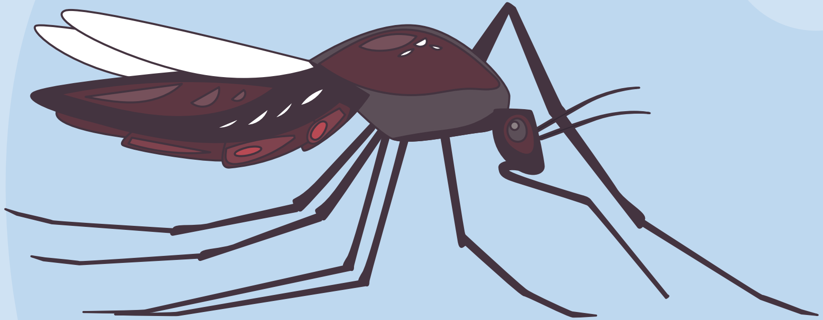
Project 4:
Prediction of Dengue Cases



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24th Aug 2023

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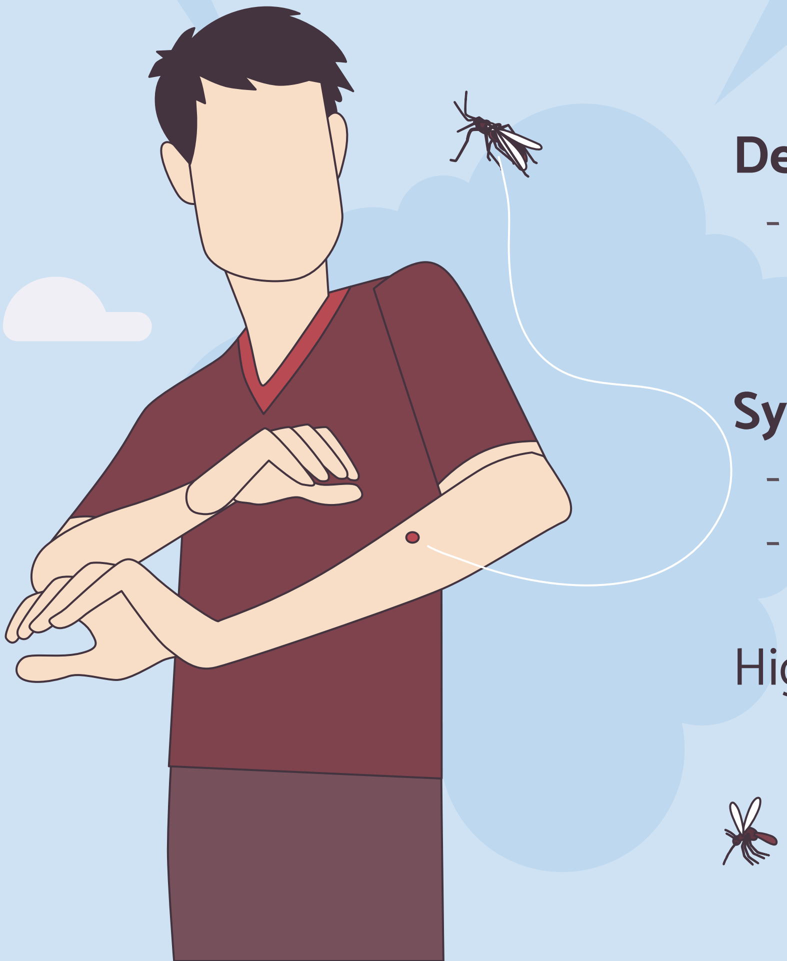


