averaged. Tables 5 and 6 in the "Appendix" explain how SMART categories were measured.

Microsoft Excel was used to capture and display the results in Figs. 1 and 2[31].

Results

This study included all countries classified as South-East Asian by the OECD[20]. Of the ten countries, 20% were high income countries (HICs), 20% were upper-middle income countries (UMICs), 50% were lower-middle income countries (LMICs), and one country is considered a low-income country (LICs)[24].

All countries are signatories of the Paris Agreement,[25] and all have national climate change plans in place, however the years effective for each plan differ. Four countries have climate strategies through to 2050, one is effective through to 2035, three are effective until 2030, and two have climate plans that expire before 2030.

All plans mentioned 'disease' at least once, with one country mentioning 'disease' only once, two countries mentioned 'disease' twice, one country mentioned 'disease' three times, three countries mentioned 'disease' four times, two countries mentioned 'disease' eight times, and one country mentioned 'disease' twelve times.

Three national climate change strategies referenced the impact of climate change on diseases in their priorities.

All countries have submitted an updated NDC to the UNFCCC, although only four countries have included long-term strategies as part of their NDC submission[27]. 70% of countries included references to the potential loss and damage from climate change. Countries NDC's were also analysed according to their acknowledgement of and address towards SDG 3·3 and 3b. 30% of countries address SDG 3·3 through their NDC, and 20% of countries address SDG 3b. However, only one country addressed both SDG 3·3 and 3b through their NDC.

Tables five and six in the Appendix detail how SMART categories were defined and measured. Majority of countries (60%) included in the study scored a rating of 'very good' for the specific category, whilst 30% of countries scored a rating of 'good', and only one country scored a rating of 'moderate' for specificity in infectious disease references. Half of all countries were rated 'poor' in this category for lack of performance indicator or metric, and the remaining 50% scored 'good' for including a metric or performance indicator in their national climate change strategies. Only 20% of countries included in the study achieved an attainable rating of 'very good', however half of the countries achieved a rating of 'good', and the remaining 30% of countries were rated 'poor' against the attainable target. Majority of countries (60%) achieved a rating of 'very good' in the relevant category, a further two countries achieved a rating of 'good', and the remaining two countries were rated 'moderate' for relevance. Lastly, four countries achieved a 'very good' rating for strategies that were effective to 2050, a further four countries achieved a rating of 'good', one country achieved a 'moderate' rating, and one country received a 'poor' rating. Each SMART category contributed to a countries overall SMART rating, as described in Table 6. The study was equally split for overall SMART score with 50% of countries achieving an overall rating of 'moderate' and the other half (50%) achieving an overall SMART rating of 'good'.

In comparing Tables 1 and 2, no correlation was found between income group and overall SMART rating. Of the two HIC's, one achieved an overall SMART rating of 'good' (Singapore) and the other was rated 'moderate' (Brunei Darussalam). Similarly, of the two UMIC's, one achieved an overall SMART rating of 'good' (Thailand) and the other was rated 'moderate' (Malaysia). Of the five LMIC's in the study, majority (30%) achieved a rating of 'good' (Myanmar, The Philippines, and Viet Nam), and the remaining two were rated 'moderate' (Indonesia and Lao PDR). Cambodia is the only LIC and was rated an overall SMART score of 'moderate'.

This study conducted an analysis of infectious disease group prevalence per 100,000 persons, with a comparison against the SEA average. IHME data collected is from 2019, therefore infectious disease rates are not impacted by Covid-19[29.] Majority of countries included in this study (90%) recorded the highest prevalence per 100,000 from the Respiratory Infections and TB infectious disease group. Notably, only HIC's and UMIC's were consistently below the SEA average prevalence per 100,000 for the Respiratory Infections and TB group, with Lao PDR as an outlier to this trend. The second most prevalent infectious disease group per 100,00 was a result of the NTD's and Malaria group for 50% of countries, whereas the other 50% of countries recorded the HIV/AIDs and STI's group as their second highest most prevalent infectious disease group per 100,000. Only HIC's and UMIC's were below the SEA average for NTD's and Malaria prevalence per 100,000. In comparison, HIC's were the only income group under the HIV/AIDs and STI's infectious disease group SEA average prevalence per 100,000. The UMIC group were all above the SEA average and 60% of LMIC's ($n = 3$) were below the SEA average. The Other

