Ministry of Health of Viet Nam
Pasteur Institute in Ho Chi Minh City

Prospect of Geo-mapping application in Vector-borned diseases control

Do Kien Quoc, MPH

Pasteur Institute in Ho Chi Minh City

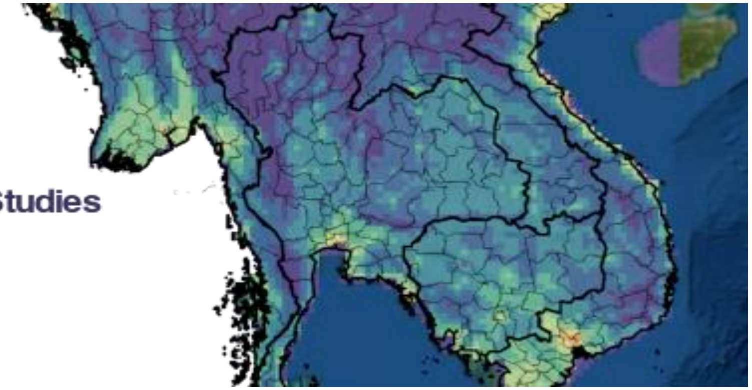
OHSEA

GeoOneHealth 2022

South-East Asia

Symposium on Geospatial Approaches in One Health Studies

5 December 2022, Phnom Penh, Cambodia



IRD Institut de Recherche pour le Développement FRANCE
French National Research Institute for Sustainable Development