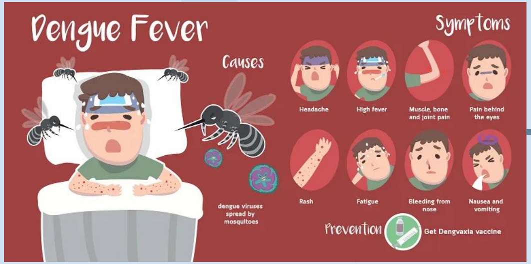
Dengue fever

- Virus transmitted via bite of female *Aedes aegypti mosquitoes*

Symptoms

- Fever, joint and muscle pain
- Generalised skin flushing

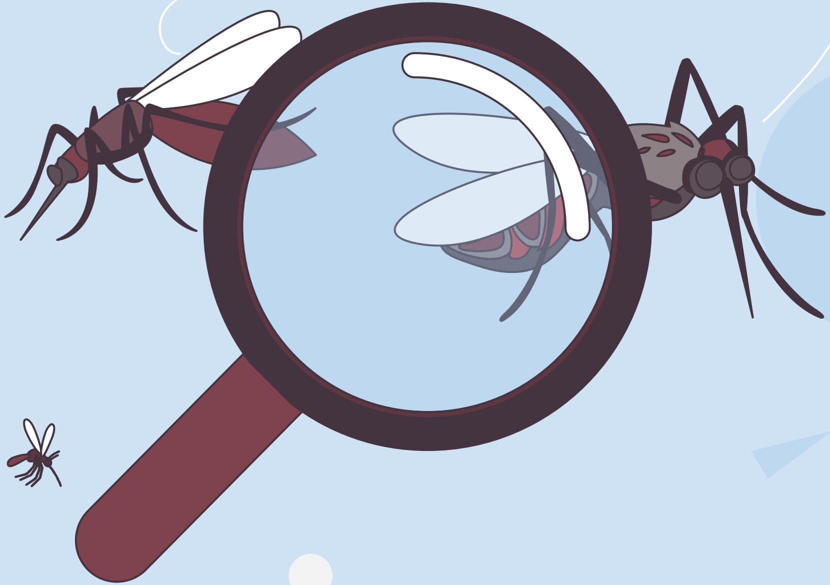
High morbidity but very low mortality rate.



Economic burden

Dengue prevention programs

↓ Economic burden



02

Problem Statement

Use of machine learning models to predict the cases of dengue fever in Singapore using historical climate and Google search trends.

Metrics from the optimal modeling process,

- perform cost benefit analysis of dengue prevention program to optimize resource allocation for public health initiatives.

Approach

Data

- Dengue data - data.gov API
- Weather data - Meteorological Service Singapore
- Google search terms - Google Trends using PyTrends

Modelling

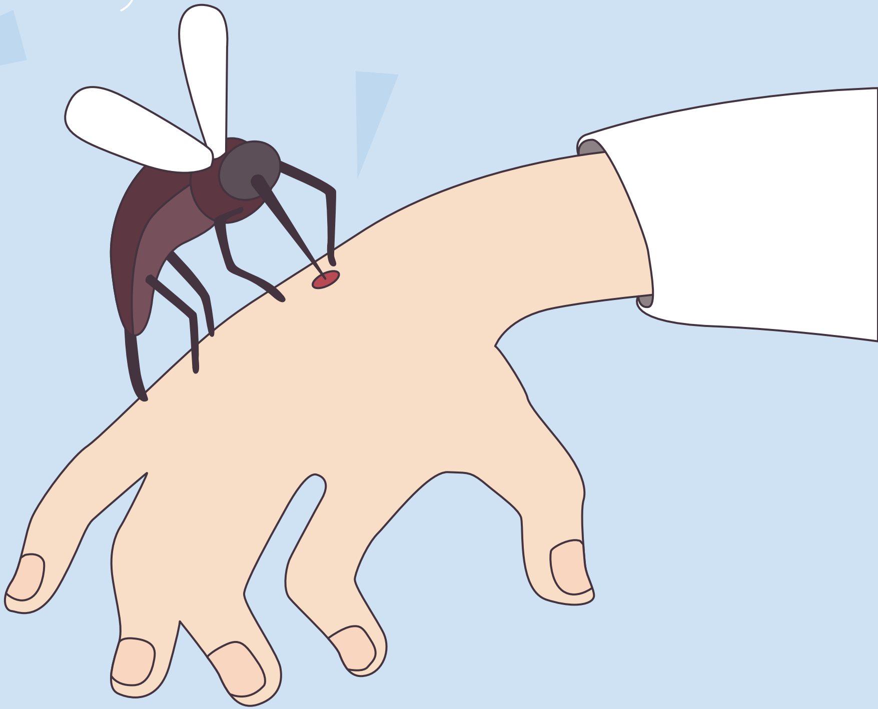
- ARIMA
- SARIMA
- SARIMAX (Weather & Google Search)

