Predicting Dengue Cases

Cheryl, Kit Fai, Mak & Eliza

Do you know?

Dengue is a common viral infection caused by mosquitoes that infects up to 400 million and kills 20,000 to 25,000 people in a year, making it a serious public health concern.

source:World Health Organisation

01

Our Objective

Develop a dengue forecasting model for the years 2019 and 2022 to predict potential dengue outbreak to implement preventive measures, enhance dengue surveillance and control.

Datasets Source

- NEA climate data
- Weekly google search trends data
- 2012 - 2022

Our Approach

1. Data gathering from publicly available datasets, journal papers, news articles, data cleaning; standardizing our units of scales, merging datasets for EDA and modeling
2. Perform an EDA on our datasets; look for positive and inverse relationships, understanding trends, making sense of the quantitative data vis-a-vis our qualitative data
3. Experiment with the different models to find one that best makes sense to us

02

What did our Research tell us?

Sources: PLOS Public Health Journal, NEA media releases, reputable news articles

In **1968**, Singapore launched a comprehensive vector control programme comprising:

- **Environmental** management
- Public health education thru **campaigns**
- **Surveillance** inspections and enforcement actions

Factor 1

The uniqueness of Singapore's **warm climate** lends to higher dengue cases providing an optimal breeding ground for mosquitoes to thrive. Climate scientist Winston Chow from the College of Integrative Studies at Singapore Management University says "We will not be able to eradicate dengue (because) the **constant weather extremes create the perfect breeding conditions for mosquitoes,"**

02

What did our Research tell us?

Factor 2

- **Urbanization** in a globalized world accounts for the rise in dengue cases. Singapore is a **densely populated nation** with 7810 persons per sqm as compared to Indonesia (which is one of the most populous nation) but has only 4383 persons per sqm.

Factor 3

- **Social distance policy** due to Covid-19 accounted for a significant rise of dengue cases in 2020, an all time high of 35,000 cases that year. With **residential places in naturally ventilated spaces** compared to air-conditioned office spaces invites more mosquitoes who are **day-biters** to bite people, leading to an increased rise of dengue cases.

02 What did our Research tell us?

F**actor 4**

- Singapore's **low herd immunity** to denv3 is one of the leading causes of the sudden increase of dengue cases in 2020. Serological research studies show that Singapore's exposure to denv3 compared to Indonesia is low. Singaporean kids **exposure to denv3 is below 10%** which is much lower to Indonesian kids who are 90% exposed to it which accounts for the low herd immunity to this new strain of dengue.

03a

What do the data tell us?

1. **Warm climate** lends to higher dengue cases

2.Positive correlation between **temperature** and dengue cases

3.Dengue cases reached its peak when temperature is at 28.4

03b

What do the data tell us?

1. Negative correlation between dengue cases and total rainfall

2.Dengue cases are lower when **total rainfall** is more than 2000mm; flushing event that disrupts the reproductive cycle

3.Explains rainy months in Nov and Dec when dengue cases are lower

03c

What do the data tell us?

1.**Low herd immunity** due to exposure to new dengue strain i.e. denv3

2.Dengue cases in 2013 and 2014 were driven by denv1

3.In 2015 - 2017 dengue cases were driven by denv2.

4. Thereafter from **2019 onwards denv3** were the predominant serotypes which could explain why there was a spike of dengue cases in 2019 from 2018.

5. Coupled with the **social distance policy**, in 2020 dengue cases exploded in Singapore reaching an all time high

03e

What do the data tell us?

1. Dengue cases are higher in Postal District 13~15 and Postal District 19~20, which are East and North East

2. Dengue cases are lower in Postal District 1~11 which are in the Western side of Singapore

3.The trend holds when subdivided into Postal Sectors

03f

What do the data tell us?

1. Over the years, indeed that the high number of cases are concentrated in areas like Woodlands, AMK-Bishan, Hougang, East Coast, and Tampines, which coincidentally are the large residential towns

2. We also can see the "slump" in dengue cases in 2017

Linear model prediction 10 week

04a

- Modelling Linear model using feature: Weekly Mean Temperature, Weekly Dengue Searches and Weekly Rainfall.
- Using Data from 10 week ago to predict current week, therefor model is able to forecast 10 week in advance. shift.() Method

Coef			
Feature	Linear	Lasso	Ridge
Weekly Mean Temperature	46.80	46.80	48.3
Weekly Dengue Searches	9.14	9.16	0.914
Weekly Rainfall	0.76	0.75	0.76
MSE & RMSE			
MSE	45923	45930	45919
RSME	214.29	214.31	214.28

ARIMA model prediction 10 week

04b

- there are no autoregressive terms, no moving average terms, and no differencing. Therefore, this model simply uses the mean of the time series to forecast future values.
- MSE: 45390
- RMSE: 385.37

Predictors

04c

DENGUE CASES

cumulative + lagged

RAINFALL

cumulative + lagged

WIND SPEED

mean, maximum + lagged

TEMPERATURE

minimum, maximum + lagged

Cumulative Rainfall
2500
2000
1500
1000
500
0
mm
2013
2014
2015
Year

Total Rainfall
200
175
150
125
100
75
50
25
0
mm
2013
2014
2015
Year

Cyclical Dengue Cases (2012 - 2018)