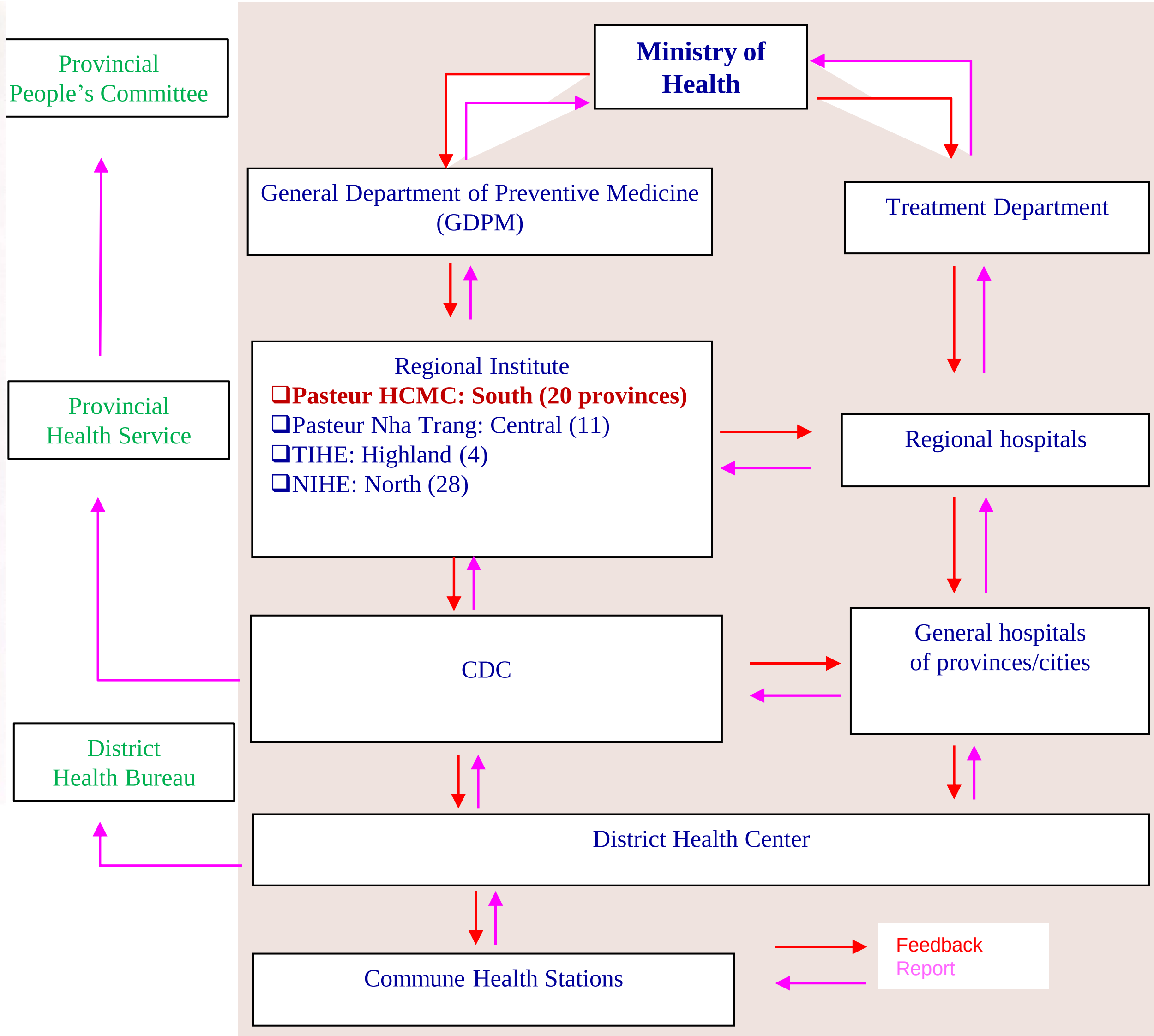
Institut Pasteur du Cambodge

SMRU. Shoklo Malaria Research Unit

Contents

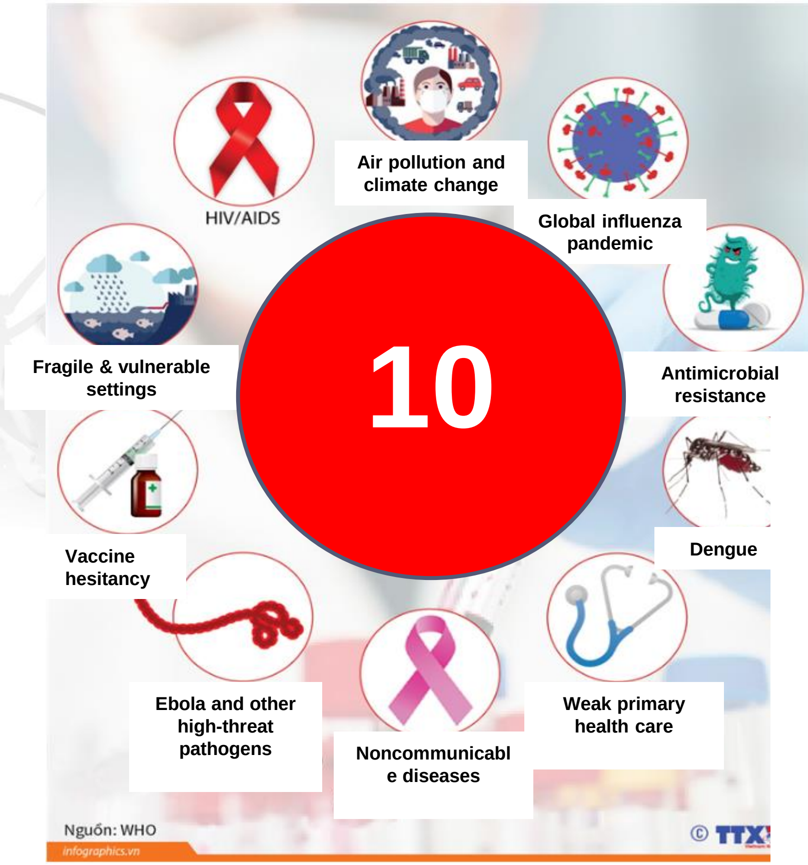
Introduction

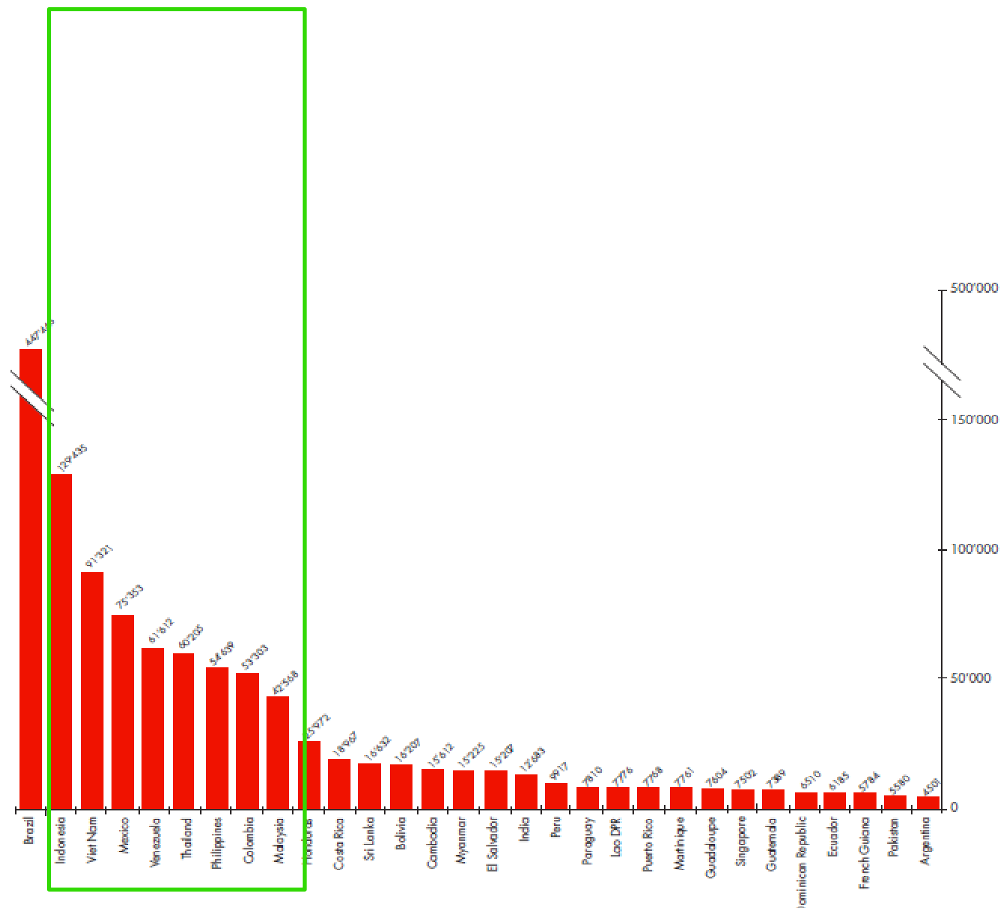
Health care system in Vietnam



Dengue situation

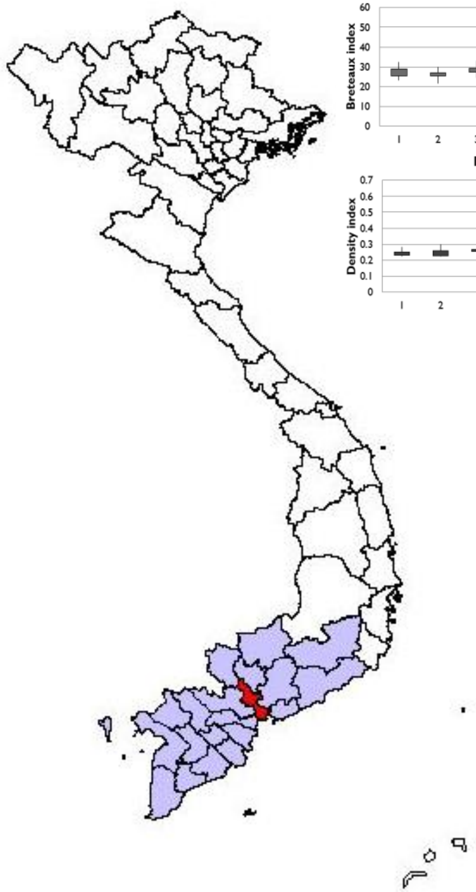
Situation

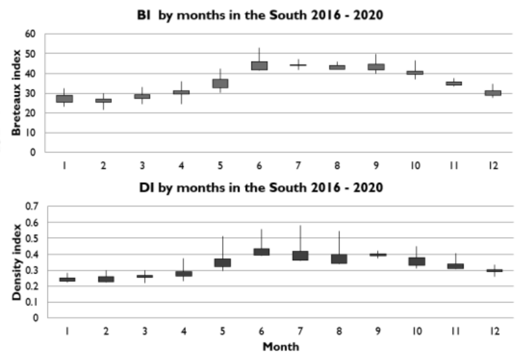




Source: Global Strategy for dengue prevention and control, 2012–2020 (WHO)
http://apps.who.int/iris/bitstream/10665/75303/1/9789241504034_eng.pdf

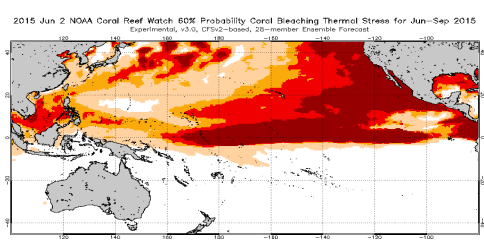
Situation

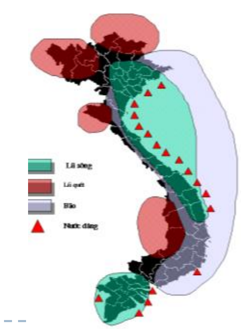




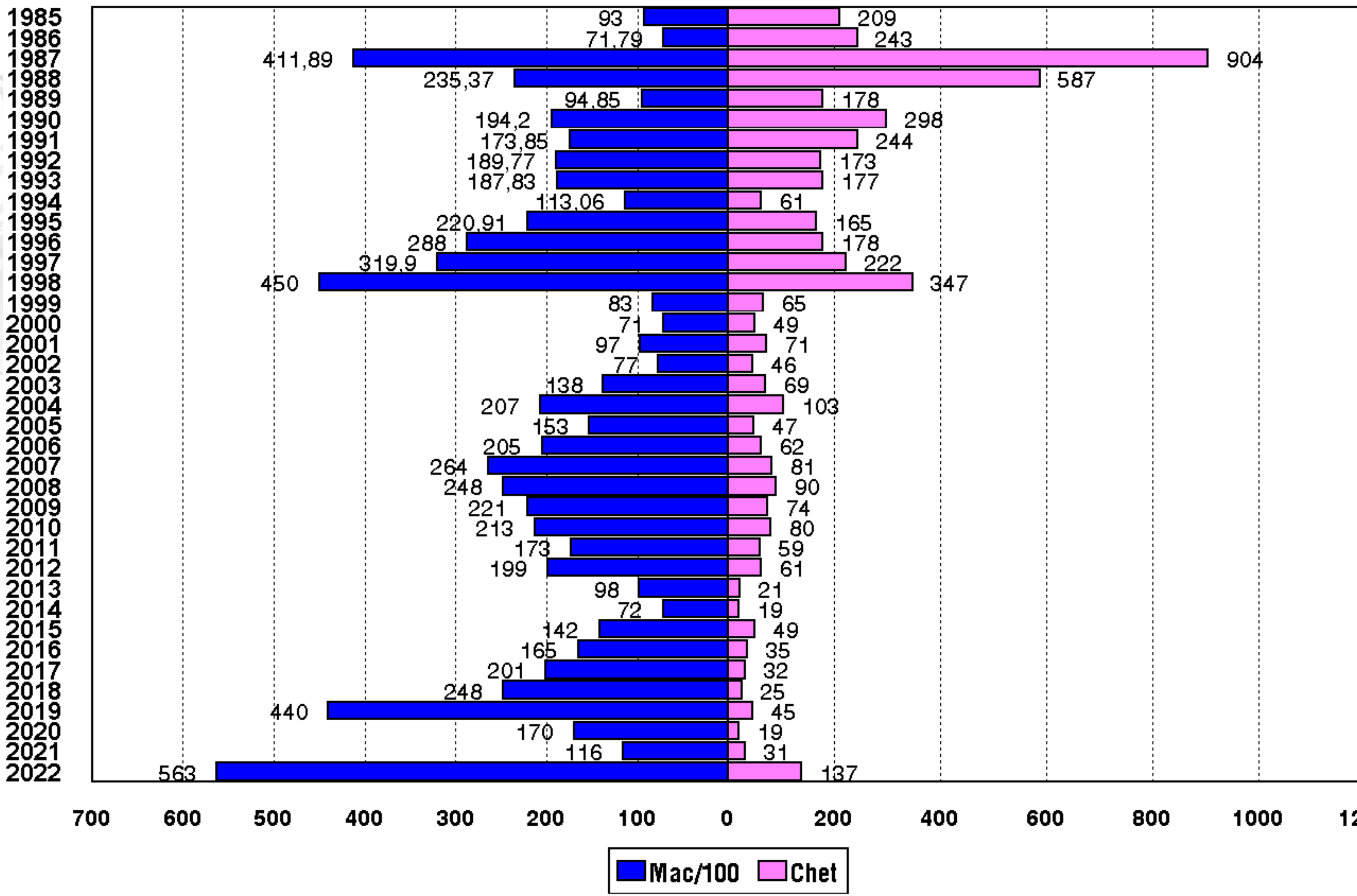
The South in compare to VN

- ❑ 75% Dengue cases
- ❑ >90% Dengue deaths
- ❑ 96% Zika confirmed cases
- ❑ 100% CHIK confirmed cases

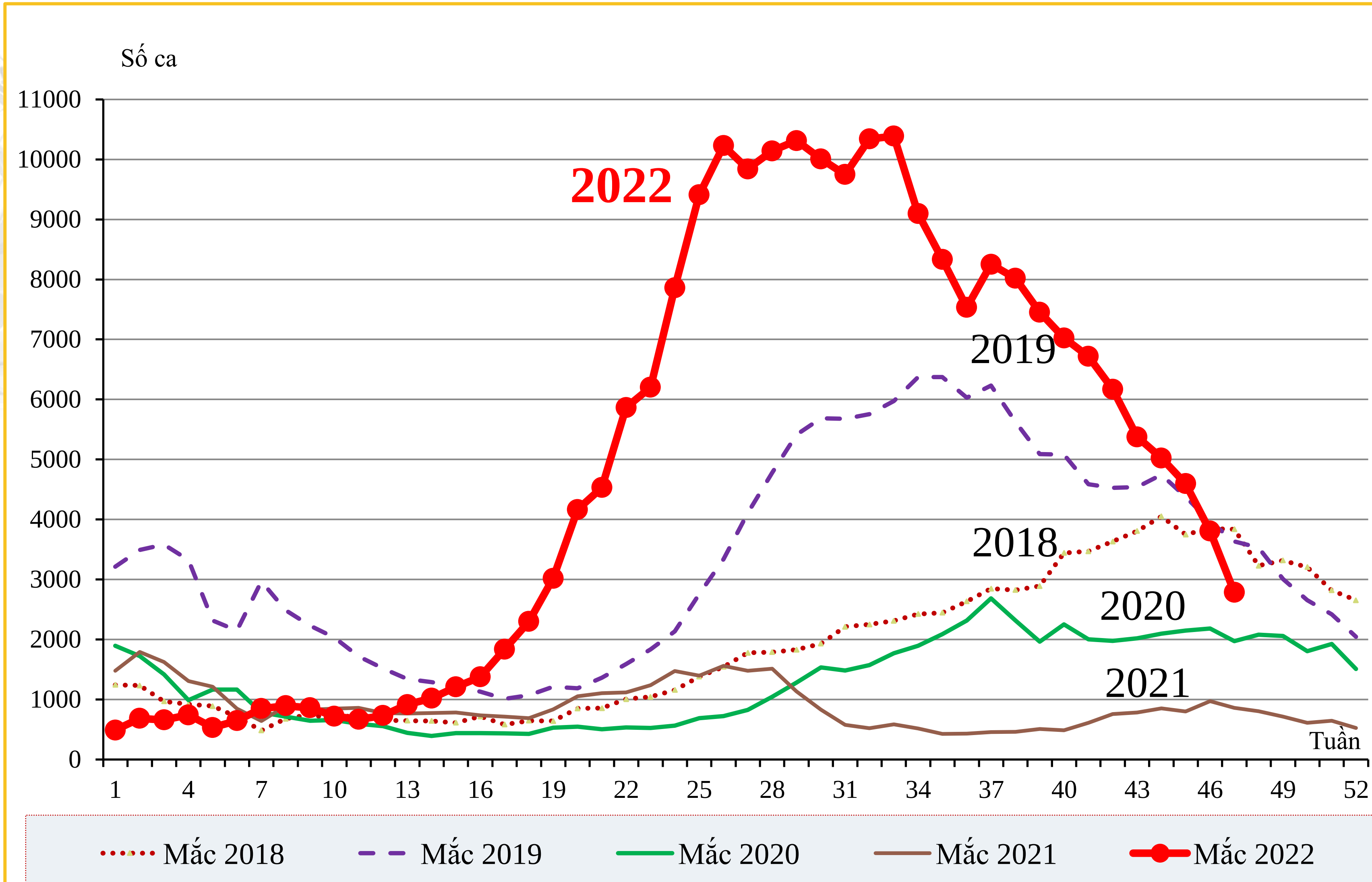




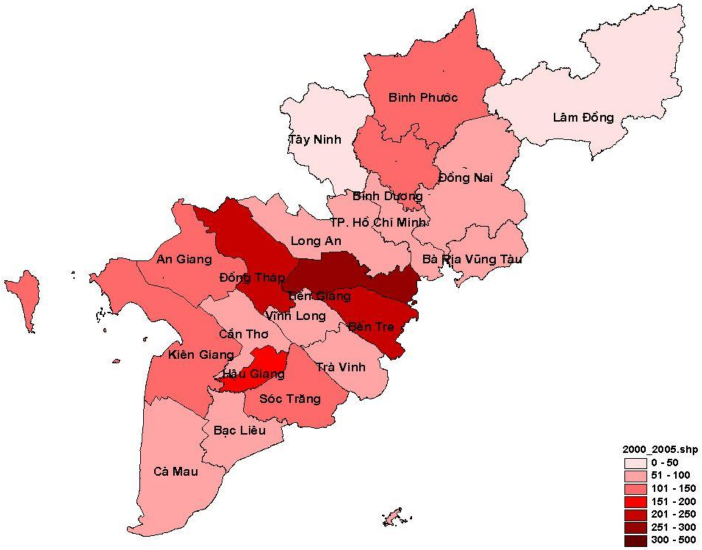
Morbidity and number of death of Dengue in Southern Vietnam 1985 – 2022

