



Vietnam Climate Change and Health Vulnerability and Adaptation Assessment, 2018

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ABSTRACT

BACKGROUND: The Global Climate Risk Index 2020 ranked Vietnam as the sixth country in the world most affected by climate variability and extreme weather events over the period 1999–2018. Sea level rise and extreme weather events are projected to be more severe in coming decades, which, without additional action, will increase the number of people at risk of climate-sensitive diseases, challenging the health system. This article summarizes the results of a health vulnerability and adaptation (V&A) assessment conducted in Vietnam as evidences for development of the National Climate Change Health Adaptation Plan to 2030.

METHODS: The assessment followed the first 4 steps outlined in the World Health Organization's Guidelines in conducting "Vulnerability and Adaptation Assessments." A framework and list of indicators were developed for semi-quantitative assessment for the period 2013 to 2017. Three sets of indicators were selected to assess the level of (1) exposure to climate change and extreme weather events, (2) health sensitivity, and (3) adaptation capacity. The indicators were rated and analyzed using a scoring system from 1 to 5.

RESULTS: The results showed that climate-sensitive diseases were common, including dengue fever, diarrheal, influenza, etc, with large burdens of disease that are projected to increase. From 2013 to 2017, the level of "exposure" to climate change-related hazards of the health sector was "high" to "very high," with an average score from 3.5 to 4.4 (out of 5.0). For "health sensitivity," the scores decreased from 3.8 in 2013 to 3.5 in 2017, making the overall rating as "high." For "adaptive capacity," the scores were from 4.0 to 4.1, which meant adaptive capacity was "very low." The overall V&A rating in 2013 was "very high risk" (score 4.1) and "high risk" with scores of 3.8 in 2014 and 3.7 in 2015 to 2017.

CONCLUSIONS: Adaptation actions of the health sector are urgently needed to reduce the vulnerability to climate change in coming decades. Eight adaptation solutions, among recommendations of V&A assessment, were adopted in the National Health Climate Change Adaptation Plan.

KEYWORDS: Climate change, health impacts, vulnerability and adaptation assessment, Vietnam

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Introduction

Vietnam is located in Southeast Asia, with a high level of exposure to climate-related hazards and extreme weather and climate events. Climate change is projected to increase temperature, the severity and frequency of extreme weather events and sea level rise, which in turn would increase the number of people at risk of climate-sensitive diseases without additional interventions.^{1,2} The health effects of climate change can be

direct and immediate, such as drownings, injuries, and heat-related illnesses, or indirect and delayed, such as waterborne infections, vector-borne diseases, air-borne diseases, mental health consequences, and food shortages.^{3–7} Increases in the number of cases of climate-sensitive diseases can increase pressures on health care system, especially in low- and middle-income countries. WHO⁸ projected the potential risks of climate change for priority climate-sensitive health risks in 2030



and 2050 under different climate and development scenarios. Under a base case socioeconomic scenario, climate change was estimated to cause approximately 250 000 additional deaths per year worldwide from heat stress, diarrhea, malaria, and undernutrition in 2030 and to put 4.26 billion people at risk of dengue in 2030, 4.64 billion people at risk in 2050, and an additional 48 000 deaths in 2030 and 33 000 deaths in 2050 among children below 15 years due to diarrheal diseases.⁸ Natural disasters such as storms and floods can damage infrastructure and disrupt the capacity of health systems to respond to health crises and affect the overall quality of and access to health care.^{6,9,10} Climate change will be a major challenge to the capacity of the Vietnamese health system in the coming decades.

The Global Climate Risk Index 2020 ranked Vietnam as the sixth country in the world most affected by climate variability and extreme weather events over the period 1999–2018.¹¹ Climate change is projected to increase the frequency of natural disasters and extreme heat events in most areas in Vietnam. Inundation due to sea-level rise of 100 cm could affect about 16.8% of the population of the Red River Delta, 1.5% of the Central coastal provinces, 17.8% of Ho Chi Minh City, and 38.9% of the Mekong Delta.¹² Extreme temperature and the number of hot days and nights were projected to have an upward trend, and droughts could become more severe due to rising temperatures and decreasing rainfall.¹² Several small-scale studies explored the relationship between weather variables, climate change, and diseases such as diarrhea, dengue fever, malaria, and respiratory diseases in some provinces and cities in Vietnam.^{3,13–15} However, to our knowledge, no publication has comprehensively assessed health risks from climate change in the country.

The adaptive capacity of the health sector is an important determinant of community vulnerability to climate change. Especially in rural areas, the health system faces increasing challenges from changing climatic conditions and extreme weather events.¹⁶ Commune health stations, for example, often did not have enough equipment and medicine for first aid or treatment (especially waterborne disease outbreaks) during and after heavy rainfall and floods.¹⁷ Isolated facilities could be severely damaged in some extreme weather events.

To reduce the adverse effects of changing climatic conditions, the health sector needs to be actively involved in developing long-term plans to respond to climate change. Conducting a Vulnerability and Adaptation (V&A) assessment is a key instrument for identifying and preparing for changing health risks in a specific location. Countries have been developing national health adaptation plans, where V&A assessments are essential for providing information for policymakers on the magnitude and pattern of prioritized climate change-sensitive health risks, and for synthesizing priority policies and programs to prevent or reduce the severity of future impacts.¹⁸ This is a core activity in protecting populations from the adverse health

risks of climate change.¹⁸ To assist countries, World Health Organization (WHO) and Pan American Health Organization (PAHO) developed a technical document to provide basic and flexible guidance in conducting a national or subnational V&A assessment.¹⁸

Here we describe the initial stages of a study aimed to assess the vulnerability and adaptive capacity of the health sector in Vietnam in 2018. The assessment identified current and future risks of climate-sensitive diseases in Vietnam, assessed the climate change-related vulnerability and adaptive capacity of the health sector using a list of criteria, and identified effective solutions to reduce potential climate-related risks for the health sector in Vietnam. Results of this V&A assessment yielded useful insights for developing appropriate policy and program responses in Vietnam and in similar settings in other countries. The assessment provided evidence-based information for development of a National Health Adaptation Plan.¹⁹ Also, this research may serve as an example for other countries in undertaking this type of assessment.