Metrics

- Primary: MAPE
- Secondary, MAE and RMSE

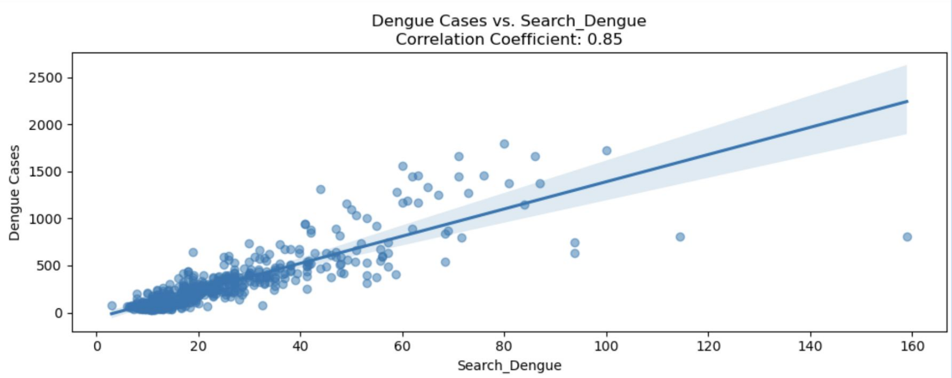
03

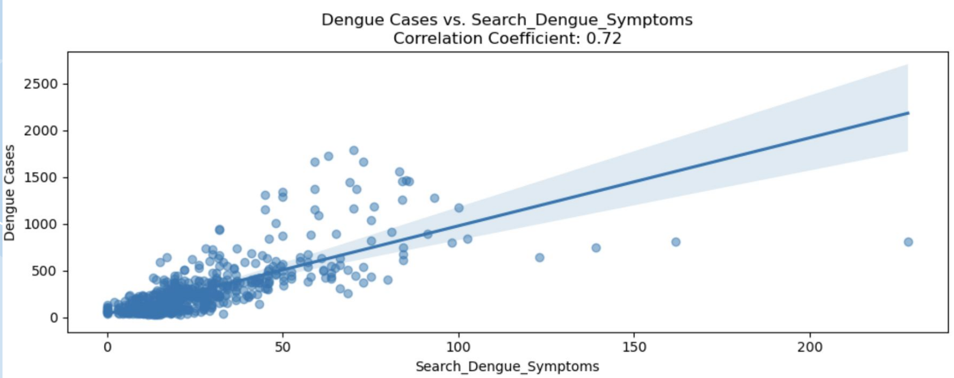
Exploratory Data Analysis



Dengue Cases vs Google Searches

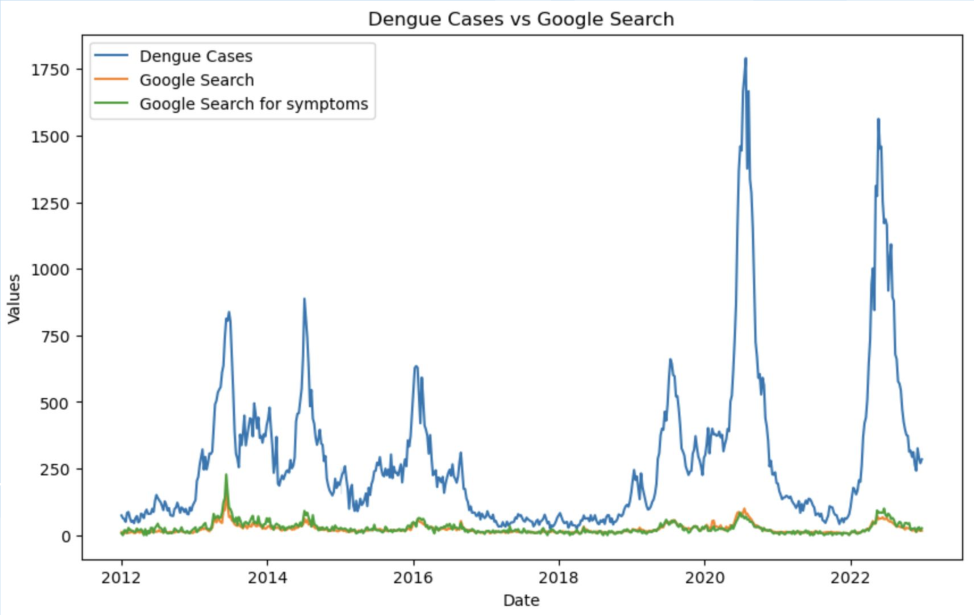