ASEAN country	Income group	Paris agreement	Name of plan	Years effective	# of disease mentions in climate plan	Do climate plan priorities mention disease	Revised NCD submitted	Long-term strategy submitted	Does the NDC mention loss and damage from climate change?	Addressing SDG target 3.3 through NCDs	Addressing SDG target 3b through NCDs
Brunei Darussalam	HIC	Y	Brunei Darussalam National Climate Change Policy	2020–2035	2	N	Y	Not Submitted	Y	N	Y
Cambodia	LIC	Y	Cambodia Climate Change Strategic Plan	2014–2023	3	Y	Y	Carbon neutrality by 2050	Y	Y	N
Indonesia	LMIC	Y	Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050	2021–2050	2	Y	Y	Reach 540 MtCO2e by 2050, with further exploration of "the opportunity to rapidly progress towards net-zero emissions in 2060."	N	N	N
Lao PDR	LMIC	Y	National Strategy on Climate Change of the Lao PDR	2021–2050	4	N	Y	Not Submitted	N	Y	N
Malaysia	UMIC	Y	Green Technology Master Plan Malaysia	2017–2030	1	N	Y	Not Submitted	Y	Y	Y
Myanmar	LMIC	Y	Myanmar Climate Change Strategy	2018–2030	9	N	Y	Not Submitted	Y	N	N
Singapore	HIC	Y	Singapore's National Climate Change Strategy	2008–2030	4	N	Y	Net-zero emissions by 2050 (per 2022 addendum)	N	N	N
The Philippines	LMIC	Y	National Climate Change Action Plan	2011–2028	8	Y	Y	Not Submitted	Y	N	N
Thailand	UMIC	Y	Climate Change Master Plan	2015–2050	12	N	Y	Carbon neutrality by 2050 and net-zero emissions by 2065	Y	N	N
Vietnam	LMIC	Y	National Climate Change Strategy	2023–2050	4	N	Y	Not Submitted	Y	N	N

Table 1. Country characteristics.

ASEAN country	Specific	Measurable	Attainable	Relevant	Time-bound	Overall score
Brunei Darussalam	Specifically mentions vector-borne diseases, causes to increases in vector-borne diseases, and has included performance indicators	Yes	2.39%	Surveillance: Y Prevention: N Treatment: N	To 2035	2.6
	Very Good	Good	Poor	Moderate	Good	Moderate
Cambodia	Recognises that women are more susceptible to diseases, and identifies capacity and infrastructure to respond to water and vector borne diseases	No	7.51%	Surveillance: Y Prevention: Y Treatment: N	Expired in 2023	2.4
	Good	Poor	Very Good	Good	Poor	Moderate
Indonesia	Uses climate estimates to analyse areas affected by vectors, and projects impacts of vector-borne diseases on GDP	Yes	3.41%	Surveillance: Y Prevention: N Treatment: N	To 2050	2.6
	Good	Good	Poor	Moderate	Very Good	Moderate
Lao PDR	Mentions Covid-19 and livestock diseases, generally mentions disease outbreaks and the need to tackle climate related disease outbreak including malaria, diarrhea, and sickness	No	2.69%	Surveillance: Y Prevention: Y Treatment: Y	To 2050	2.6
	Good	Poor	Poor	Very Good	Very Good	Moderate
Malaysia	Mentions improving lifestyle and emerging diseases as a goal	No	4.12%	Surveillance: Y Prevention: Y Treatment: Y	To 2030	2.6
	Moderate	Poor	Good	Very Good	Good	Moderate
Myanmar	Mentions loss of agriculture as a factor in disease spread, projects increased diarrhoeal diseases through contaminated water and skin disease from exposure to flood waters and a reduction in the development time for pathogens thereby increasing transmission rates from vectors. Notes what is needed to strengthen response	No	4.62%	Surveillance: Y Prevention: Y Treatment: Y	To 2030	3
	Very Good	Poor	Good	Very Good	Good	Good
Singapore	Notes that the country is in a region where communicable diseases are endemic. Notes possible resurgence of communicable diseases due to climate change. Identifies specific climate factors related to specific communicable diseases such as dengue	No	6.05%	Surveillance: Y Prevention: Y Treatment: N	To 2030	3
	Very Good	Poor	Very Good	Good	Good	Good
The Philippines	Estimated infrastructure costs of water-borne diseases. Notes services, activities, and departments for disease control. Has indicators for water-borne disease incidence	Yes	5.11%	Surveillance: Y Prevention: Y Treatment: Y	To 2028	3.2
	Very Good	Good	Good	Very Good	Moderate	Good
Thailand	Notes specific climate events and how they impact multiple infectious diseases. Has strategies and indicators for monitoring infectious diseases, including surveillance, research, public awareness, and health policies	Yes	4.36%	Surveillance: Y Prevention: Y Treatment: Y	To 2050	3.6
	Very Good	Good	Good	Very Good	Very Good	Good
Vietnam	Clarifies the need to develop a medical and healthcare network to meet the requirements of epidemic prevention and new diseases arising from climate change —including infectious disease metrics, investment and initiatives in highly impactful areas	Yes	4.68%	Surveillance: Y Prevention: Y Treatment: Y	To 2050	3.6
	Very Good	Good	Good	Very Good	Very Good	Good