Methods

Timeframe and study setting

This V&A assessment was undertaken from January to September 2018 in Vietnam.

Measurement and data collection

We followed WHO Guidelines on conducting V&A Assessments, which consists of six steps¹⁸:

- Step 1: Frame and scope the assessment;
- Step 2: Describe current risks, vulnerabilities, and adaptive capacities;
- Step 3: Project future health risks;
- Step 4: Identify, describe, evaluate, and prioritize adaptation options to manage the additional health risks expected with a changing climate;
- Step 5: Develop a climate change and health adaptation plan; and
- Step 6: Establish an interactive process for managing and monitoring health risks.

The first four steps were conducted by the study team; while the last two steps were subsequently taken by the Ministry of Health of Vietnam. Disease models were used to project selected climate change-sensitive diseases in the coming decades with and without consideration of climate change. Primary and secondary data (from National Institute of Hygiene and Epidemiology—NIHE, General Department of Preventive Medicine, Institute of Hydrology and Meteorology Science

and Climate Change, and Vietnam Health Statistics Yearbook 2015, 2016) were collected and used to semi-quantitatively assess the vulnerability and adaptive capacity of the health sector according to a list of 45 indicators. There was no existing set of indicators or guidance on rating the indicators. Therefore, the research team and National Scientific Committee (organized by Vietnam Environment Management Agency—Ministry of Health) and international experts discussed and proposed a semi-quantitative rating system what was applied in this research. Each indicator was ranked from 1 to 5, which corresponded to the exposure level, sensitivity level, and capacity level from very low to very high. The criteria for rating each indicator were developed based on expert judgment of experts who were working in the fields of public health, environmental health, and climate change in Vietnam.

$$\text{Average score for Exposure level} = \frac{\text{Total score of all indicators}}{\text{Total number of indicators}}$$

$$\text{Average score for Sensitivity level} = \frac{\text{Total score of all core indicators} \times 2 + \text{Total score of all co-indicators}}{\text{Number of core indicators} \times 2 + \text{Number of co-indicators}}$$

$$\text{Average score for adaptive capacity level} = \frac{\text{Total score of all core indicators} \times 2 + \text{Total score of all co-indicators}}{\text{Number of core indicators} \times 2 + \text{Number of co-indicators}}$$

$$\begin{aligned} &\text{Average score for vulnerability and capacity of the Health Sector} \\ &= \frac{\text{Average score for exposure} + \text{Average score for sensitivity} + \text{Average score for adaptive capacity}}{3} \end{aligned}$$

Rating the exposure level and sensitivity level:

- Average exposure and sensitivity score < 1.0: Very low
- Average exposure and sensitivity score from 1.0 to < 2.0: Low
- Average exposure and sensitivity score from 2.0 to < 3.0: Average
- Average exposure and sensitivity score from 3.0 to < 4.0: High
- Average exposure and sensitivity score from 4.0 to ≤ 5: Very high

Rating the adaptive capacity level:

- Average score < 1.0: very high capacity
- Average score from 1.0 to < 2.0: High adaptive capacity
- Average score from 2.0 to < 3.0: Average adaptive capacity
- Average score from 3.0 to < 4.0: Low adaptive capacity
- Average score from 4.0 to ≤ 5: very low adaptive capacity

Overall rating for vulnerability and adaptive capacity of the Health Sector

- Average score < 1.0: Very low risk
- Average score from 1.0 to < 2.0: Low risk
- Average score from 2.0 to < 3.0: Average risk

Data analysis

All quantitative data analyses were conducted using General Additive Models (GAMs) in R with package “mgcv” and “splines.” Projections were available for malaria, dengue, heat-related mortality, and diarrheal disease for 2030, for a single emission scenario and a single General Circulation Models (GCM). All maps represented a change in risk, relative to 2010, based on daily temperature projections from a single emission scenario (Representative Concentration Pathway (RCP) 4.5) and a single GCM (Geophysical Fluid Dynamics Laboratory Coupled Model [GFDL-CM3]).

Data analysis for V&A assessment

The average score for each group of indicators was calculated as

- Average score from 3.0 to < 4.0: High risk
- Average score from 4.0 to ≤ 5: Very high risk

Prioritizing Adaptation Options to Reduce Potential Climate-Related Risks for the Health Sector in Vietnam

Prioritization was conducted by 48 stakeholders who were purposely selected, including policymakers, health managers at central and provincial levels, experts from different universities, institutions, nongovernmental organizations, and WHO professionals. Multi-Criteria Analysis was used for prioritization.²⁰ Multi-Criteria Analysis is “any structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives.”²⁰ To prioritize adaptation measures, the feasibility of different aspects, such as the technical, financial, social, and environmental, were taken into account. The proposed adaptation options were prioritized using six criteria, including technical feasibility, operational feasibility, effectiveness, environmental acceptance, financial feasibility, and social and political acceptance.²¹

Ethical issues

The study was implemented after official approval by the Ethics Committee of Hanoi University of Public Health under

Decision No. 377/2018/YTCC-HD3. The study also received official approval from the Ministry of Health (MOH), the acceptance of communities, and the support of local government and managers in the health sector. Participants participated in in-depth interviews (IDIs) and focus group discussions (FGDs) where the study objectives were explained. Their participation was completely voluntary, as was clearly indicated in the Consent Form for Participation in the Research. Participants in IDIs and FGDs had the right to withdraw from the study or refuse to answer any questions at any time without any consequences. All personal information of participants was kept confidential and all information was encrypted.