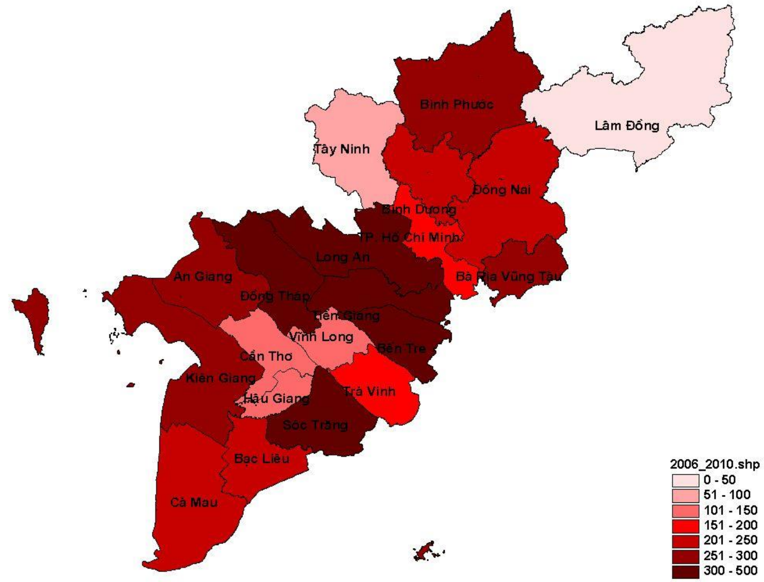


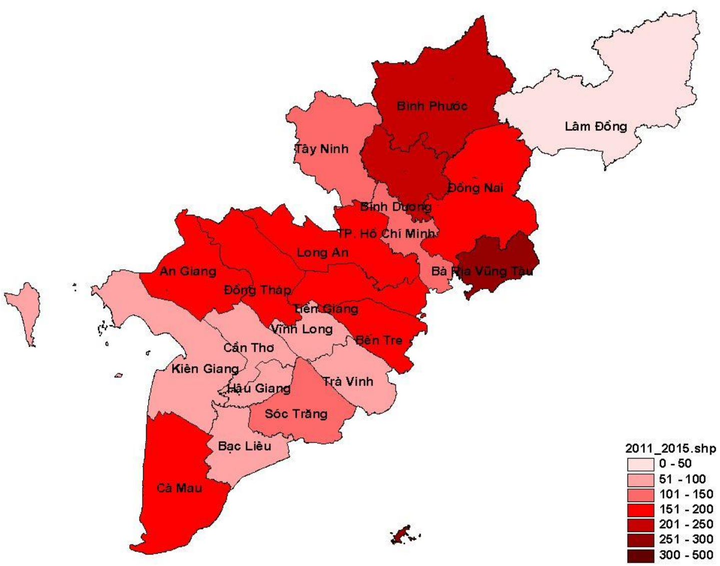
Distribution of dengue cases by weeks

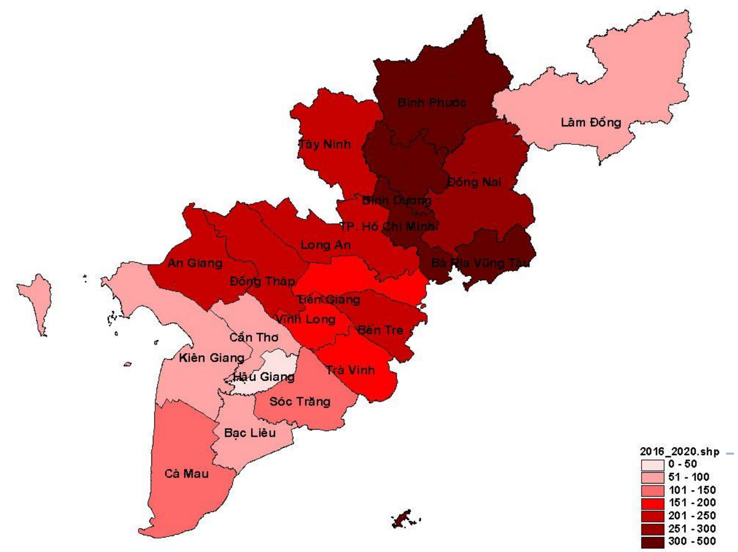


Distribution of dengue cases by provinces



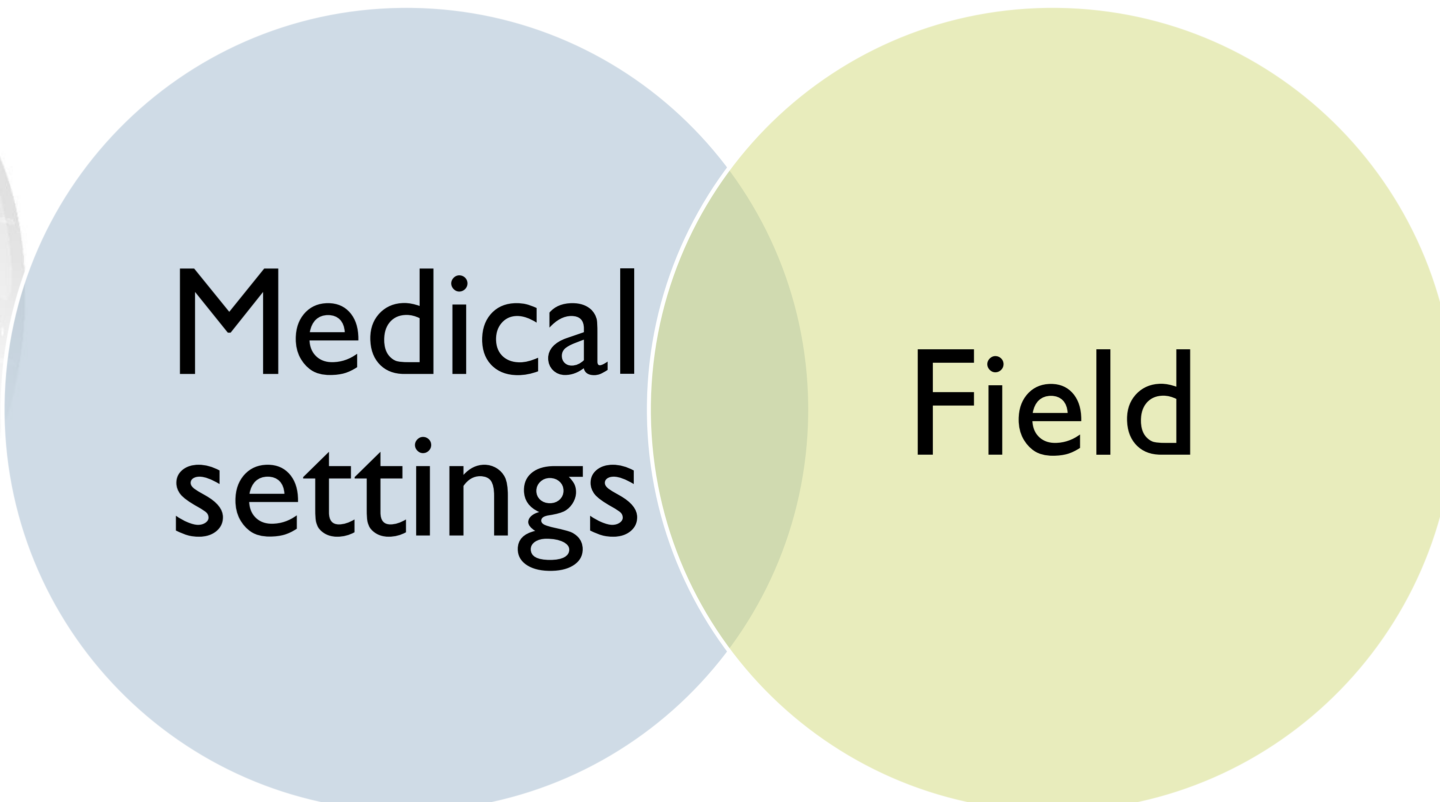






Surveillance system

Principles



Current dengue surveillance system

As a passive surveillance system enhanced by laboratory, including:

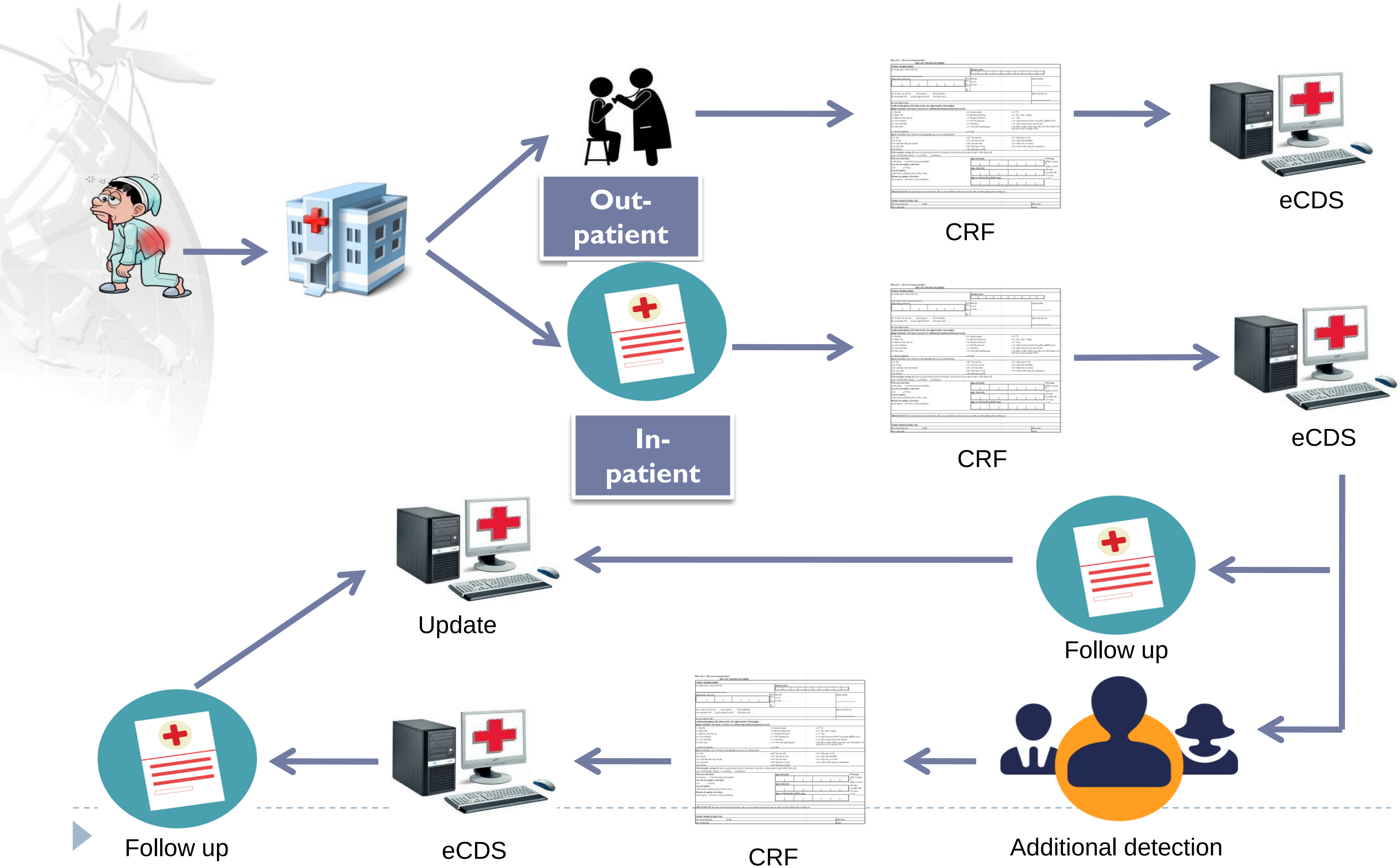
- Epidemiology surveillance
  - Daily/weekly/monthly report of inpatient clinical case
  - Line listing of cases
- Laboratory surveillance
  - 7% of clinical dengue case for MAC-ELISA
  - 3% of clinical dengue case for virus isolation
  - Randomly collected in all hospitals
- Entomology surveillance: monthly survey
  - 1 sentinel point of each district

Current sentinel surveillance system

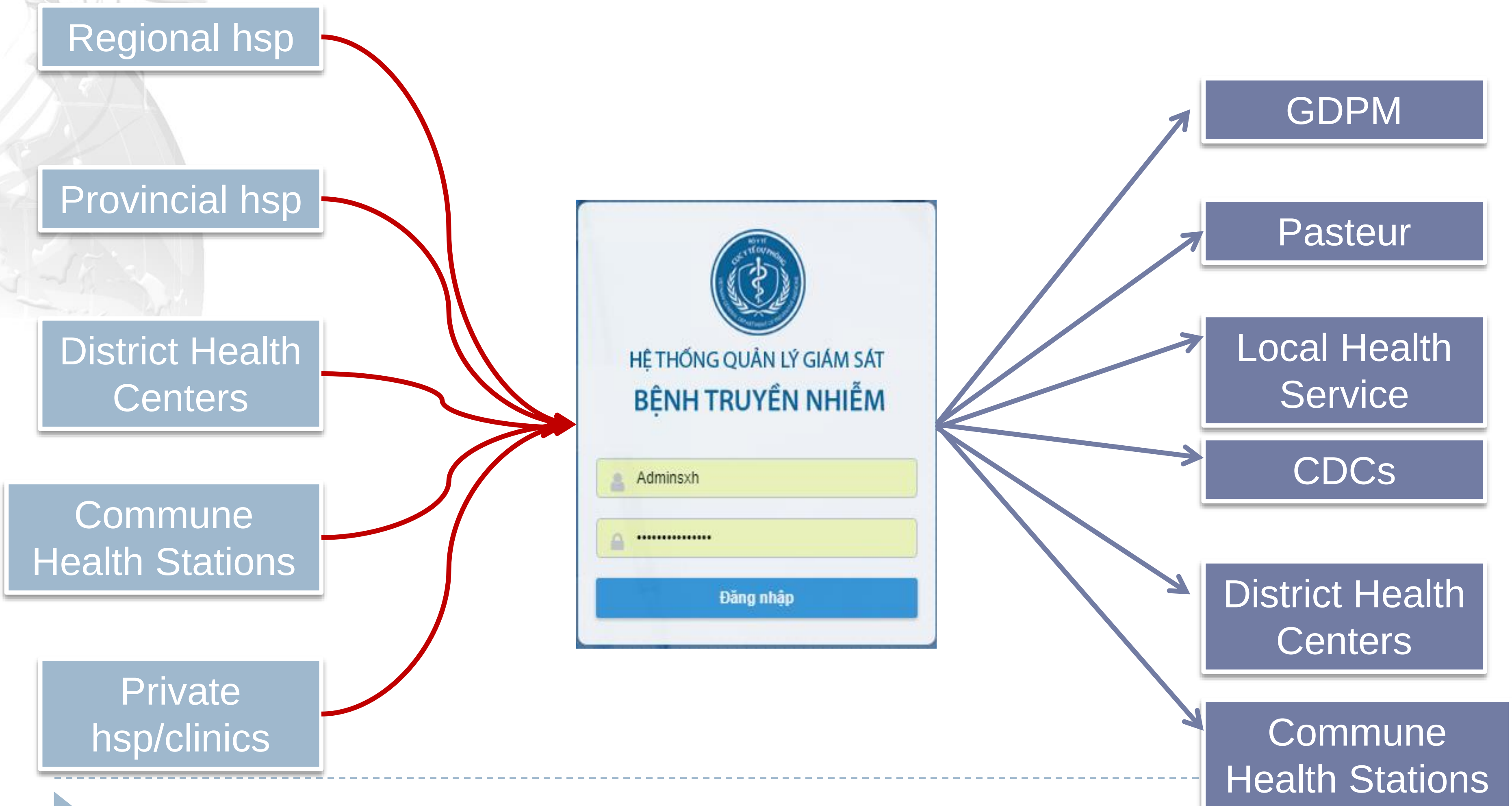
In order to determine Dengue pattern

- Implementing all of 3 types of dengue surveillance in 1 site
- Sentinel site: 1 district / province
- Case and virology surveillance for all dengue cases in district hospital
  - Collect epidemiological and clinical information
  - Collect blood for testing: NS1 (≤ 5 days of illness), ME (> 5 days)
  - Feedback NS1 testing result within 30 minutes for case management and outbreak control
- Monthly entomology survey in representative site

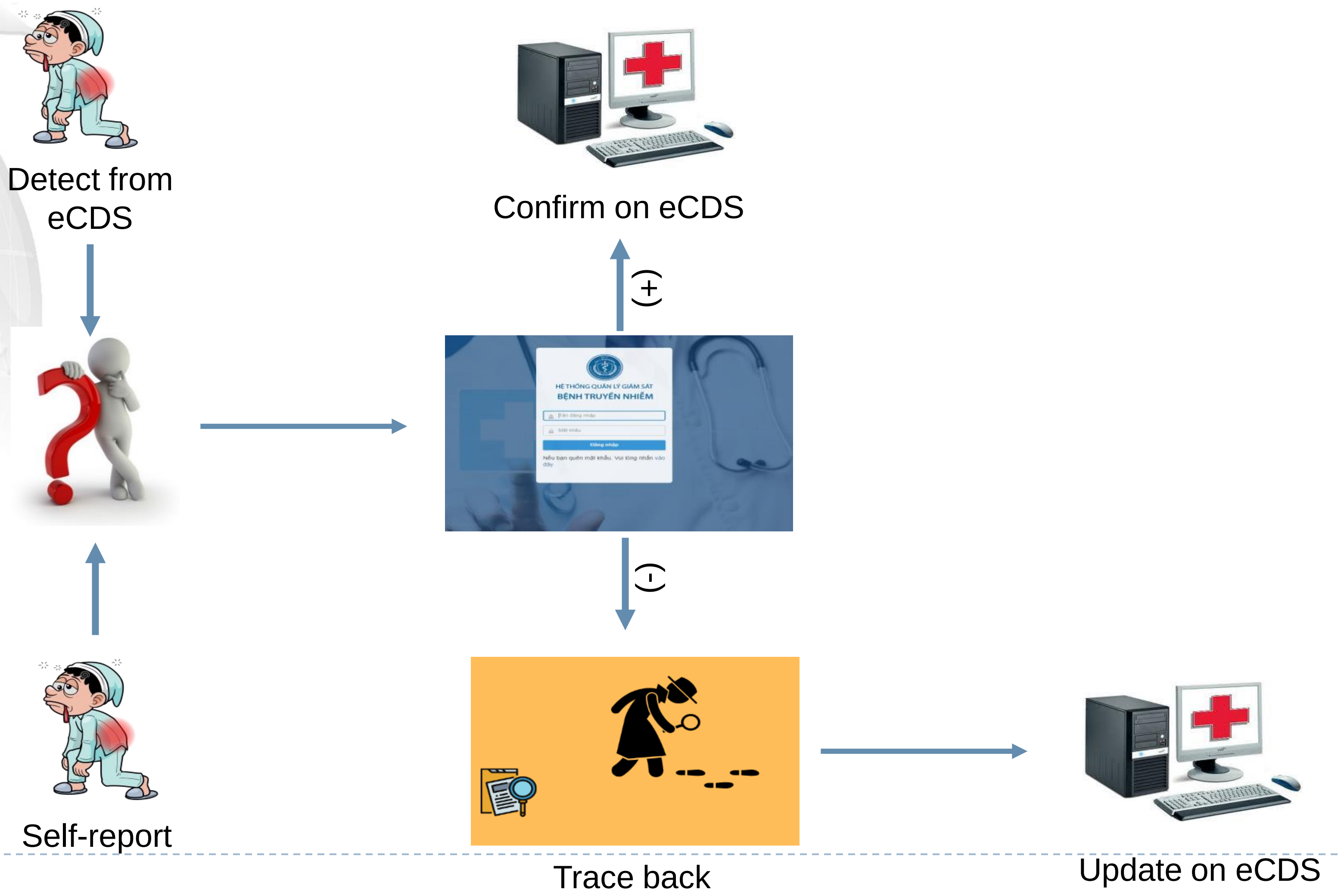
In hospital


Out-patient
CRF
eCDS
In-patient
CRF
eCDS
Update
Follow up
Follow up
eCDS
CRF
Additional detection