We can see quite a strong linear relationship between the number of dengue cases and related Google searches.





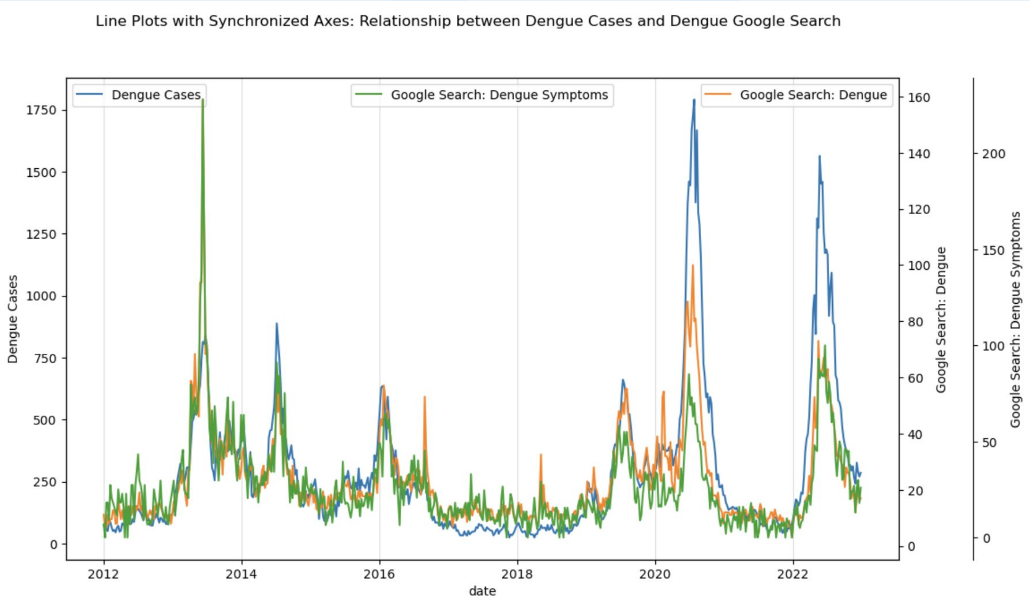
Dengue Cases vs Google Searches over time

Plotting them over time is an issue due to the difference in scale.