Results

The burden of climate change-sensitive diseases in Vietnam

Quantitative results for the period of 1997 to 2016 showed that climate-sensitive diseases including dengue fever, malaria, diarrheal diseases, and influenza were common in Vietnam. Influenza was responsible for a huge burden of disease in Vietnam with 26 123 358 notified cases during 1997 to 2016 (on average 1 306 167 case per year). Incidence rates of influenza increased from 1672 per 100 000 population in 1997 to 2278 per 100 000 population year in 2009 and declined afterward. Influenza incidence and death rates were high during September and October, with death rates higher in the winter months (Figure 1).

There were 1 618 767 notified cases of dengue fever during the period of 1997 to 2016, with on average, about 80 938 cases per year (or 110 cases per 100 000 population). There were 1389 deaths from dengue hemorrhagic fever in this period with most of the deaths occurring before 2000. In 1998, the death rate of dengue fever was especially high at 0.5 per 100 000 (Figure 2A). The incidence of dengue fever and mortality rates increased as temperature increased. The rates in June to October were higher than in other months (Figure 2B).

Although the burden of diarrheal disease in Vietnam decreased significantly from 1990 to 2016, this disease still ranked at the sixth leading cause of disability-adjusted life years (DALYs) and the fifth leading cause of premature death in 2016, accounting for 140 425 DALYs and 1958 deaths. The incidence rate declined from 1321 cases per 100 000 population in 1997 to 470 cases per 100 000 population in 2016, while the death rate decreased from 0.04 cases per 100 000 to 0.01 cases per 100 000 population year during the period of 1997 to 2016 (Figure 3A). The incidence of near zero in 2001 may be due to missing data in the reporting system. Diarrheal incidence increased with higher temperatures; both incidence and mortality were higher between April and August (Figure 3B).

Projection of the burden of climate-sensitive diseases in the coming decades

Years of life lost from noncommunicable diseases were projected to increase from about 67% in 2016 to nearly 80% while

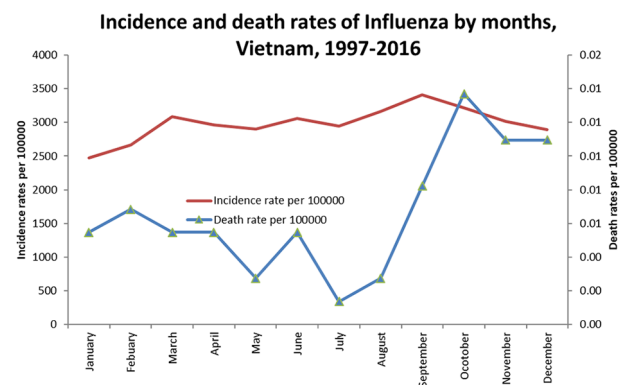


Figure 1. Influenza incidence rate and death rates by month in Vietnam, 1997 to 2016.

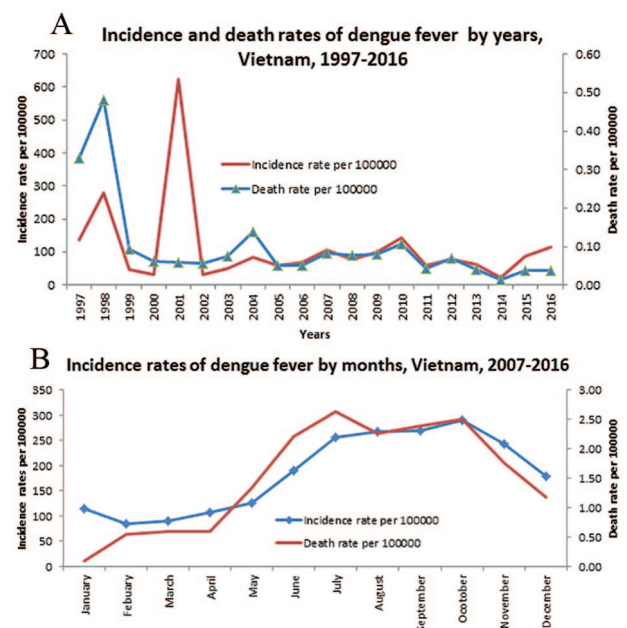


Figure 2. (A) Trend of dengue fever incidence and deaths in Vietnam from 1997 to 2016 and (B) incidence rates of dengue fever by month in Vietnam, 2007 to 2016.

the burden due to diarrheal diseases was projected to remain at a low level until 2040.²² The burden of dengue fever was projected to increase. These projections show that modest increases are projected in temperature suitability for dengue transmission in northern and central areas, with some areas of substantially increased suitability in central parts of the country (approximately 23%–62% increase) by 2030. Diarrheal disease mortality is associated with average temperature, with increases on the order of 10%–15% projected by 2030.²²

V&A assessment using the set of indicators and qualitative data

Tables 1 to 3 show the results of the V&A indicators within 5 years (2013–2017).

The level of exposure to climate change-related hazards in Vietnam in 2013 was “very high,” with an average score of 4.4 (out of 5.0). From 2014 to 2017, the exposure level was “high,”