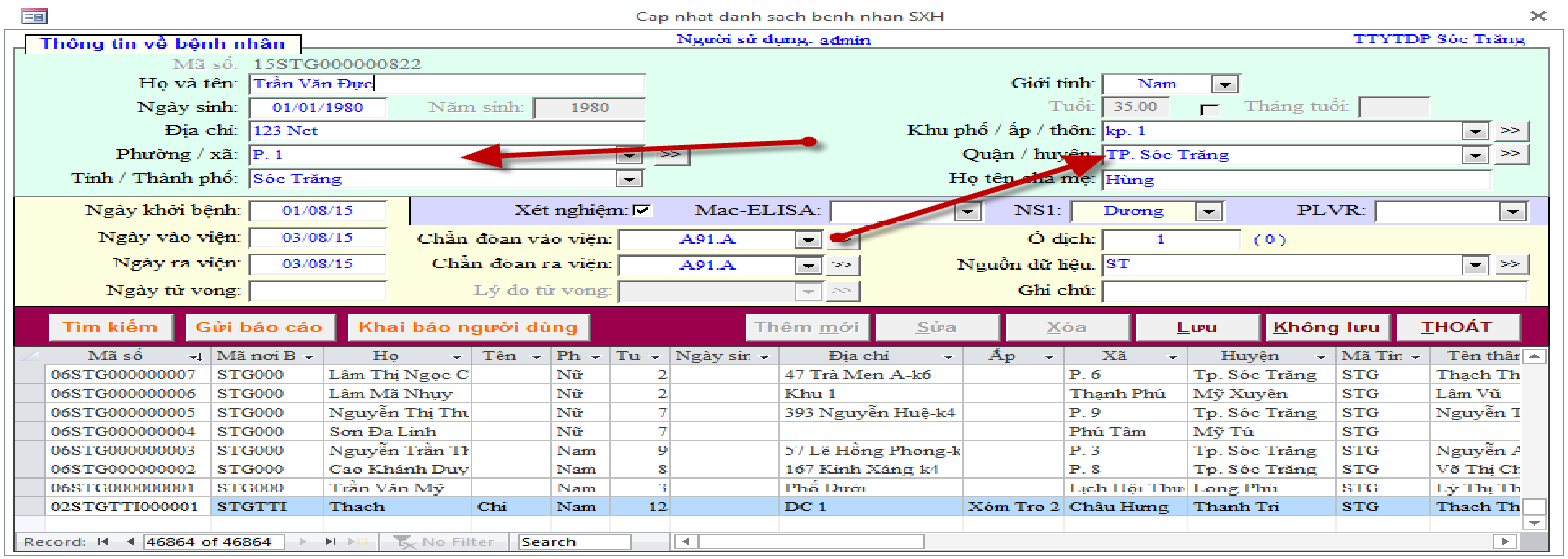
In hospitals



In the field


Detect from eCDS
Confirm on eCDS
HỆ THỐNG QUẢN LÝ GIÁM SÁT
BỆNH TRUYỀN NHIỄM
Self-report
Trace back
Update on eCDS

Data management and report



Mã số	Mã nơi B	Họ	Tên	Ph	Tu	Ngày sir	Địa chỉ	Ấp	Xã	Huyện	Mã Tir	Tên thâr
06STG000000007	STG000	Lâm Thị Ngọc C		Nữ	2		47 Trà Men A-k6		P. 6	Tp. Sóc Trăng	STG	Thạch Th
06STG000000006	STG000	Lâm Mã Nhụy		Nữ	2		Khu 1		Thạnh Phú	Mỹ Xuyên	STG	Lâm Vũ
06STG000000005	STG000	Nguyễn Thị Thu		Nữ	7		393 Nguyễn Huệ-k4		P. 9	Tp. Sóc Trăng	STG	Nguyễn T
06STG000000004	STG000	Sơn Đa Linh		Nữ	7				Phú Tâm	Mỹ Tú	STG	
06STG000000003	STG000	Nguyễn Trần Tl		Nam	9		57 Lê Hồng Phong-k		P. 3	Tp. Sóc Trăng	STG	Nguyễn A
06STG000000002	STG000	Cao Khánh Duy		Nam	8		167 Kinh Xáng-k4		P. 8	Tp. Sóc Trăng	STG	Võ Thị Ch
06STG000000001	STG000	Trần Văn Mỹ		Nam	3		Phố Dưới		Lịch Hội Thư	Long Phú	STG	Lý Thị Th
02STGTTI000001	STGTTI	Thạch	Chi	Nam	12		DC 1	Xóm Tro 2	Châu Hưng	Thạnh Trị	STG	Thạch Th

Data management and report

BAN ĐIỀU HÀNH DỰ ÁN PHÒNG CHỐNG CÁC BỆNH LÂY NHIỄM THÀNH PHẦN PCSXH KVPN

VIỆN PASTEUR TP. HỒ CHÍ MINH

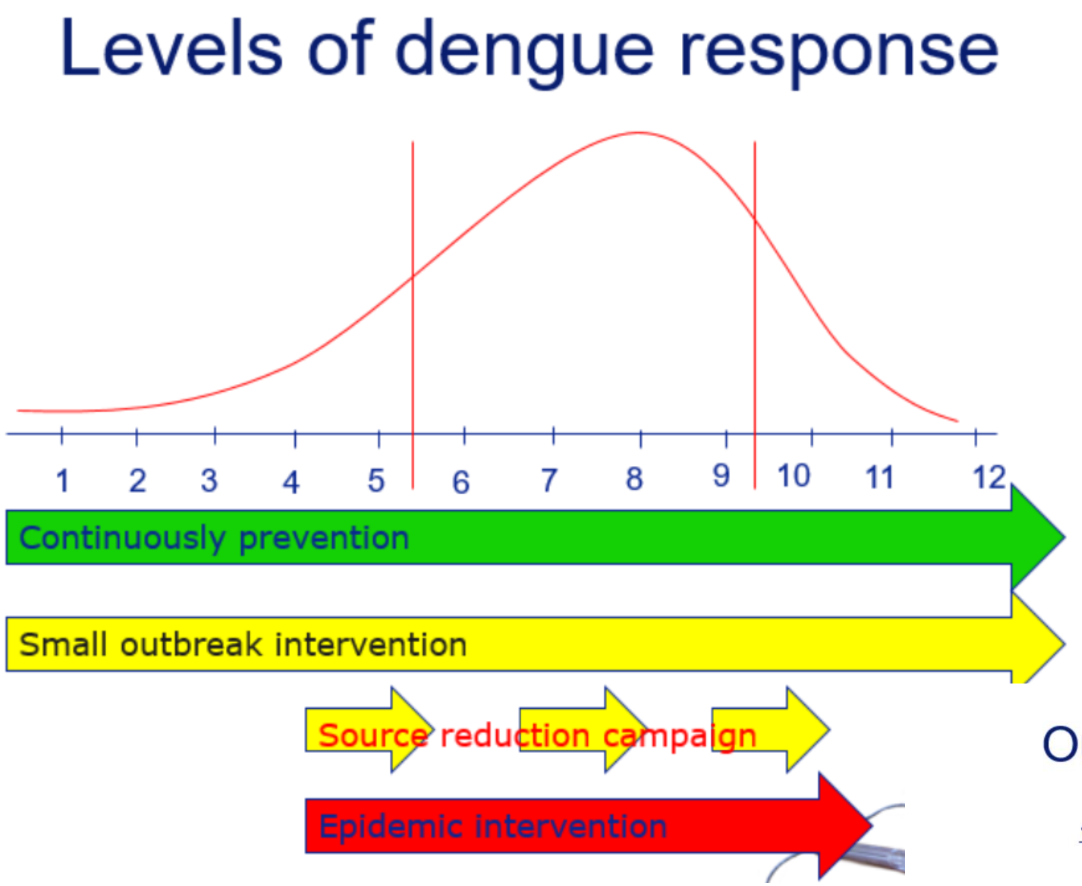
BÁO CÁO TUẦN BỆNH SỐT XUẤT HUYẾT DENGUE

Tuần **44** từ ngày ***27-10-1900*** đến ngày ***02-11-1900***

Stt	Địa phương	MẮC								CHẾT		
		SXHD/SXHD có cảnh báo			SXHD nặng			TS	CD	TS	≤15t	CD
		Tông	≤15t	CD	Tông	≤15t	CD					
1	TP. Cao Lãnh											
2	TX. Sa Đéc											
3	H. Cao lãnh											
4	H. Tháp Mười											
5	H. Thanh Bình											
6	H. Tam Nông											
7	H. Hồng Ngự											
8	H. Tân Hồng											
9	H. Lấp Vò											
10	H. Lai Vung											
11	H. Châu Thành											
12	TX. Hồng Ngự											
13												
14												
15												
Tổng cộng												

Mapping application

Mapping application



Mapping application

JOHN SNOW

Doctor

He shares the name with a famous TV character but should be famous for other reasons. He was the one who mapped the Cholera outbreak in London in 1854. His finding led to a public health overhaul around the world.

Mapping application

The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

FOSSIL-FUEL POLLUTION AND CLIMATE CHANGE

Caren G. Solomon, M.D., M.P.H., *Editor*, and Renee N. Salas, M.D., M.P.H., *Guest Editor*

Climate Change and Vectorborne Diseases

Madeleine C. Thomson, Ph.D., and Lawrence R. Stanberry, M.D., Ph.D.