Table 2. SMART comparison of countries.

Infectious Diseases group was the fourth most prevalent infectious disease group per 100,000 persons for 70% of countries included in the study, and the Enteric Infections group was the least prevalent infectious disease group per 100,000 for these countries. The remaining 30% of countries (Malaysia, The Philippines, and Thailand) recorded the Enteric Infections group as the fourth most prevalent infectious disease group per 100,000 and the Other Infectious Diseases group was the least prevalent infectious disease group per 100,000 for these countries. Only HIC's were below the SEA average prevalence per 100,000 for the Enteric Infections infectious disease group, however HIC's, UMIC's, and 40% of LMIC's ($n=2$; The Philippines and Viet Nam) were below the SEA average prevalence per 100,000 for the Other Infectious Diseases group. Overall, the country with the highest prevalence per 100,000 for the Respiratory Infections and TB group was Viet Nam. The country with the highest prevalence per 100,000 for the Enteric Infections group was Thailand. The country with the highest prevalence per 100,000 for the NTD's and Malaria group was Lao PDR. The country with the highest prevalence per 100,000 for the HIV/AIDS and STI's group was Thailand. The country with the highest prevalence per 100,000 for the Other Infectious Diseases group was Cambodia.

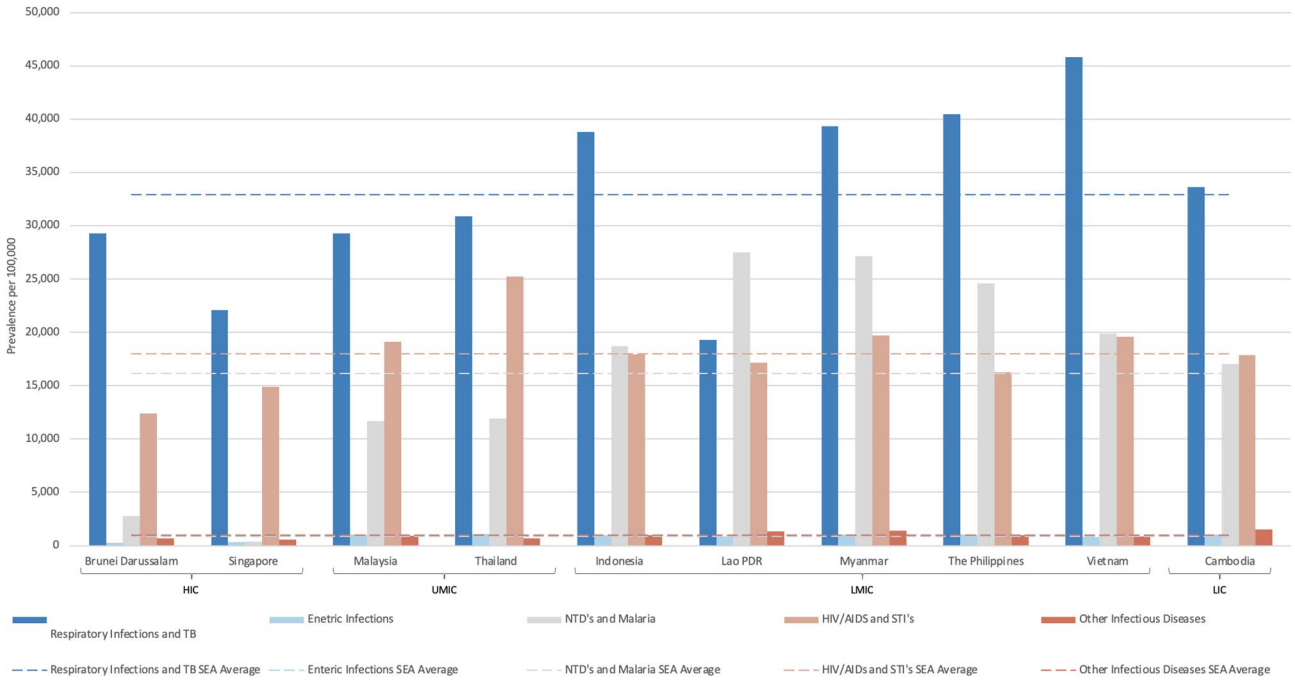

Fig. 1. Prevalence of Infectious Disease Group per 100,000 by country and income group, including SEA average trendlines (2019)[24,29].