04d

Cyclical Dengue Cases (2012 - 2018)

04d

CatBoost: 2019 W01 to W20

RMSE_TEST: 89
RMSE_TRAIN: 31

04d

CatBoost: 2019 W01 to W20

RMSE_TEST: 89
RMSE_TRAIN: 31

04d

CatBoost: 2019 W13 to W32

RMSE_TEST: 65
RMSE_TRAIN: 32

04d

CatBoost: 2019 W13 to W32

RMSE_TEST: 65
RMSE_TRAIN: 32

04d

CatBoost: 2019 W23 to W42

RMSE_TEST: 80
RMSE_TRAIN: 32

04d

CatBoost: 2019 W23 to W42

RMSE_TEST: 80
RMSE_TRAIN: 32

04d

CatBoost: 2019 W33 to W52

RMSE_TEST: 81
RMSE_TRAIN: 34

04d

05a

What is the impact of NEA campaigns?

05b

Economic Impact of Dengue & Cost- Effectiveness of Project Wolbachia

- Dengue's economic impact is around 1B$ to 2B$ over 10 years
- **Project Wolbachia reduced the economic impact costs by 290M$ (after accounting for project costs) over 10 years assuming a 40% efficacy**

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Estimated economic cost (Mn, USD2010)[1]	24.15	28.20	29.25	160.64	150.89	86.94	113.17	23.22	23.90	121.04	261.68
Estimated economic cost (Mn, SGD)[2]	32.84	36.60	38.40	214.85	208.87	129.83	171.79	35.89	37.11	192.59	429.72
Case Prevention (40% Efficacy)[3]	1,712	1,708	1,508	7,203	5,753	3,618	4,197	889	1,041	5,130	11,282
Incidence Prevention (40% Efficacy)[4]	4,362	4,529	4,387	21,844	19,793	11,910	15,413	3,466	3,441	17,392	38,255
Estimated DALYs[5]	250	252	242	1282	1139	667	842	168	173	831	1851
US$000s per DALYs averted (40% Efficacy)[5]	285	282	295	56	63	107	85	424	412	86	39
SG$000s per DALYs averted (40% Efficacy)[6]	502	498	519	98	110	188	149	749	723	151	68
	Costs Averted (Mn, 2010USD)										
40% efficacy[7]	7.76	9.06	9.40	51.677	48.55	27.9	36.40	7.47	7.68	38.91	84.11
50% efficacy[7]	9.70	11.33	11.76	64.58	60.68	34.96	45.50	9.33	9.61	48.64	105.14
60% efficacy[7]	11.64	13.60	14.11	77.50	72.82	41.95	54.60	11.20	11.53	58.36	126.17
70% efficacy[7]	13.58	15.86	16.46	90.42	84.95	48.94	63.71	13.07	13.45	68.09	147.20
80% efficacy[7]	15.52	18.13	18.81	103.33	97.09	55.93	72.81	41.93	15.37	77.82	168.22
90% efficacy[7]	17.46	20.40	21.16	116.25	109.23	62.92	81.91	16.80	17.29	87.54	189.25

[1]Direct and indirect economic costs attributable to dengue from 2010 to 2020 under the friction cost method and constant symptomatic rate expansion factors in millions (Mn) 2010USD.

[2]Direct and indirect economic costs attributable to dengue from 2010 to 2020 under the friction cost method and constant symptomatic rate expansion factors in nominal Singapore dollars (SGD).

[3]Hypothetical dengue cases averted from the national implementation of Wolbachia interventions.

[4]Hypothetical dengue incidence averted from the national implementation of Wolbachia interventions, as calculated under constant symptomatic rate expansion factors.

[5] DALYs were computed using age dependent disability weights, with constant symptomatic rate expansion factors.

[6]Hypothetical $ per DALYs averted, assuming steady state cost of 40Mn SGD a year in 2020 for national Wolbachia programme and intervention efficacy of 40%. DALYs were computed using age dependent disability weights, with constant symptomatic rate expansion factors. $ per DALYs averted were reported in nominal SGD here.

[7]Hypothetical economic costs averted assuming percentage reductions in dengue cases from national implementation of Wolbachia interventions in 2010USD.

https://doi.org/10.1371/journal.pgph.0000024.t003

Source: PLOS Journal - **Economic impact of dengue in Singapore from 2010 to 2020 and the cost-effectiveness of Wolbachia interventions**

06

Conclusions

1. Temperature and rainfall correlates strongly to dengue cases

2. Low herd immunity to new dengue strain

3. Singapore is densely populated

4. NEA Campaigns, Project Wolbachia are effective

Recommendations

1. NEA to spend more resources in vector control in East and North East

2. Consider climate change predictors into future model

3. Consider amount of Wolbachia Mosquito to be released, in the model

4.Model dengue outbreak by zone

The best way to prevent dengue is with S-A-W and B-L-O-C-K!

THANK YOU FOR LISTENING!