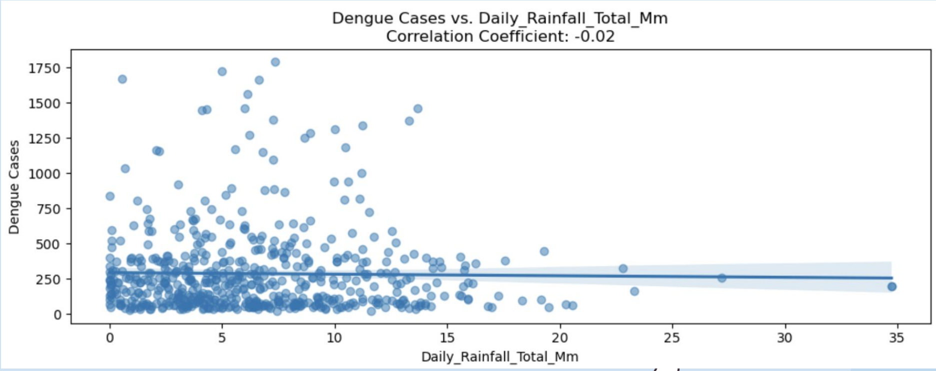


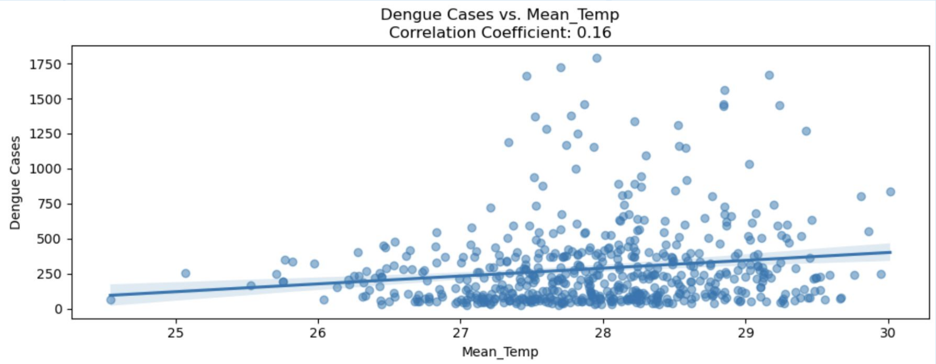
Dengue Cases vs Google Searches over time

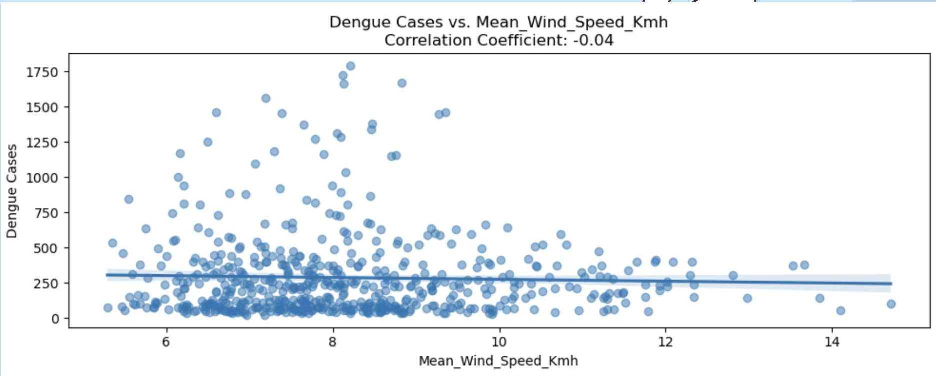
By using a dual (or in this case, triple) axis, we can see that there is a very strong correlation between the number of dengue cases and dengue-related Google searches.