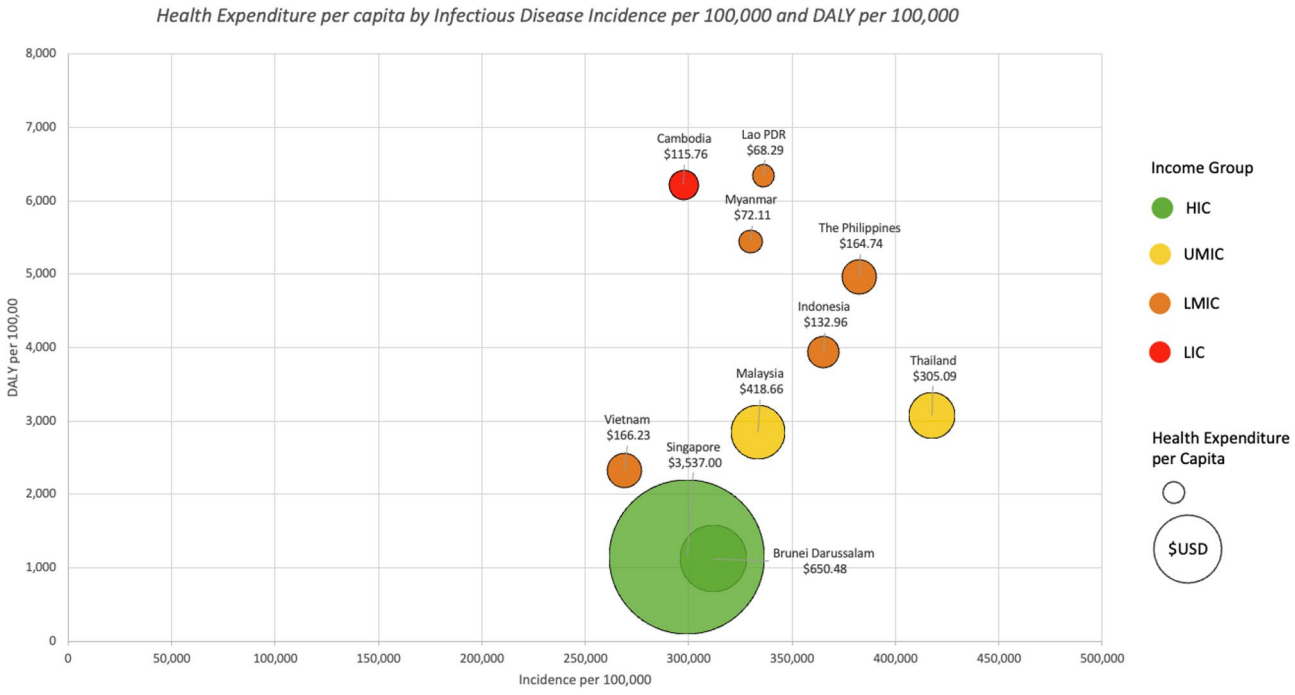

Fig. 2. Health Expenditure per capita by Infectious Disease Incidence per 100,000 and DALY per 100,000[32–34].

Singapore has approximately 52 times the dollar amount (USD) dedicated to health expenditure per capita than the country with the smallest health expenditure per capita (Lao PDR). Despite this, their incidence of infectious disease per 100,000 is relatively similar. However, Singapore has the lowest DALY per 100,000 for infectious diseases and Lao PDR has the highest DALY per 100,000 rate. Malaysia and Thailand have relatively similar health expenditures per capita and are also clustered in similar ranges for DALY per 100,000. Brunei Darussalam has the second highest contributions to health expenditure per capita and has the second lowest

DALY per 100,00 rate. Viet Nam and The Philippines have similar contributions to health expenditure per capita, however Viet Nam has more than half the DALY per 100,000 and a significantly lower incidence per 100,000 rate. Indonesia and Cambodia also have similar contributions to health expenditure per capita, however Cambodia's DALY per 100,000 rate is 50% higher than Indonesia's. Lao PDR and Myanmar are both similar in terms of health expenditure per capita, incidence per 100,000, and DALY per 100,000. When analysing this graph by income group, the HIC's are similar in terms of DALY per 100,000, however Brunei Darussalam has a higher incidence per 100,000 and lower health expenditure per capita than Singapore. Of the UMIC's, Malaysia has a higher health expenditure per capita and lower incidence per 100,000 rate and DALY per 100,000 rate than Thailand. Of