

Embracing an environmental health approach to strengthen frontline healthcare in Southeast Asia

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Climate change is expected to disproportionately impact tropical regions including Southeast Asia. Proactive action is needed in such regions to mitigate future disruptions and bolster frontline healthcare. Our aim was to synthesize the existing relevant literature and outline novel strategies to mitigate environmental shocks to emergency medical care in Southeast Asia. We propose four main preventative interventions, including i) standardizing environmental health medical education, ii) improving integration of environmental data into healthcare workflows, iii) leveraging environmental data in medical predictive models, and iv) incorporating frontline healthcare into broader climate adaptation plans.

On a particularly hot and humid summer day, a bustling emergency department in Southeast Asia (SEA) has just received advanced warning that multiple patients are about to be brought in via ambulance; several are critically ill. When the patients arrive, the attending medical provider observes symptomologies of high fever, slurred speech, and altered mental status. The critically ill patients are largely unable to respond to questions, and over the course of their evaluation, the patients acutely decompensate. Stabilization, accurate diagnoses, and timely initiation of appropriate treatments are now essential.

As climate change, ecological degradation, and anthropogenic pollution continue to intensify environmental impacts on human health over the coming decades, emergency departments in SEA are likely to face an increased risk of climate-driven disaster scenarios like that described above. This is particularly concerning given that the region already i) contends with one of the highest burdens of acute illness,¹ ii) grapples with over-crowded hospitals and healthcare infrastructure deficiencies² and iii) experiences the highest estimated number of deaths due to climate change, including an estimated 2.4 million deaths per year from air pollution alone.³ Studies examining Thailand, Vietnam, and the Philippines have demonstrated recent increases as high as 61% in heat-related mortality attributable to climate change,⁴ as well as increased risks of hospitalization and mortality associated with extreme heat, cyclones, flooding, and droughts.⁵

In this article, we propose that one way to support frontline healthcare providers in SEA is to improve the availability and assimilation of local environmental data into clinical infrastructure. While the field of medicine has traditionally considered environmental exposures secondary to other, more established risk factors like genetics and

demographics (prominently featured today in many Electronic Medical Records), there is a growing appreciation for environmental factors as *primary* drivers of disease pathogenesis for many illnesses. These environmental drivers are projected to be particularly salient in SEA due to the region's austere climates and unique environmental phenomena, including:

- Monsoons & flooding → direct injury and exacerbation of precarious social conditions (loss of housing, unemployment, etc.)
- Tropical storms → direct injury and disruption of healthcare infrastructure
- Water shortages → malnutrition and food instability
- Heat waves → increased heat-related mortality
- Vector-borne disease range shifts → fluctuating morbidity of malaria and dengue.

Despite the diagnostic relevance of environmental exposures, especially in SEA, these variables are currently not systematically considered in most healthcare triage or diagnostic processes, nor are their effects appropriately conveyed to future healthcare professionals in medical curricula. The underutilization of environmental data in healthcare is likely driven by historical inertia and limited understanding of environmental health amongst the general population. Recognizing this problem, the World Health Organization (WHO) has provided several resources with strategic guidance for how policymakers, healthcare systems, and individual healthcare providers can each contribute.^{6,7} Taking all of these data into account, we propose several concrete steps that should be taken in SEA, specifically to bolster frontline patient care from an environmental health perspective:

1. **Short-term: Standardize environmental health topics in SEA medical curricula and emergency medicine training programs.** While this solution alone would largely preserve the status quo, under which the cognitive burden of clinical management falls entirely on healthcare providers, it would at least help clinicians better appreciate the underlying environmental risk factors of common diseases and ultimately communicate more effectively with their patients to encourage effective, climate-conscious, healthy behaviors. This measure should be implemented in the short term, using standardized lectures, modules, and activities, to bridge the gap to more systemic cross-sectoral solutions.^{6,8}
2. **Short-term: Improve the accessibility and visibility of environmental data to frontline providers.** Concrete demonstrations of this solution include i) introducing regional online early warning systems to alert providers of severe flooding, high temperatures, dangerous air pollution levels, and other climate risks, ii) disseminating weekly briefs that track environmental health trends and explain potential clinically significant consequences (e.g., a 10% weekly increase in avian influenza seropositivity in local livestock should raise clinical suspicion for H5N1 infection in local farm workers presenting with consistent symptoms), and iii) integrating environmental data into EMR alerts.⁹ The ethos of these measures aimed at increasing visibility of environmental data in acute care settings is analogous to that of Atul Gawande's checklist manifesto, which famously reduced errors and universally improved outcomes in surgical operations.¹⁰
3. **Long-term: Build and leverage predictive models that use environmental data to:**
 - a. **Guide individualized patient care.**
Analogous endeavors using non-environmental data have already been piloted in the region for clinical purposes (e.g., early sepsis prediction in Bangkok).¹¹ And as the medical field's understanding of how environmental exposures influence communicable and noncommunicable disease risks continues to improve, environmental models can be fit, validated, and implemented to aid rapid triage, diagnostic reasoning, and treatment planning for individual patients. Such models could assimilate vague, nonspecific symptoms, such as those described in the patients at the beginning of this paper, and local environmental conditions to weigh the likelihood of possible diagnoses; for instance, a higher likelihood of heat stroke if the ambient temperature is high vs. meningoenzephalitis if there are reports of circulating Nipah virus. The potential of such models to accelerate treatment is critical for high-acuity patients, for whom time to initial treatment is often directly and inversely correlated with ultimate prognosis.
 - b. **Bolster healthcare system-level preparedness & resilience.**

Models using the same environmental exposure data can also be used to improve acute care *systems*.¹² For instance, hospitals can i) effectively order, based on model-generated predictions, and store medical supplies (blood transfusions, antibiotics, generator fuel, etc.) ahead of anticipated climate disruptions, ii) temporarily increase the number of providers and available beds during periods with anticipated higher patient volumes (e.g., during extreme heat waves), and iii) relocate supplies & patients before significant climate disasters (e.g., tropical storms, droughts, etc.) to avoid having to make reactive decisions *during* and *after* emergencies have begun.