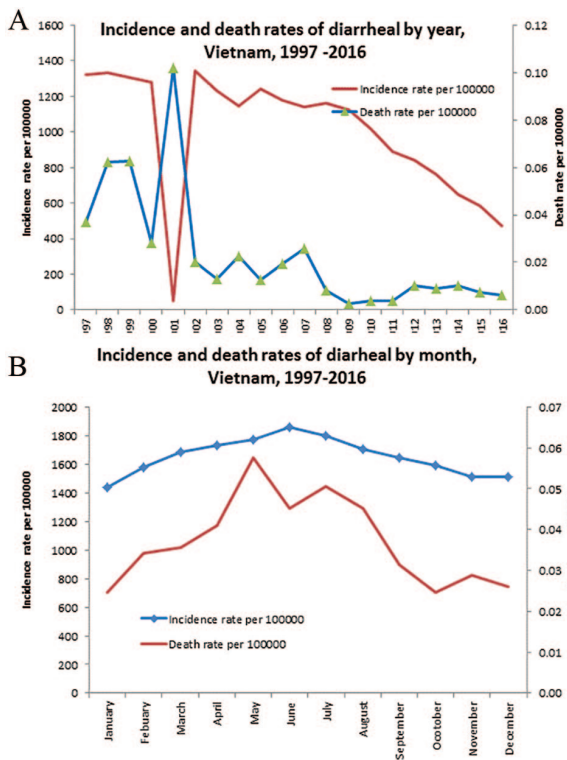


Figure 3. (A) Incidence and death rates of diarrheal disease by year; (B) incidence and death rates of diarrheal by month in Vietnam, 1997 to 2016.

with the score ranging from 3.4 to 4.0 (Table 1). Communities in different provinces/cities had different vulnerabilities to climate change, especially the challenges faced by the health sector in preventing and controlling health problems related to floods, storms, heat waves, and droughts. Local health facilities were particularly vulnerable to climate change and extreme weather events. A lot of commune health stations were at risks of being flooded, destroyed, power outage, lost access to clean water, and/or isolated during floods and storms.

For “health sensitivity,” the scores for the past 5 years slightly decreased, from 3.8 in 2013 to 3.4 in 2017, making the overall rating “high.” Five core indicators were not included due to a lack of secondary data, including number of stroke cases / 100 000 people; rate of children below 5 years having pneumonia annually (times having pneumonia/child/year); number of injuries cases due to natural disasters and extreme weather events occurring annually; number of households that lost access to clean drinking water during natural disasters and/or extreme weather events occurring annually; and number of households with toilets destroyed or not accessible during natural disasters and/or extreme weather events occurring annually. In addition, 4 co-indicators were not applicable due to lack of secondary data, including number of deaths due to stroke annually / 100 000 people; number of deaths due to natural disasters and extreme weather events occurring annually; mortality rate

Table 1. Indicators of exposure to extreme weather events and climate change hazards in the health sector in Vietnam.

I	INDICATORS	RATING EACH INDICATOR	2013	2014	2015	2016	2017
1.	Number of storms and tropical depressions occurring annually on the East Sea; and number of strong storms occurring on the East Sea annually	≥10 storms → rate 5 8-9 storms → rate 4 6-7 storms → rate 3 3-5 storms → rate 2 0-2 storms → rate 1	5	4	3	5	5
2.	Number of extreme cold episodes (days) with absolute minimum temperature < 13°C occurring annually	>12 episodes → rate 5 10-12 episodes → rate 4 7-9 episodes → rate 3 4-6 episodes → rate 2 <4 episodes → rate 1	3	3	2	2	1
3.	Number of heat waves occurring annually	>12 episodes → rate 5 10-12 episodes → rate 4 7-9 episodes → rate 3 4-6 episodes → rate 2 <4 episodes → rate 1	5	5	5	5	5
4.	Number of days with extreme heavy rain (> 100mm) occurring annually	>12 days → rate 5 10-12 days → rate 4 7-9 days → rate 3 4-6 days → rate 2 <4 days → rate 1	4	3	2	2	3
5.	Number of drought months occurring annually	≥3 months → rate 5 2 → < 3 months → rate 4 1 → < 2 months → rate 3 2 weeks → < 1 month → rate 2 0 → < 2 weeks → rate 1	5	5	5	5	4
3 other proposed indicators were not assessed due to lack of secondary data available, including: % of provinces/cities flooded annually; % of provinces/cities experiencing droughts annually; and total area inundated/flooded due to sea level rise (hectare).							
Average rating for “Exposure”			4.4	4.0	3.4	3.8	3.6

Table 2. Indicators of health sensitivity to climate change and extreme weather events in Vietnam.

II	INDICATORS	RATING EACH INDICATOR	2013	2014	2015	2016	2017
Core indicators							
1.	Number of provinces/cities with epidemic dengue hemorrhagic fever occurring annually out of 63 provinces/cities	51-63 provinces → rate 5 39-50 provinces → rate 4 26-38 provinces → rate 3 13-25 provinces → rate 2 <13 provinces → rate 1	5	4	5	4	5
2.	Number of dengue hemorrhagic fever cases / 100000 people	>50 → rate 5 >35-50 → rate 4 >20-35 → rate 3 >5-20 → rate 2 0-5 → rate 1	5	4	5	5	5
3.	Number of diarrhea cases / 100000 people	>50000 → rate 5 40000-50000 → rate 4 30000-<40000 → rate 3 20000-<30000 → rate 2 <20000 → rate 1	5	5	5	4	4
4.	Number of influenza cases / 100000 people	>500 → rate 5 300-500 → rate 4 200-<300 → rate 3 100-<200 → rate 2 <100 → rate 1	5	5	5	5	5
5.	% of poor households	>20% → rate 5 10%-20% → rate 4 5%-<10% → rate 3 3%-<5% → rate 2 <3% → rate 1	3	3	3	3	3
Co-indicators							
6.	Population density (people/km ²)	>281 → rate 5 123 → 280 → rate 4 73 → 122 → rate 3 25 → 72 → rate 2 <25 → rate 1	5	5	5	5	5
7.	(A) % of children under 5 years of age who are malnourished (underweight)	>20% → rate 5 15%-20% → rate 4 10%-<15% → rate 3 5%-<10% → rate 2 <5% → rate 1	4	3	3	3	3
	(B) % of children under 5 years of age who are malnourished (stunting: low height-for-age)	≥30% is very high. 20%-29% is high >30% → rate 5 20%-30% → rate 4 15%-<20% → rate 3 10%-<15% → rate 2 <10% → rate 1	4	4	4	4	4
8.	% households in rural areas without access to improved drinking water	>20% → rate 5 15%-20% → rate 4 10%-<15% → rate 3 5%-<10% → rate 2 <5% → rate 1	4	4	3	3	3
9.	% households in rural areas without access to hygienic toilets	>50% → rate 5 40%-50% → rate 4 25-<40% → rate 3 10%-<25% → rate 2 <10% → rate 1	4	3	3	3	2
10.	% of the elderly ≥60 years old	>30% → rate 5 20%-30% → rate 4 15%-<20% → rate 3 10%-<15% → rate 2 <10% → rate 1	2	2	2	2	2