the LMIC's, Viet Nam and the Philippines contribute the most to health expenditure per capita with each country contributing approximately double the amount contributed by Lao PDR or Myanmar. Lao PDR has the highest DALY per 100,000 rate, the Philippines has the highest incidence per 100,000 rate, and Viet Nam has the lowest DALY per 100,000 rate of the LMIC's. Despite Cambodia being the only LIC, Cambodia only has the second highest DALY per 100,000 rate and one of the lowest incidence per 100,000 rates.

Discussion

In this study, we compared Viet Nam to other SEA countries regarding efforts to mitigate infectious disease burden in national climate change adaptation plans.

Viet Nam released its National Climate Change Strategy in 2022, in which it includes mid-term goals for 2030–2035 and long-term goals for 2050[35]. The Vietnamese Climate Change Strategy does mention infectious diseases; however, the priorities of the strategy do not include reference to disease or infectious diseases resulting from climate change. The priorities included in Viet Nam's Climate Change Strategy largely focus on climate resilience, adaptation, and mitigation through emissions reductions and sector collaboration to support sustainable infrastructure and increase climate financial opportunities. Perhaps because the Climate Change Strategy is only newly released, Viet Nam has not yet submitted an NDC with its long-term strategies for mitigation and adaptation. Viet Nam's Climate Change Strategy and NDC proclamations do not contribute towards SDG 3·3, which aims to eliminate infectious disease epidemics, many of which are highly susceptible to climate change[28].