4. **Long-term: Incorporate prehospital and hospital systems into broader climate adaptation and mitigation strategies at local and national levels.** Prioritizing resilient emergency medical systems and infrastructure, with sufficient funding, will allow frontline providers in SEA countries to deliver higher-quality care while limiting disruptions and impacts from extreme weather events.⁹

Integrating an environmental health framework into frontline healthcare in Southeast Asia is undoubtedly challenging, but it has the potential to significantly improve patient care and clinical outcomes in a region uniquely vulnerable to environmental conditions. Appropriate implementation of several of the interventions proposed in this article (e.g., integrating environmental data into rudimentary local EMR systems) will require significant intellectual and financial capital investments. These may pose significant barriers to regional governments and organizations that are already forced to contend with multiple important and competing economic interests.¹³ Coordinated global efforts, including contributions from non-governmental organizations, will therefore be critical in preventing exacerbation of poverty and healthcare inequalities in a region where the downstream socioeconomic burdens of climate change are expected to concentrate most heavily.^{14, 15}

Of note, while SEA was treated as a monolith for this paper because of its shared vulnerability to climate change, there is significant diversity among the healthcare systems, governments, and economies of individual SEA countries.^{16,17} Circumstances unique to each SEA country must be considered when constructing local environmental health infrastructure. For instance, whereas the Philippines and Vietnam might concentrate on typhoon mitigation, other countries like Indonesia might instead prioritize earthquake detection and response infrastructure.¹⁷ Regardless of the individual approaches taken, given that the region already faces climate change and the exacerbation of climate-driven health risks, implementation of the core measures outlined in this article must be considered an urgent priority.

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POSITIONALITY STATEMENTS

KEENAN DUGGAL

The primary author of this manuscript is an American medical school student with a background in climate change research. Of the other three authors, one is an American physician (practicing in NYC), and the other two are Thai physicians (practicing in Bangkok). The opinions reflected in this perspective article, while not immune to bias, represent the shared, cross-cultural opinions of all authors after extended in-person and remote collaboration and discourse. Additionally, efforts were made to ensure that claims made in this essay were rigorously supported by scientific evidence.

AARON HULTGREN, MD, MAT, MPH, DCM, FAWM

As one of the authors of this study, I acknowledge my standpoint as a White American cisgender man who lives and practices emergency medicine in the United States. Throughout my academic career, I have incorporated global health into my career, collaborating with colleagues in Thailand. More recently, I was the first cohort of health professionals to complete the Diploma in Climate Medicine from the Climate and Health Program at the University of Colorado. I have observed the impacts of extreme heat, air pollution, wildfires, and hurricanes on my patients and community in New York. My interest in the climate's impacts on Bangkok and Thai patients draws on my interactions and experiences with Thai family members and colleagues. I have also witnessed climate impacts on my Thai family members, including the effects of extreme heat, air pollution, and flooding in Bangkok. This project was an opportunity to collaborate with Thai emergency medicine colleagues to learn about the impacts on their emergency department. I was excited to collaborate with our Thai research team to learn about the impacts of climate on their community and hospital, and share our knowledge and skills to investigate the impacts of air pollution on an urban

emergency medicine hospital in Bangkok, a population and community to which I am personally connected.

KHRONGWONG MUSIKATAVORN, MD

As the Head of an Emergency Department in a large hospital in Bangkok, Thailand, my perspective is shaped by clinical leadership in the geographical area vulnerable to air pollution and the health impacts of climate change. I routinely observe the effects of urban air pollution, extreme heat, and climate-sensitive infectious diseases on emergency department presentations, including acute exacerbations of respiratory and cardiovascular conditions, heat-related illness, and surges in patient volume during environmental crises. These impacts disproportionately affect children, older adults, outdoor workers, and socioeconomically marginalized populations. While my expertise is rooted in emergency medicine rather than environmental science, my position provides a frontline view of how environmental degradation and increasing temperature strain emergency care systems with limited surge capacity. With the constraints of institutional resources and regional health inequities, I assert that emergency medicine in Southeast Asia has a critical role in surveillance, preparedness, advocacy, and adaptation to mitigate the escalating health consequences of air pollution and climate change.

NORAWIT KIJPAISALRATANA, MD

I write from the positionality of a data scientist and practicing emergency physician in Thailand. My perspective is informed by routine emergency care and the analysis of routinely collected clinical and environmental data. Using time-series and observational methods, I have examined associations between PM_{2.5} levels, ambient temperature, and emergency department volume and case mix. Clinically, I observe the increases in respiratory and cardiovascular exacerbations and heat-related illness during periods of poor air quality and extreme heat. While not trained in climate science, my dual role enables integration of clinical experience with data-driven evidence on the health impacts of air pollution and global warming.

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