THE EFFECTS OF CLIMATE CHANGE ARE WIDESPREAD AND RAPIDLY INtensifying and are largely driven by greenhouse-gas emissions from burning fossil fuels.[1] Global mean temperatures have already increased by 1.1°C since 1900,[1] with most of the change having occurred in the past 50 years. The extent of change is most extreme in highland and polar regions (Fig. 1), and temperatures in tropical regions are creeping closer to the thermal limits of many organisms. Given the current policies and actions, a warming of 2.5°C to 2.9°C or more by the end of this century is expected.[2]

Warming and other manifestations of climate change — including changes in precipitation, with increased flooding in some areas and drought in others — have important implications for vectorborne diseases through their effects on pathogens, vectors, and hosts, as well as on our ability to prevent and treat these diseases (Fig. 2). Yet attributing changes in the distribution and frequency of vectors and diseases to climate change is challenging because other factors, including

CLIMATE-SENSITIVE VECTORBORNE DISEASES

The Intergovernmental Panel on Climate Change reported with high confidence that the prevalence of vectorborne diseases has increased in recent decades and that the prevalences of malaria, dengue, Lyme disease, and West Nile virus infection in particular are expected to further increase during the next 80 years if measures are not taken to adapt and strengthen control strategies.[1] Table 1 describes these and additional examples of vectorborne diseases that are responding to a changing climate. Additional details are provided in Figure S1 in the Supplementary Appendix, available with the full text of this article at NEJM.org.

gue virus are transmitted between humans — the primary reservoir host — by infected female mosquitoes, most commonly *Aedes aegypti* and *A. albopictus*. Water-storage containers, which are commonly used in regions where a piped water supply is inadequate, or rainwater-filled containers (e.g., tires, pots, and tree holes) can become mosquito breeding sites and can thus drive epidemics.[31] Transovarial transmission of dengue virus (from female mosquitoes to their offspring) and the long-distance dispersal of drought-resistant aedes eggs in suitable containers facilitate efficient expansion of the virus worldwide.[32] The northward expansion of *A. aegypti* and *A. albopictus* thus far is best explained by human movement patterns within regions in which the climatic conditions are suitable for geographic expansion; however, by 2030, the dominant cause of expansion of these vectors is pre-

OPEN ACCESS Freely available online PLoS NEGLECTED TROPICAL DISEASES

The Role of Human Movement in the Transmission of Vector-Borne Pathogens

Steven T. Stoddard[1]*, Amy C. Morrison[1], Gonzalo M. Vazquez-Prokopec[2], Valerie Paz Soldan[3], Tadeusz J. Kochel[4], Uriel Kitron[2], John P. Elder[5], Thomas W. Scott[1]

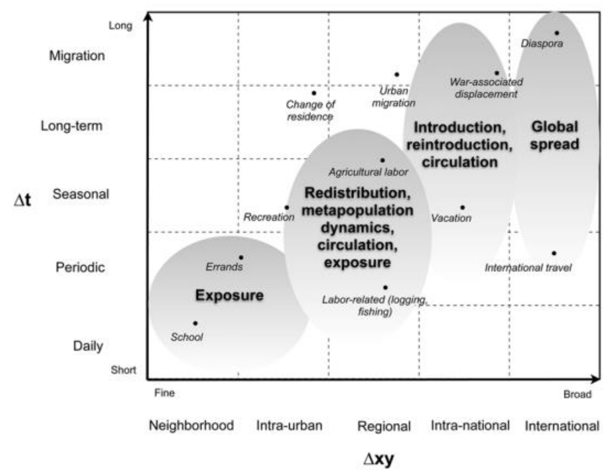
1 Entomology, University of California, Davis, California, United States of America, 2 Department of Environmental Studies, Emory University, Atlanta, Georgia, United States of America, 3 Tulane University, New Orleans, Louisiana, United States of America, 4 United States Naval Medical Research Center Detachment, Lima and Iquitos, Peru, 5 Graduate School of Public Health, San Diego State University, San Diego, California, United States of America

Abstract

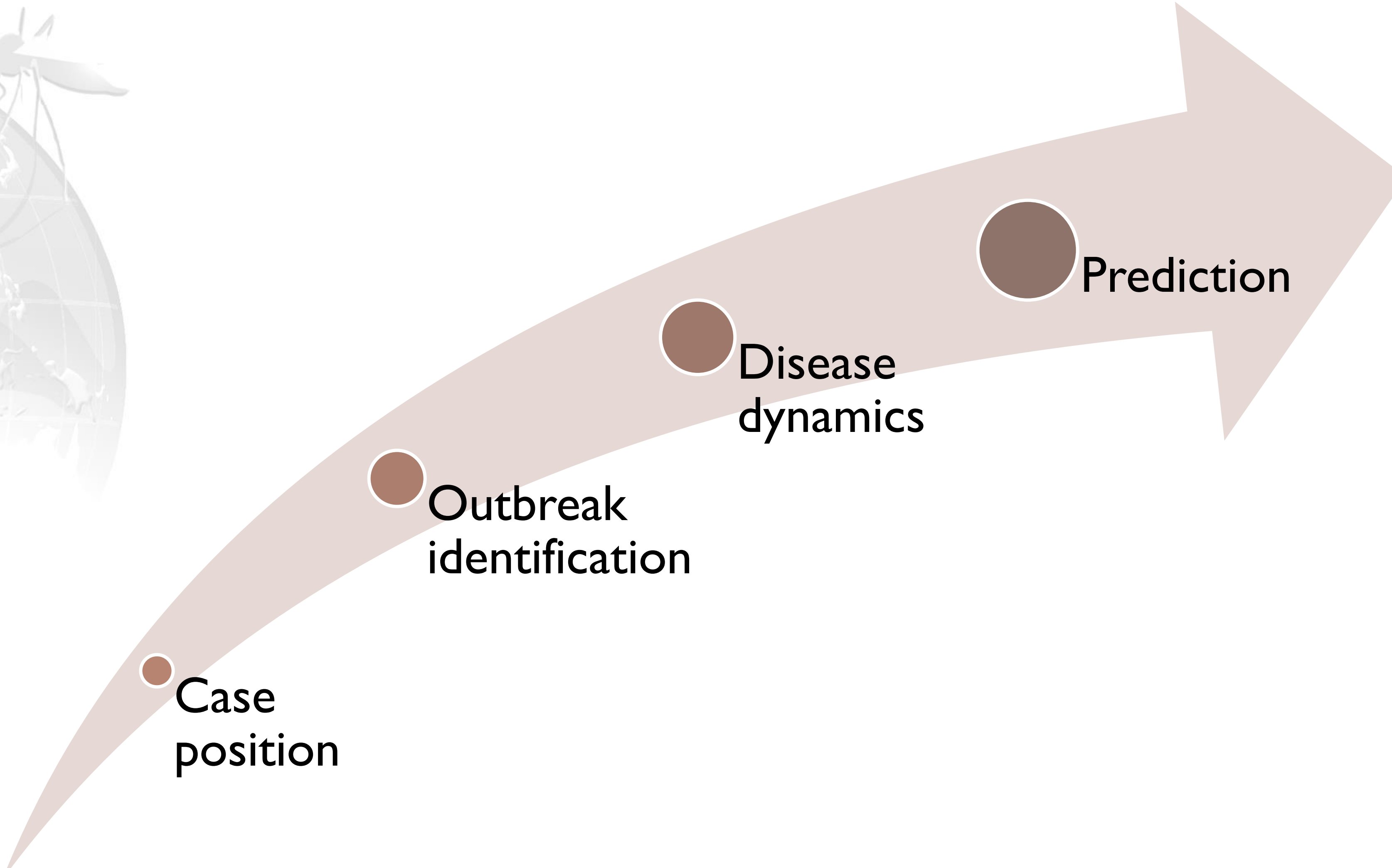
Background: Human movement is a key behavioral factor in many vector-borne disease systems because it influences exposure to vectors and thus the transmission of pathogens. Human movement transcends spatial and temporal scales with different influences on disease dynamics. Here we develop a conceptual model to evaluate the importance of variation in exposure due to individual human movements for pathogen transmission, focusing on mosquito-borne dengue virus.

Methodology and Principal Findings: We develop a model showing that the relevance of human movement at a particular scale depends on vector behavior. Focusing on the day-biting *Aedes aegypti*, we illustrate how vector biting behavior combined with fine-scale movements of individual humans engaged in their regular daily routine can influence transmission. Using a simple example, we estimate a transmission rate (R_0) of 1.3 when exposure is assumed to occur only in the home versus 3.75 when exposure at multiple locations—e.g., market, friend's—due to movement is considered. Movement also influences for which sites and individuals risk is greatest. For the example considered, intriguingly, our model predicts little correspondence between vector abundance in a site and estimated R_0 for that site when movement is considered. This illustrates the importance of human movement for understanding and predicting the dynamics of a disease like dengue. To encourage investigation of human movement and disease, we review methods currently available to study human movement and, based on our experience studying dengue in Peru, discuss several important questions to address when designing a study.

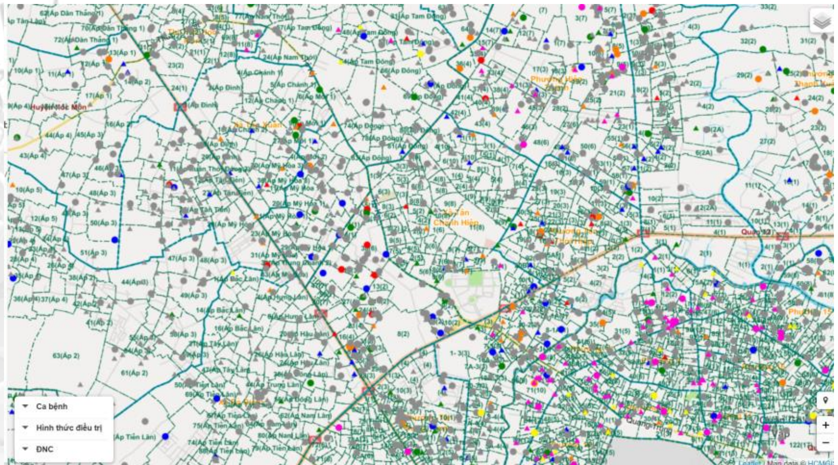
Conclusions/Significance: Human movement is a critical, understudied behavioral component underlying the transmission dynamics of many vector-borne pathogens. Understanding movement will facilitate identification of key individuals and sites in the transmission of pathogens such as dengue, which then may provide targets for surveillance, intervention, and improved disease prevention.