Referencing the SMART analysis in Table 2, Viet Nam is one of the best countries for overall score, with only Thailand achieving the same score. Viet Nam's Climate Change Strategy specifically mentions infectious diseases impacted by climate change and has clarified the need to develop the infrastructure and healthcare network to meet the requirements needed to effectively manage epidemics, including metrics to measure disease spread and investment opportunities. Currently, Viet Nam only spends 4·68% of GDP on health, which is below the recommended 5%[32]

As shown in Fig. 1, Viet Nam has the highest prevalence per 100,000 for Respiratory Infections and TB compared to all other SEA countries included in this study. Viet Nam's prevalence of 45,797 per 100,000 for Respiratory Infections and TB is due to the high burden of TB in the country and increasing public health burden resulting from chronic pulmonary aspergillus[36]. Viet Nam also has prevalence per 100,000 rates above the SEA average for NTDs and Malaria, and HIV/AIDs and STI's, but is below the SEA average for Enteric Infections and Other Infectious Diseases. Although Viet Nam is above the SEA average for prevalence per 100,00 for NTDs and Malaria, Viet Nam has made significant progress in reducing the burden from NTDs and Malaria since 2009[37]. Researchers have reported that the age-adjusted prevalence cases or incidence rates from 2009 to 2019 dropped 93·6% from 275,203 to 17,600[37]. The National Malaria Control Program was established in 1992 in Viet Nam and with extra funding support from the Global Fund to Fight AIDS, Tuberculosis, and Malaria, and Viet Nam's own Ministry of Health, and subsequently the country has developed robust detection, surveillance, and treatment systems for urban populations and mobile communities, contributing to the declining malaria burden[38]. However, the Southern and Central Mountains regions are still at a significant public health risk from Malaria due to their rural location and limited accessibility options for healthcare[39].

The main disease contributing to Viet Nam's high prevalence per 100,000 from the NTDs and Malaria group, as estimated by IHME,[29] is attributed to the rising burden of Dengue in the country. Dengue epidemics are a regular occurrence in Viet Nam and 2019 recorded the highest number of dengue cases ever recorded in a year, totalling 320,000 cases. Without the same funding and attention Malaria receives, Dengue is left to the mercies of climate change in Viet Nam[13,37]. Climate change in Viet Nam has created favourable precipitation, temperature, and humidity conditions for dengue to spread, and with rapid urbanisation and dense populations, dengue epidemics are sure to continue without effective interventions.

Viet Nam's health expenditure per capita has fallen from 2018 rates (5·05%) down to 4·68%, the current rate in 2023 shown in Fig. 2. However, Viet Nam has the highest health expenditure per capita in comparison to countries in the same income group[40]. The United States International Trade Administration released a report in March of 2023, citing the American Chamber of Commerce Viet Nam, expecting Viet Nam's health expenditure per capita to grow to 5·8% of GDP by 2025[41]. Out of pocket (OOP) household spending contributes the largest share of spending in the health system and is a large contributor to financing the health sector in Viet Nam. Despite this, the impact on households' well-being is limited as a result of government efforts to protect households against health associated financial risks[40]. However, without reducing the people's reliance on hospital-based care, OOP costs and associated financial risks will not change and health expenditure per capita will remain inefficient.

Overall, despite the limited mentions of disease in Viet Nam's National Climate Change Strategy, Viet Nam is doing relatively well in terms of addressing infectious diseases through climate change mitigation efforts, both individually and in comparison to other OECD SEA countries. This research is the first of its kind in comparing national climate change strategies in the South-East Asia region and their impact in mitigating infectious diseases. Therefore, the importance of this research lies both in its ability to bring attention to the links between

climate change efforts and infectious disease spread in Viet Nam, and for the transparency created between South-East Asian countries on this issue. However, our research also has a few limitations. Firstly, Cambodia's rating and analysis is likely out of date since its national climate change strategy expired in 2023[21]. Secondly, data collected assessing whether national climate change strategies address SDG's 3·3 and 3b is from 2021 NDC data and may not be reflective of 2023 efforts. Furthermore, the Viet Nam Climate Change Plan was informally translated into English for analysis, whereas other climate change plans had been officially published in English. Therefore, there is a slight risk of miscommunication occurring during translation, although this is mitigated by several of the co-authors being bilingual. Finally, despite best efforts, this report may not have captured all existing climate change strategies for the OECD countries, as some may not be openly available online.

The following list outlines strategies that could support Viet Nam, and other OECD SEA countries, to improve mitigation, adaptation, and resilience against the negative effects of climate change on infectious diseases.