(Continued)

Table 2. (Continued)

II	INDICATORS	RATING EACH INDICATOR	2013	2014	2015	2016	2017
11.	Number of deaths due to dengue hemorrhagic fever annually / 100000 people	>0.5 → rate 5 0.3-0.5 → rate 4 0.2-<0.3 → rate 3 0.1-<0.2 → rate 2 <0.1 → rate 1	1	1	1	1	1
12.	Number of deaths due to diarrhea annually/ 100000 people	8.6-<45 → rate 4 2.6-<8.6 → rate 3 1.15-<2.6 → rate 2 <1.15 → rate 1	1	1	1	1	1
13	Number of deaths due to influenza annually / 100000 people	≥2.0 → rate 5 1.0-<2.0 → rate 4 0.5-<1.0 → rate 3 0.1-<0.5 → rate 2 <0.1 → rate 1	1	1	1	1	1
Average rating for "Health sensitivity"			3.8	3.5	3.6	3.4	3.5

Table 3. Indicators of the adaptive capacity to climate change and extreme weather events of the health sector in Vietnam.

III	INDICATORS	RATING EACH INDICATOR	2013	2014	2015	2016	2017
Leadership/governance							
1.	MOH established a national steering committee in responding climate change, natural disasters and emergencies.	No → rate 5 Yes, work not so effectively → rate 4 Yes, work quite effectively for some aspects → rate 3 Yes, work effectively for most aspects → rate 2 Yes, work very effectively for all aspects → rate 1	2	2	2	2	2
2.	% provinces/cities have a specific health action plan to respond to climate change	<20% → rate 5 20%-<40% → rate 4 40%-<60% → rate 3 60%-<80% → rate 2 ≥80% → rate 1	5	5	5	5	5
3.	% of health policies that are integrated with relevant climate change response contents.	<20% → rate 5 20%-<40% → rate 4 40%-<60% → rate 3 60%-<80% → rate 2 ≥80% → rate 1	5	5	5	5	5
Health care financing							
4.	In the national master development and investment plan, there is a budget line for climate change adaptation in the health sector.	0 → rate 5; Funded <25% of estimated budget → rate 4; Funded 25%-<50% of estimated budget → rate 3 Funded 50%-<75% of estimated budget → rate 4 Funded ≥75% of estimated budget → rate 1	5	5	5	5	5
Health workforce							
5.	The Health Sector has training programs and short courses for health staff at different levels in planning for and responding to climate change.	No training programs at uni., no short courses → 5 No training programs at uni., short courses at national level → 4 No training programs at uni., short courses at provincial level → 3 Training programs at uni. + short courses at national level → 2 Training programs at uni. + short courses at different level → 1	5	5	5	5	5
6.	% of health staff trained in climate change and health adaptation	<20% → rate 5 20%-<40% → rate 4 40%-<60% → rate 3 60%-<80% → rate 2 ≥80% → rate 1	5	5	5	5	5

(Continued)

Table 3. (Continued)

III	INDICATORS	RATING EACH INDICATOR	2013	2014	2015	2016	2017
	Infrastructure, medical products, technologies						
7.	% provincial/district hospitals and commune health stations applied measures to response to health impacts of climate change.	<20% → rate 5 20%-<40% → rate 4 40%-<60% → rate 3 60%-<80% → rate 2 ≥80% → rate 1	NA	NA	NA	NA	NA
8.	% provincial/district hospitals and commune health stations with adequate infrastructure, medical products and equipment for disaster and emergency responses	<20% → rate 5 20%-<40% → rate 4 40%-<60% → rate 3 60%-<80% → rate 2 ≥80% → rate 1	NA	NA	NA	NA	NA
	Information and research						
9.	% provinces, cities with organized community-based communication programs/activities to raise public awareness of climate change and health	<20% → rate 5 20%-<40% → rate 4 40%-<60% → rate 3 60%-<80% → rate 2 ≥80% → rate 1	5	5	5	5	5
10.	Number of research projects at the national level implemented in the last year on climate change and health and on adaptation options	0 → rate 5 1-2 → rate 4 3-4 → rate 3 5-6 → rate 2 >6 → rate 1	5	5	4	4	4
	Service delivery						
11.	Health sector has developed and used an early warning system for health risks from natural disasters, including extreme weather events and climate variability	No → rate 5; Yes, for 1-2 diseases, rarely implemented → rate 4 Yes, for few vector-borne, waterborne and heat-related diseases, implemented in adequately → rate 3 Yes, for important vector-borne, waterborne and heat related diseases, implemented well → rate 2 Yes, for important vector-borne, waterborne, heat-related diseases, implemented very well → rate 1	5	5	5	5	5
12.	Number of hospital beds per 10000 population	<10 → rate 5; 10-<20 → rate 4 20-<30 → rate 3; 30-<40 → rate 2; ≥40 → rate 1	3	3	3	3	3
13.	Number of doctors (physicians) per 10000 population	<5 → rate 5; 5-<10 → rate 4 10-<20 → rate 3; 20-<30 → rate 2; ≥30 → rate 1	4	4	4	4	4
	Average score		4.5	4.5	4.4	4.4	4.4

per 10000 children below 5 years of age due to pneumonia annually; and % of ethnic minority people (no scientific basis for rating this criteria). These indicators can be included in future V&A assessments once data are available.