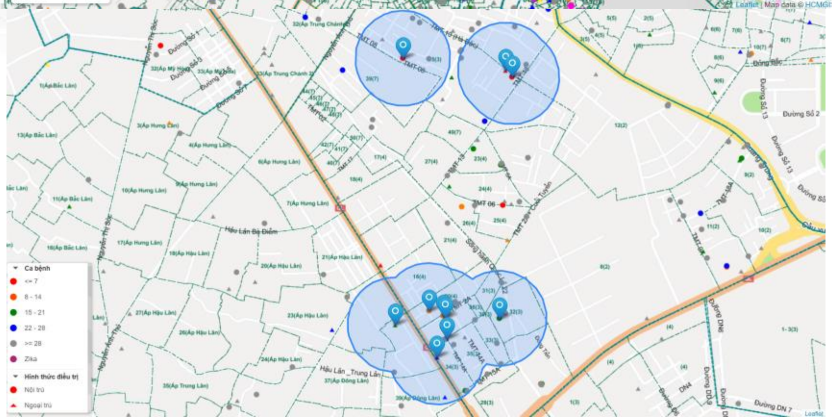


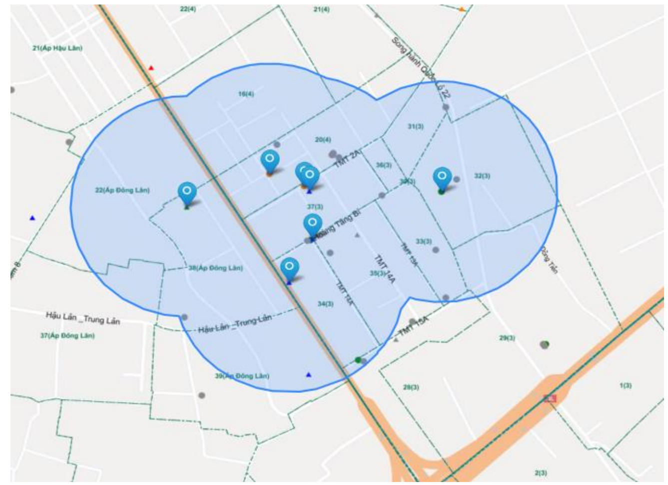
Mapping application



Mapping application



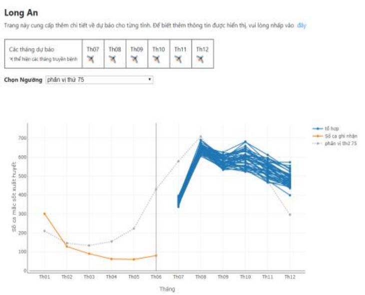




- ❑ Suitable for case intervention
- ❑ Could not be described by:
  - ❑ Spatial-temporal dynamics
  - ❑ Risk factors
- ❑ Un-suitable for indicating large scale intervention

Mapping application

Stt	Địa phương	MẮC								CHẾT		
		SXHD & SXHD có cảnh báo			SXHD nặng			TS mắc	CD mắc	TS	≤15t	CD
		Tổng	≤15t	CD	Tổng	≤15t	CD					
1	AN GIANG	121	68	1127	6	6	42	127	1169	0	0	0
2	BẠC LIÊU	10	7	65	1	1	1	11	66	0	0	0
3	BẾN TRE	166	117	655	4	3	14	170	669	0	0	0
4	BÌNH DƯƠNG	124	58	971	1	1	3	125	974	0	0	0
5	BÌNH PHƯỚC	128	38	501	2	1	4	130	505	0	0	1
6	BR-VT	81	29	775	0	0	0	81	775	0	0	0
7	CẦN THƠ	58	37	420	0	0	6	58	426	0	0	0
8	CÀ MAU	31	23	161	2	2	6	33	167	0	0	0
9	ĐỒNG NAI	233	110	1513	0	0	12	233	1525	0	0	0
10	ĐỒNG THÁP	59	43	653	4	3	31	63	684	0	0	0
11	HẬU GIANG	3	3	58	0	0	0	3	58	0	0	0
12	KIÊN GIANG	25	16	234	2	1	9	27	243	0	0	0
13	LÂM ĐỒNG	80	29	212	0	0	0	80	212	0	0	0
14	LONG AN	97	38	717	1	0	12	98	729	0	0	0
15	SÓC TRĂNG	28	18	185	1	1	19	29	204	0	0	0
16	TÂY NINH	60	26	369	0	0	0	60	369	0	0	1
17	TIỀN GIANG	111	55	945	1	0	30	112	975	0	0	0
18	TP. HCM	746	207	7084	2	2	23	748	7107	0	0	0
19	TRÀ VINH	94	86	376	1	1	9	95	385	0	0	0
20	VĨNH LONG	68	46	655	1	1	17	69	672	0	0	0
Tổng cộng		2323	1054	17676	29	23	238	2352	17914	0	0	2



Inputs

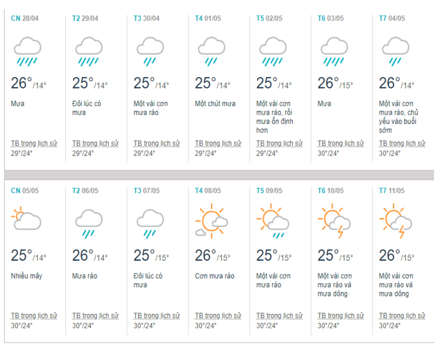
- Monthly Dengue data
- Monthly meteorological forecast data

Black box

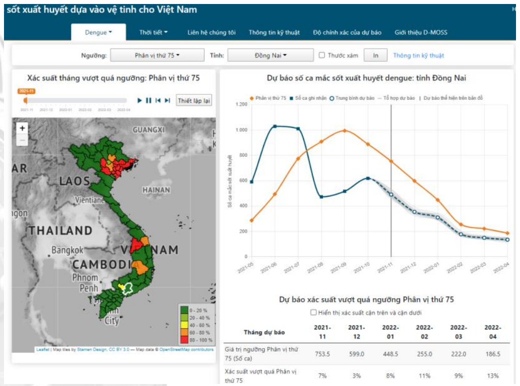
- 56 ensembles

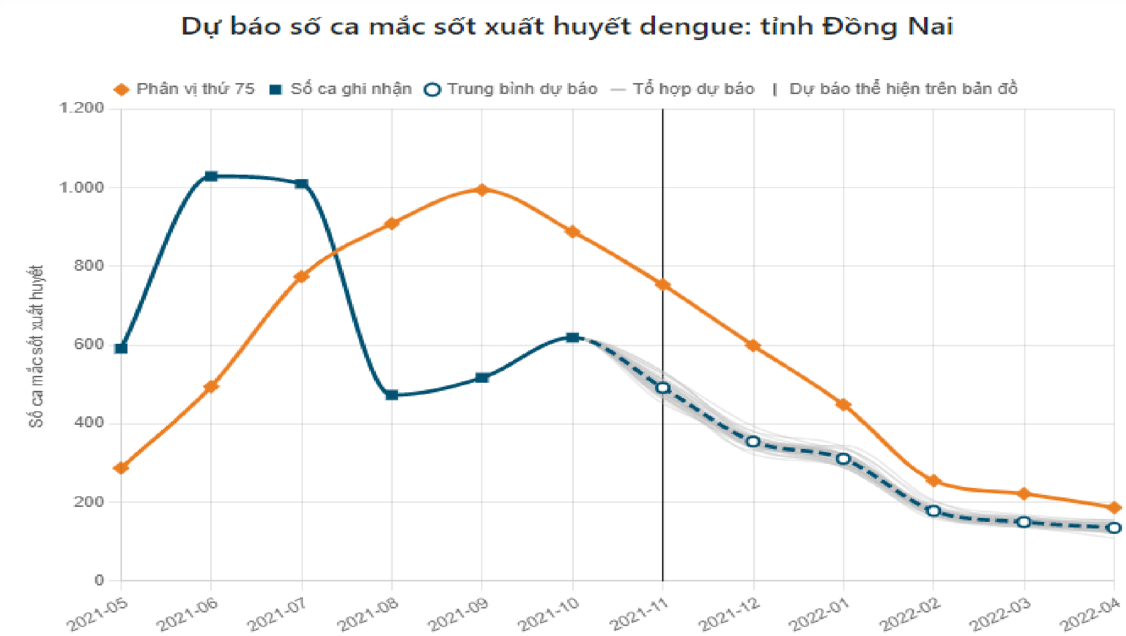
Outputs

- Probabilities of exceeding epidemic threshold by provinces and 6 month in advance



Mapping application





Dự báo xác suất vượt quá ngưỡng Phân vị thứ 75

☑ Hiển thị xác suất cận trên và cận dưới

Tháng dự báo	2021-11	2021-12	2022-01	2022-02	2022-03	2022-04
Giá trị ngưỡng Phân vị thứ 75 (Số ca)	753.5	599.0	448.5	255.0	222.0	186.5
Xác suất vượt quá Phân vị thứ 75	7%	3%	8%	11%	9%	13%
Cận dưới của xác suất vượt quá Phân vị thứ 75	3%	1%	4%	5%	4%	2%
Cận trên của xác suất vượt quá Phân vị thứ 75	11%	7%	16%	22%	16%	25%

Mapping application

PLOS MEDICINE

RESEARCH ARTICLE

Probabilistic seasonal dengue forecasting in Vietnam: A modelling study using superensembles

Felipe J. Colón-González[1,2,3,4]*, Leonardo Soares Bastos[1,3,5], Barbara Hofmann[6], Alison Hopkin[6], Quillon Harpham[6], Tom Crocker[7], Rosanna Amato[7], Iacopo Ferrario[6], Francesca Moschini[6], Samuel James[6], Sajni Malde[6], Eleanor Ainscoe[6], Vu Sinh Nam[8], Dang Quang Tan[9], Nguyen Duc Khoa[9], Mark Harrison[7], Gina Tsarouchi[6], Darren Lumbroso[6], Oliver J. Brady[1,2], Rachel Lowe[1,2,3]

1 Centre for the Mathematical Modelling of Infectious Diseases, London School of Hygiene & Tropical Medicine, London, United Kingdom, **2** Department of Infectious Disease Epidemiology, Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London, United Kingdom, **3** Centre on Climate Change and Planetary Health, London School of Hygiene & Tropical Medicine, London, United Kingdom, **4** Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, United Kingdom, **5** Scientific Computing Programme, Oswaldo Cruz Foundation (Fiocruz), Rio de Janeiro, **6** HR Wallingford, Wallingford, Oxfordshire, United Kingdom, **7** Met Office, Exeter, Devon, United Kingdom, **8** National Institute of Hygiene and Epidemiology, Hanoi, Vietnam, **9** General Department of Preventive Medicine, Hanoi, Vietnam

These authors contributed equally to this work.
* Felipe.Colon@lshtm.ac.uk

Check for updates

OPEN ACCESS

Citation: Colón-González FJ, Soares Bastos L, Hofmann B, Hopkin A, Harpham Q, Crocker T, et al. (2021) Probabilistic seasonal dengue forecasting in Vietnam: A modelling study using superensembles. PLoS Med 18(3): e1003542. https://doi.org/10.1371/journal.pmed.1003542

Academic Editor: Alex Richard Cook, National University of Singapore, SINGAPORE

Received: June 25, 2020

Accepted: January 22, 2021

Published: March 4, 2021

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pmed.1003542

Abstract

Background

With enough advanced notice, dengue outbreaks can be mitigated. As a climate-sensitive disease, environmental conditions and past patterns of dengue can be used to make predictions about future outbreak risk. These predictions improve public health planning and decision-making to ultimately reduce the burden of disease. Past approaches to dengue forecasting have used seasonal climate forecasts, but the predictive ability of a system using different lead times in a year-round prediction system has been seldom explored. Moreover, the transition from theoretical to operational systems integrated with disease control activities is rare.