- Dengue is highly susceptible to climate change and Viet Nam has experienced increased frequency of dengue outbreaks since 2017. Viet Nam would benefit from prompt interventions that combat dengue prevalence whilst Viet Nam continues its climate change mitigation efforts. Further, increased training for healthcare workers on recognising signs and symptoms, and centralised dengue health programs on dengue mitigation, could be prioritised[37].
- As Viet Nam has the highest burden of respiratory infections and TB in the OECD SEA area, the Viet Nam government could consider measures to reduce the health risks from *Aspergillus fumigatus*, a pathogen which complicates both conditions. Climate change has created favourable conditions for increased *Aspergillus fumigatus* burden,[42,43] and existing agricultural practices in Viet Nam have increased the risk of azole-resistant *Aspergillus fumigatus*. Regulating the type of agricultural products that are used in the country could tackle the burden of disease. Whilst climate change mitigation efforts take time, implementing regulations on agricultural products can be a short-term and quick solution to reduce the risks associated with this climate susceptible, opportunistic fungus[42].
- Viet Nam is likely to need to increase its health expenditure per capita—a reasonable target would be 5%—to meet the recommended level and match 2018–2019 spending levels[32,33]. This funding could primarily support identification, surveillance, and treatment initiatives for the infectious diseases susceptible to climate change and posing the greatest public health risks. One potential avenue for Viet Nam to increase its health expenditure per capita is to reduce spending on pharmaceuticals, as recommended by the World Bank[40].
- Viet Nam could benefit from implementing a horizontal holistic health promotion and preventative care initiative. Viet Nam has a reliance on hospital-based care as indicated by the contributions of OOP to total health spending[40]. Implementing horizontal holistic health promotion and prevention initiatives can incorporate easy, at-home measures to protect against the effects of climate change (such as using mosquito-nets) and improve general well-being and baseline immunity. Not only would this reduce the financial health risks for the Vietnamese people and empower individuals to manage their health, but the Viet Nam healthcare system would also benefit from a decreased burden and enable the health system to prioritise spending and infrastructure where it is most needed.
- Including infectious disease mitigation efforts in all current and future national development plans is one way of ensuring it is prioritised. For example, the Mekong-Delta Master Plan for 2021–2030 does not mention vector- or water-borne diseases at all, despite reports that the Mekong-Delta region's largest health burden results from infectious diseases susceptible to climate change, namely vector- and water-borne diseases[44].
- Above and beyond integrating infectious disease mitigation efforts in national development plans, Viet Nam could place a greater focus on intensifying One Health approaches by increasing collaboration across all sectors and partners that are responsible for environmental, animal, and human health[17].
- Viet Nam could consider partnering with other SEA countries who share a border with Viet Nam and have similar climates, such as Lao PDR, Cambodia, and Thailand, to collaborate on climate change mitigation efforts. For example, taking advantage of comparative advantages between the countries could see the region fast track its progress in reaching respective net zero targets and collectively contribute to reducing the burden of infectious diseases. Potential areas to collaborate include investments and developments in climate resistant crops and cross-border super grids for renewable energy[45].
- It would be beneficial for Viet Nam to implement these measures in the next three years in order for the 2027 Viet Nam NDC to actively contribute to SDG's 3·3 and 3b.

Conclusion

Viet Nam is one of the most vulnerable countries to climate change and has already experienced increased healthcare strain as a direct result of climate change. Viet Nam's national climate change strategy's potential to mitigate infectious diseases was ranked highly in comparison to its OECD neighbours, with only Thailand achieving an equivalent score. Tuberculosis and Dengue remain large contributing factors to Viet Nam's high prevalence per 100,000 for the Respiratory Infections and TB, and NTDs and Malaria groups, and are highly susceptible to climate conditions. Health expenditure per capita in Viet Nam has fallen since 2018 and currently does not meet the 5% spending level recommended by the World Bank. Due to these factors, some recommendations may include greater implementation of One Health frameworks in future government strategies, implementing horizontal holistic health promotion and preventative care initiatives, increasing health expenditure per capita to at least 5%, and focussing that increased spending on infectious diseases that are susceptible to climate change.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article. Raw data that support the findings of this study are available from the corresponding author, upon reasonable request. Corresponding author can be contacted at Caillin.dunsford@sydney.edu.au.