For the indicator “adaptive capacity,” the overall score was 4.5 in 2013 and 2014, and 4.4 for the past 3 years, which means the capacity was “very low” (Table 3). The overall assessment of vulnerability and adaptive capacity of the health sector in Vietnam had overall scores of 4.2 in 2013, 4.0 in 2014, 3.8 in 2015 and 2017, and 3.9 in 2016. This means the risks were very high and high in the past 5 years.

Health adaptation options

Table 4 shows the adaptive options for the health sector in Vietnam identified in this V&A assessment. They were

generally assessed as highly feasible (with an average score ranging from 3.7 to 4.0 out of 5.0). Therefore, these adaptation options should be prioritized for inclusion in the national adaptation plan of the health sector.

Discussion

This V&A project assessed the magnitude and pattern of climate-sensitive diseases in Vietnam, and the vulnerability and capacity of the health sector to manage current and future health risks. The results showed that dengue fever, diarrhea, and influenza were common diseases causing a significant number of illnesses and deaths. The findings showed that Vietnam has been facing many risks of climate-sensitive health and the sensitivity level is “high.” Previous studies in Vietnam reported similar findings.²³⁻²⁵ The association between meteorological factors and dengue fever, diarrhea, and influenza were described

Table 4. Proposed health adaptation options and the rating of 48 stakeholders.

HEALTH ADAPTATION OPTIONS IN THE HEALTH SECTOR	TF	OF	E	EA	FF	SF	AVERAGE SCORE
1. Strengthen the capacity of health staff at different levels through developing and implementing short, core/elective training courses on climate change and health adaptation.	4.2	4.0	4.0	3.9	3.8	4.1	4.0
2. Improve awareness and capacity of the community in health adaptation through risk communication activities.	4.1	3.7	3.5	3.8	4.0	4.1	3.9
3. Develop and implement early warning systems for prioritized climate-sensitive diseases (dengue fever, malaria, influenza, diarrhea, heat stroke) to protect vulnerable people. Strengthen surveillance systems for these diseases.	4.0	3.7	3.4	3.8	4.0	4.1	3.8
4. Promote intersectoral and international collaboration in developing and implementing health adaptation options for climate-sensitive diseases/health outcomes.	3.9	3.5	3.5	3.8	3.9	4.0	3.8
5. Strengthen scientific research about the health risks of climate change, vulnerable groups, and effective health adaptation measures.	4.2	3.8	3.4	3.7	3.9	3.8	3.8
6. Strengthen infrastructure and equipment capacity to increase health facility resilience to natural disasters and extreme weather events, prioritizing commune and district health centers/ hospitals.	3.9	3.6	3.2	3.8	4.0	3.9	3.7
7. Adapt health services to improve management of climate-sensitive diseases: strengthen health facilities in preventing and controlling emerging and re-emerging diseases in a changing climate. Develop, pilot, and implement effective community adaptations to climate change	3.9	3.6	3.3	3.9	3.8	3.8	3.7
8. Develop and refine regulations, policies, and mechanisms of the health sector in managing the health risks of climate change and extreme weather events.	3.8	3.6	3.5	3.7	3.7	3.7	3.7

Abbreviations: E, effectiveness; EA, environmental acceptance; FF, financial feasibility; OF, operational feasibility; SF, social feasibility; TF, technical feasibility.

in many studies in Vietnam and worldwide.^{3,26-30} Similar V&A assessments in Ontario, Canada³¹ and in Madagascar,³² although the common sensitive-climate diseases were different in Vietnam, also described the existing and future health burden due to climate change.

The level of exposure to climate-related risks in Vietnam's health sector in the period of 2013 to 2017 was "high" to "very high," with the average "exposure" fluctuating between 3.4 and 4.4 (out of 5.0). This may be due to Vietnam's unique geographic (long coastal line), demographic (over 90 million people, high density, and an aging population), and socioeconomic characteristics combined with its high exposure to changing weather patterns associated with climate change. In the context of high levels of exposure and sensitivity, the current capacity of the health sector was considered very low. Overall, the level of risk associated with vulnerability and adaptive capacity of Vietnam's health sector was very high. Thus, adaptation options to reduce the vulnerability of the Vietnamese health sector to climate change in the coming decades are urgently needed.

Adaptive solutions were developed and assessed by experts and stakeholders through Multi-Criteria Analysis using a Delphi Technique and expert consultations. Eight adaptive solutions were assessed as highly feasible (with an average score ranging from 3.7 to 4.0 out of 5.0). These priority programs focused on strengthening the capacity of health staff, improving awareness and capacity of the community, developing and implementing early warning systems, promoting intersectoral and international collaboration, strengthening scientific

research, adapting health services to improve management of climate-sensitive diseases, and developing and refining regulations, policies, and mechanisms. The solutions identified support the recommendation of WHO³³ and other studies.^{31,34}

Several countries have implemented V&A assessments for the health sector.^{31,32} However, it was difficult to compare their findings with this assessment because each country applied different methods. Although most V&A assessments followed the 6 main steps proposed by WHO,³³ the scale, approach, methods, and tools applied were different. Also, climate characteristics, disease patterns, and health systems varied considerably. Furthermore, the indicators used to assess exposure, sensitivity, and capacity were very different, which was appropriate to each country-specific context. For example, the V&A assessment for Madagascar prioritized malnutrition, acute respiratory infections, diarrhea, and malaria. The study used data on weather, epidemiology, and socioeconomics.³² In Ontario, Canada, the 6 climate-sensitive health vulnerability categories included extreme temperatures, extreme weather, air quality, food and water safety and security, vector-borne disease, and exposure to ultraviolet radiation.³¹ Health impacts considered included heat-related hospitalizations, injuries, illness, community emergencies, bacteriological contamination of food and water, as well as vectors that spread West Nile virus and Lyme disease.³¹ Unlike in our study, specific indicators were not used. To identify current and future capacity, the research used qualitative data through key informant interviews and focus groups.³¹