Methods and findings

We introduce an operational seasonal dengue forecasting system for Vietnam where Earth observations, seasonal climate forecasts, and lagged dengue cases are used to drive a

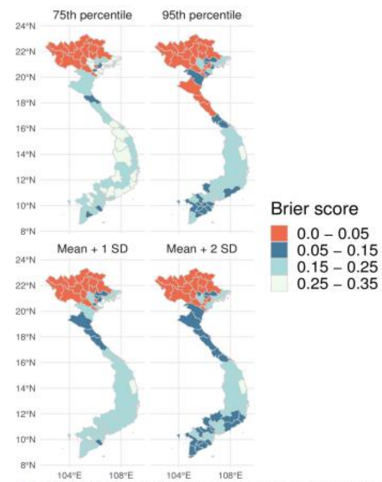


Fig 5. Spatial variation in the Brier score. Spatial variation of the mean Brier score averaged across all lead times calculated for 4 different moving outbreak thresholds over the period January 2007 to December 2016 and for each of the 63 Vietnamese provinces. Lower Brier scores (in orange) indicate a greater accuracy for detecting outbreaks. The Brier scores assume values between 0 and 1, with 0 as ideal. The shapefile used to create this figure was obtained from DIVA-gis (https://www.diva-gis.org).

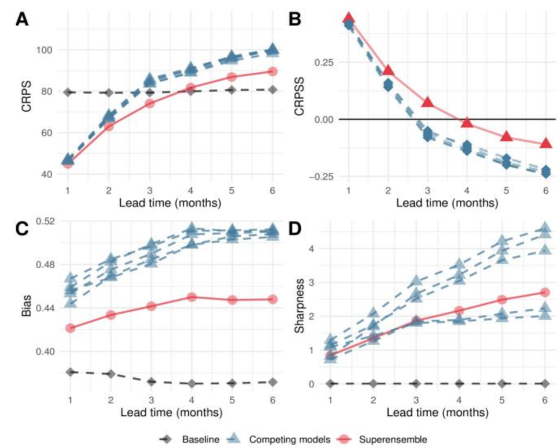


Fig 1. Verification metrics by lead time. Variation across all lead times averaged across the whole of Vietnam for (A) the CRPS, (B) the CRPSS, (C) the bias of the forecasts, and (D) the sharpness of the forecasts. Red lines indicate the performance of the model superensemble; blue lines depict the metrics for each of the 5 competing models; and grey lines indicate the behaviour of the baseline model. CRPS and sharpness assume values between 0 and infinity, with 0 representing a perfect forecast. Bias assumes values between −1 and 1, with 0 representing unbiased forecasts. CRPS, continuous rank probability score; CRPSS, continuous rank probability skill score.

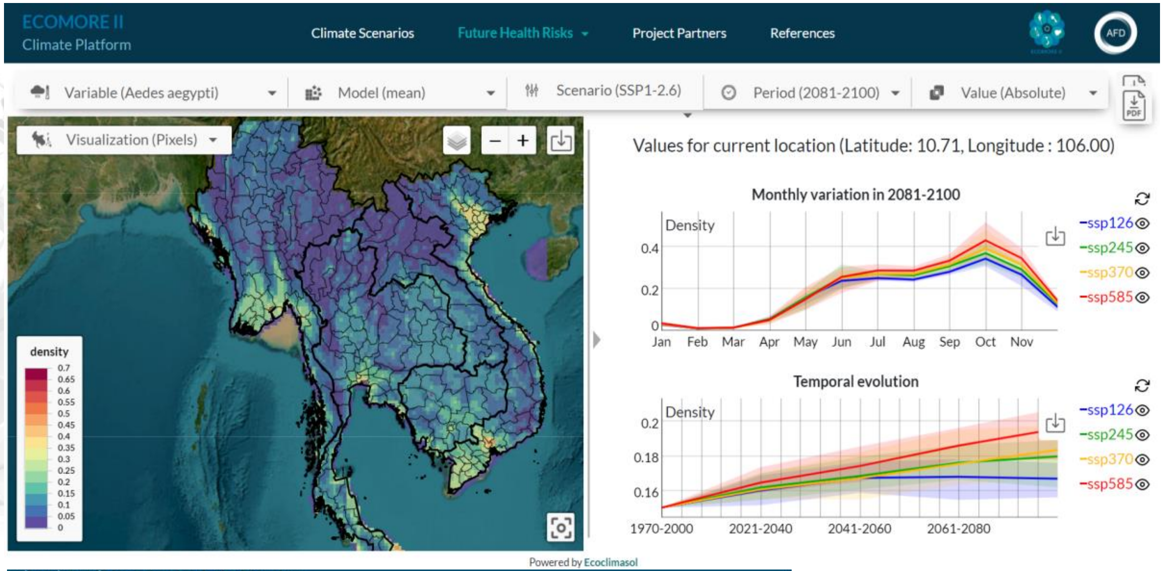
https://doi.org/10.1371/journal.pmed.1003542.g001

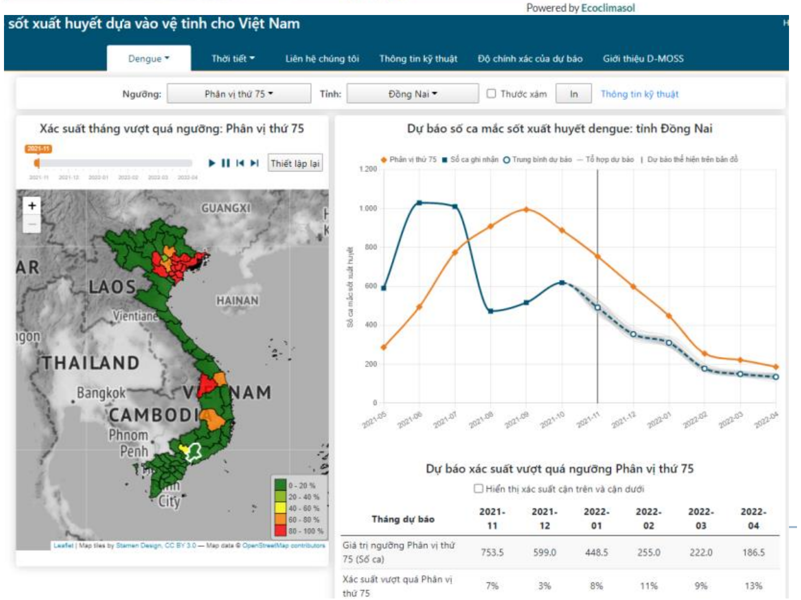
suite of time horizons and transmission settings. Using historical data, the superensemble made slightly more accurate predictions (continuous rank probability score [CRPS] = 66.8, 95% CI 60.6–148.0) than a baseline model which forecasts the same incidence rate every month (CRPS = 79.4, 95% CI 78.5–80.5) at lead times of 1 to 3 months, albeit with larger uncertainty. The outbreak detection capability of the superensemble was considerably larger (69%) than that of the baseline model (54.5%). Predictions were most accurate in southern Vietnam, an area that experiences semi-regular seasonal dengue transmission. The system also demonstrated added value across multiple areas compared to previous practice of not using a forecast. We use the system to make a prospective prediction for dengue incidence in Vietnam for the period May to October 2020. Prospective predictions made with the superensemble were slightly more accurate (CRPS = 110, 95% CI 102–575) than those made with the baseline model (CRPS = 125, 95% CI 120–168) but had larger uncertainty. Finally, we propose a framework for the evaluation of probabilistic predictions.

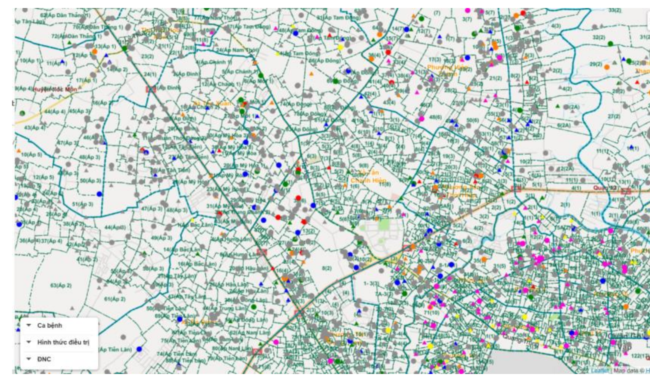
Mapping application

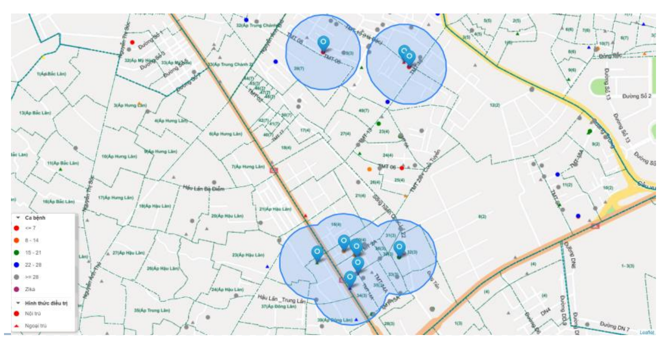
- Limitations
  - Using weather forecast to predict
  - Hydrological and meteorological data are not included in surveillance system
  - Need to refer other information to determine where to conduct intervention
  - Depend on staff abilities and experience

Mapping application









Conclusion

Conclusion

- Dengue is great concerns and difficult to control
- Mapping is a strong application for Dengue control
- Flexible and well organized surveillance system
- Current data
  - Detailed and could be positioned
  - Adequate for disease dynamic, mapping studies and forecasting tool development
- Challenges:
  - Innovative approach
  - Resources
  - Sustainability

Thank you