Appendix

Details captured from climate strategies	Country of strategy
	Title of strategy
	Strategy years effective
	Mentions of disease
Key search terms within climate strategies	'disease'
	'infectious disease'
	'infectious'
	'communicable'
	'vector'
	'vector-borne' or 'vector borne'
	'water-borne' or water borne'
	'malaria'
	'dengue'
	'zika'
	'cholera'
	'diarrhea' and 'diarrhoea'
	'typhoid'
	'mosquito'
Key search terms for climate strategy priorities	"disease"
	"health"
	"infectious"
	"communicable"

Table 3. Details of climate strategies and key search terms.

Detailed search strategy used on GBB compare tool	1. Use the arrow diagram graph,
	2. Change the settings to advanced,
	3. Select single view as the view option,
	4. Under advanced settings:
	(a) Display should be set to 'cause',
	(b) Rank should be set to 'cause',
	(c) Category should be set to 'Communicable, maternal, neonatal, and nutritional diseases',
	(d) Level setting should be kept at 2,
	(e) Range should be kept at 1990–2019,
	(f) Age should be kept to 'all ages',
	(g) Sex should be set to 'both',
	(h) Units should be set to 'rate',
	5. Change the location setting to capture each OECD country in turn,
	(a) Also capture the global result,
	6. For each country, measure:
	(a) Prevalence,
	(b) Incidence,
	(c) DALY,
	7. Manually calculate OECD average once data has been captured for each country

Table 4. Detailed search strategy used on GBB compare tool.

SMART Element	Description	Measure
Specific	The specific element was assessed according to the specificity of disease mention in each climate change strategy	**Very good**: Mentions specific infectious diseases such as vector-borne diseases, water-borne diseases, dengue, cholera, etc. and the impact of climate change on these diseases **Good**: Specifically mentions the term 'infectious disease' or identifies specific infectious diseases but does not note the impacts from climate change **Moderate**: Generally mentions 'disease' or 'health' with implications of reference to infectious diseases **Poor**: No references to health or disease
Measurable	The measurable element was assessed according to whether climate change strategies had a metric or performance indictor to measure the impact of climate change on infectious diseases or the change in infectious disease rates as a result of climate change	**Good**: Countries included a metric or performance indictor **Poor**: No metric or performance indictor outlined in climate change strategy Note: This metric was only assessed with a 'yes' or 'no' response, hence results are only rated good or poor accordingly
Attainable	The attainable element was measured according each countries' health expenditure per capita, with a 5% recommended target[25,27,28]	**Very good**: Health expenditure was over 6% of GDP per capita **Good**: Health expenditure was between 4–6% of GDP per capita **Poor**: Health expenditure was below 4% of GDP per capita Note: This metric did not include a 'moderate' rating as countries were considered 'good' if they were within 1% of the recommended expenditure per capita, or 'poor' if they were below 1% of the recommended expenditure per capita
Relevant	The relevant element was assessed according to whether each countries climate change strategy mentioned infectious disease surveillance, prevention, and treatment measures	**Very good**: Climate change strategies mentioned all 3 measures **Good**: Climate change strategies mentioned at least 2/3 measures **Moderate**: Climate change strategies only mentioned 1/3 measures **Poor**: No mentions of measures
Time-Bound	The time-bound element was assessed according to the years effective of each climate change strategy	**Very good**: Climate change strategies are effective until 2050 **Good**: Climate change strategies are effective until at least 2035 **Moderate**: Climate change strategies are effective up to the year 2030 **Poor**: Climate change strategies are not effective until at least 2025

Table 5. SMART element description and measure.

Rating	Score
Very Good	4
Good	3
Moderate	2
Poor	1

Table 6. SMART scoring system.

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C Dunsford is the corresponding author and was responsible for conceptualising, writing, and editing the manuscript. V Luu assisted with data collection. J Beardsley and VQ Dat were responsible for supporting with conceptualisation and feedback. Y Zhang was responsible for final review.

Competing interests

The authors declare no competing interests.

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