The strengths of this study

This study was the first V&A assessment in Vietnam; it provided a comprehensive picture of climate change risks on the emergence and development of common diseases in Vietnam, and the vulnerability and adaptive capacity of the health sector to manage these risks. The list of indicators provided a practical tool to assess the vulnerability and capacity of Vietnam's health sector; this tool could be used by other countries when they conduct an assessment. The findings of this study help health decision-makers build effective adaptation strategies, including to develop early warning systems. Institutionally, the Ministry of Health recently approved the *climate change response action plan of the health sector in the 2019 to 2030 period with the vision to 2050*.¹⁹

Limitations of the study

The V&A assessment was a new and challenging task, being implemented for the first time in Vietnam. There were very few in-depth studies on the effects of weather/climate variables, such as temperature, precipitation, and humidity, on disease patterns and community health. There was also no existing mechanism for managing and sharing databases among health agencies, and between the health sector and other stakeholders (for example, for weather/climate variables).

Limitations of this V&A assessment included our reliance on routine monthly data from the health care systems, which included all cases not just confirmed cases. In addition, data on gender, age, and residential address were not available. Therefore, associations could not be estimated by grid cell or for gender-specific associations. In addition, the assessment did not undertake a cost-effective assessment or cost-benefit assessment for adaptation solutions related to climate change-sensitive diseases. There was also no list of indicators available from other countries. A quantitative assessment using indicators from other sectors, for example, Ministry of Natural Resources and Environment (MONRE), would take a long time to be developed and verified, with a much larger budget. Thus, we proposed a list of indicators that were assessed semi-quantitatively. In addition, the prioritization of adaptation options was non-quantitative, mainly based on expert judgment and consultations with policymakers, health managers, and experts.

Conclusion

The findings of this V&A assessment in Vietnam revealed some striking results. The burdens of climate-sensitive infectious diseases including dengue fever, diarrhea, and influenza in Vietnam were large and were projected to increase in the next decades without additional actions. The level of exposure to climate change and extreme weather events of the health system was “high” to “very high.” The level of health sensitivity was considered as “high.” The adaptive capacity of the Vietnamese health care system was “very low.” The overall rankings were “very high risk” in 2013 and 2014 and “high risk”

in 2015 to 2017. Eight prioritized adaptive solutions were suggested focusing on strengthening the capacity of health staff, improving awareness and capacity of the community, developing and implementing early warning systems, promoting inter-sectoral and international collaboration, strengthening scientific research, adapting health services to improve management of climate-sensitive diseases, and developing and refining regulations, policies, and mechanisms.



Recommendations

It is recommended that in the future, the Ministry of Health and provincial department of health should use the proposed framework and indicators to conduct similar studies on the vulnerability and adaptive capacity of the health sector to climate change to develop a comprehensive database for policymakers in Ministry of Health and Ministry of Natural Resources and Environment. The assessment should be conducted and used as part of planning as well as monitoring/evaluating the implementation progress of the “Climate change response action plan of the health sector in the 2019-2030, vision to 2050.” The list of indicators can be adjusted to suit specific situations, consistent with the data available in each year, but it is needed to ensure no influence to the entire assessment framework. The indicators should be of sufficient number to assess exposure, sensitivity, and capacity. To facilitate a revised and comprehensive V&A assessment in the coming years, there is a strong need for effective resources mobilization, cooperation between MOH and MONRE to establish and maintain a system for integrating disease and weather data, and strengthening competence of health officials in data collection and analysis of V&A assessments.

Author Contributions

TTTH, HVN, LTTH, and HVM conceived and designed the study, agreed with the results, conclusions and came up with arguments for the manuscript. NTTN, TNQL, and NHQ analyzed the data. TTTH and TNQL wrote the first draft of the manuscript. All the authors made critical revision and agreed on the final version of the manuscript. TTTH, KE, SH, NDC, and HVM reviewed the final manuscript and approved it for submission, which was done by LTTH.

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REFERENCES

1. Birkmann J, Garschagen M, Van Tuan V, Binh NT. Vulnerability, coping and adaptation to water related hazards in the Vietnamese Mekong Delta. In: Renaud F, Kuenzer C, eds. *The Mekong Delta System*. Dordrecht, The Netherlands: Springer; 2012:245-289.
2. Porter JR, Xie L, Challinor AJ, et al. Food security and food production systems. In: Field CB, Barros VR, Dokken DJ, eds. *Climate Change 2014: Impacts,*

- Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK: Cambridge University Press; 2014:485-533.
3. Phung D, Huang C, Rutherford S, et al. Association between climate factors and diarrhoea in a Mekong Delta area. *Int J Biometeorol.* 2015;59:1321-1331.
 4. Lam HM, Wesolowski A, Hung NT, et al. Nonannual seasonality of influenza-like illness in a tropical urban setting. *Influenza Other Respir Viruses.* 2018;12:742-754.
 5. Huang C, Vaneckova P, Wang X, Fitzgerald G, Guo Y, Tong S. Constraints and barriers to public health adaptation to climate change: a review of the literature. *Am J Prev Med.* 2011;40:183-190.
 6. Watts N, Adger WN, Ayeb-Karlsson S, et al. The Lancet Countdown: tracking progress on health and climate change. *Lancet.* 2017;389:1151-1164.
 7. Wu X, Lu Y, Zhou S, Chen L, Xu B. Impact of climate change on human infectious diseases: empirical evidence and human adaptation. *Environ Int.* 2016; 86:14-23.
 8. World Health Organization. *Quantitative Risk Assessment of the Effects of Climate Change on Selected Causes of Death, 2030s and 2050s.* Geneva, Switzerland: World Health Organization; 2014.
 9. Austin S, Biesbroek R, Berrang-Ford L, Ford J, Parker S, Fleury M. Public health adaptation to climate change in OECD countries. *Int J Environ Res Public Health.* 2016;13:889.
 10. Confalonieri UE, Menezes JA, Margonari de, Souza C. Climate change and adaptation of the health sector: the case of infectious diseases. *Virulence.* 2015;6:554-557.
 11. Eckstein D, Künzel V, Schäfer L, Wings M. *Global Climate Risk Index 2020, Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2018 and 1999 to 2018.* Bonn, Germany: Germanwatch; 2020.
 12. Thuc T, Van Thang N, Huong HLL, Van Khiem M, Hien NX, Phong DH. *Climate Change and Sea Level Rise Scenarios for Vietnam.* Hanoi, Vietnam: Ministry of Natural Resources and Environment; 2016.
 13. Toai NP, Chinh DV, Vittor AY, Huy NN. Associations between dengue hospitalizations and climate in Can Tho, Vietnam, 2001-2011. *EnvironmentAsia.* 2016;9:55-63.
 14. Phuong LTD, Hanh TTT, Nam VS. Climate variability and dengue hemorrhagic fever in Ba Tri District, Ben Tre Province, Vietnam during 2004-2014. *AIMS Public Health.* 2016;3:769-780.
 15. Wangdi K, Canavati SE, Ngo TD, et al. Analysis of clinical malaria disease patterns and trends in Vietnam 2009-2015. *Malaria J.* 2018;17:332.
 16. Gilfillan D, Nguyen TT, Pham HT. Coordination and health sector adaptation to climate change in the Vietnamese Mekong Delta. *Ecol Soc.* 2017;22:14.
 17. Alga A, Dang TAT, Saulnier DD, Nguyen GT, von Schreeb J. Hope for the best, prepare for the worst—an assessment of flood preparedness at primary health care facilities in Central Vietnam. *Int J Environ Res Public Health.* 2018;15:2689.
 18. Ebi K, Berry P, Campbell-Lendrum D, Corvalan C, Guillemot J. *Protecting Health from Climate Change: Vulnerability and Adaptation Assessment.* Geneva, Switzerland: World Health Organization; 2013.
 19. Ministry of Health. *Climate Change Response Action Plan of the Health Sector in the 2019-2030 Period with the Vision to 2050, Decision No. 7562 / QĐ-BYT dated December 24, 2018* [in Vietnamese: Quyết định phê duyệt Kế hoạch hành động ứng phó với biến đổi khí hậu của ngành y tế giai đoạn 2019-2030 và tầm nhìn đến năm 2050]. Hanoi, Vietnam: Ministry of Health; 2018.
 20. UNFCCC Secretariat. *Compendium on Methods and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change.* Rio de Janeiro, Brazil: UNFCCC; 2005.
 21. CARE. *Community-Based Adaptation Toolkit.* CARE; 2010. http://www.managingforimpact.org/sites/default/files/resource/care_cba_toolkit_0.pdf.
 22. Foreman KJ, Marquez N, Dolgert A, et al. Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016-40 for 195 countries and territories. *Lancet.* 2018;392:2052-2090.
 23. Nguyen YT, Graitcer SB, Nguyen TH, et al. National surveillance for influenza and influenza-like illness in Vietnam, 2006-2010. *Vaccine.* 2013;31:4368-4374.
 24. World Health Organization. Update on the Dengue situation in the Western Pacific Region. <https://iris.wpro.who.int/bitstream/handle/10665.1/14329/Dengue-20190103.pdf>. Updated 2019. Accessed December 25, 2019.
 25. Global Burden of Disease. GBD Compare. <https://vizhub.healthdata.org/gbd-compare/heatmap>. Updated 2018. Accessed December 30, 2019.
 26. Pham HV, Doan HT, Phan TT, Minh NNT. Ecological factors associated with dengue fever in a Central Highlands province, Vietnam. *BMC Infect Dis.* 2011;11:172.
 27. Lee HS, Nguyen-Viet H, Nam VS, et al. Seasonal patterns of dengue fever and associated climate factors in 4 provinces in Vietnam from 1994 to 2013. *BMC Infect Dis.* 2017;17:218.
 28. Choi Y, Tang CS, McIver L, et al. Effects of weather factors on dengue fever incidence and implications for interventions in Cambodia. *BMC Public Health.* 2016;16:241.
 29. Hii YL, Zaki RA, Aghamohammadi N, Rocklöv J. Research on climate and dengue in Malaysia: a systematic review. *Curr Environ Health Rep.* 2016;3: 81-90.
 30. Thompson CN, Zelner JL, Nhu Tdo H, et al. The impact of environmental and climatic variation on the spatiotemporal trends of hospitalized pediatric diarrhea in Ho Chi Minh City, Vietnam. *Health Place.* 2015;35:147-154.
 31. Levison M, Butler A, Rebellato S, Armstrong B, Whelan M, Gardner C. Development of a climate change vulnerability assessment using a public health lens to determine local health vulnerabilities: an Ontario health unit experience. *Int J Environ Res Public Health.* 2018;15:2237.
 32. Rakotoarison N, Raholijao N, Razafindramavo L, et al. Assessment of risk, vulnerability and adaptation to climate change by the health sector in Madagascar. *Int J Environ Res Public Health.* 2018;15:2643.
 33. World Health Organization. *Protecting Health from Climate Change: Vulnerability and Adaptation Assessment.* Geneva, Switzerland: World Health Organization; 2013.
 34. McIver L, Kim R, Woodward A, et al. Health impacts of climate change in Pacific Island countries: a regional assessment of vulnerabilities and adaptation priorities. *Environ Health Perspect.* 2015;124:1707-1714.