Dengue Cases vs Weather Data



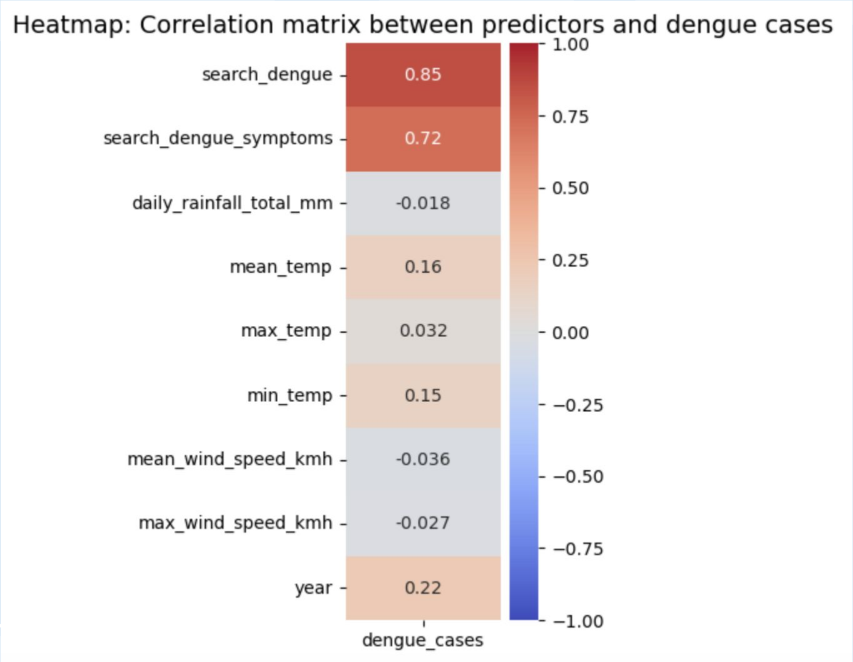




We found little to no correlation between the number of dengue cases and weather data.

Correlation Matrix

This correlation matrix shows us that the number of dengue cases is more correlated with Google Search scores than weather scores.



04

Modeling

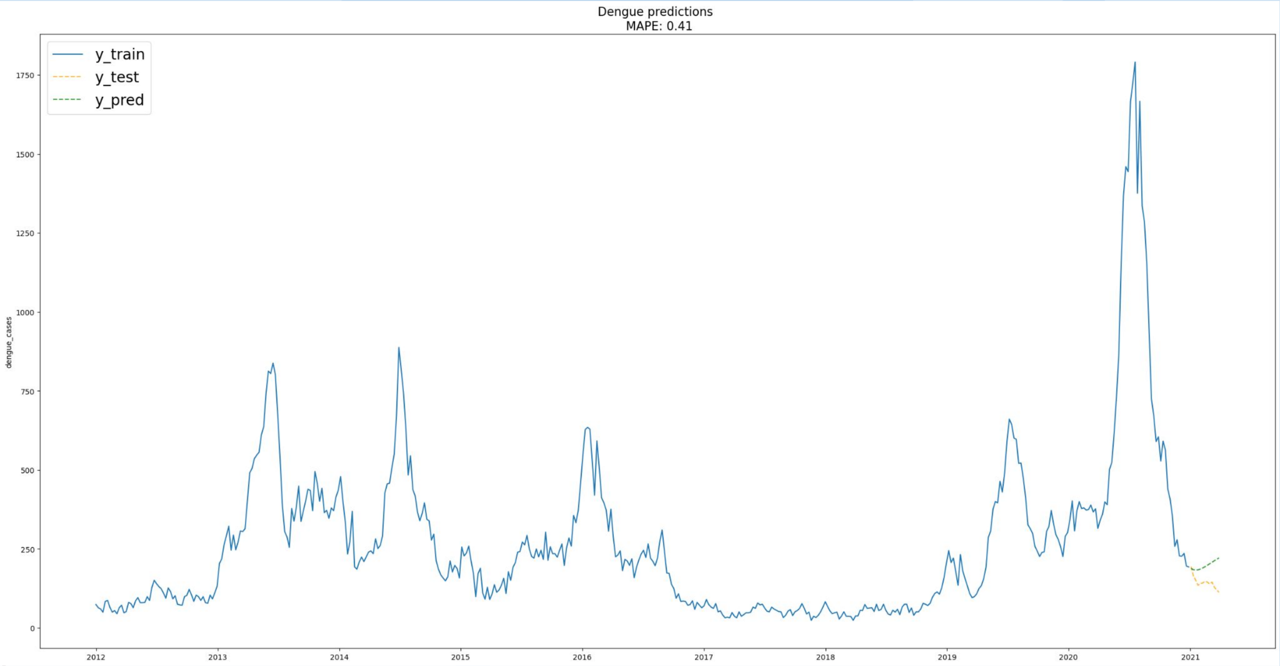
ARIMA

Score:

- MAPE: 0.414
- MAE: 55.03
- RMSE: 61.70

From the graph :

- Poor MAPE, overfit



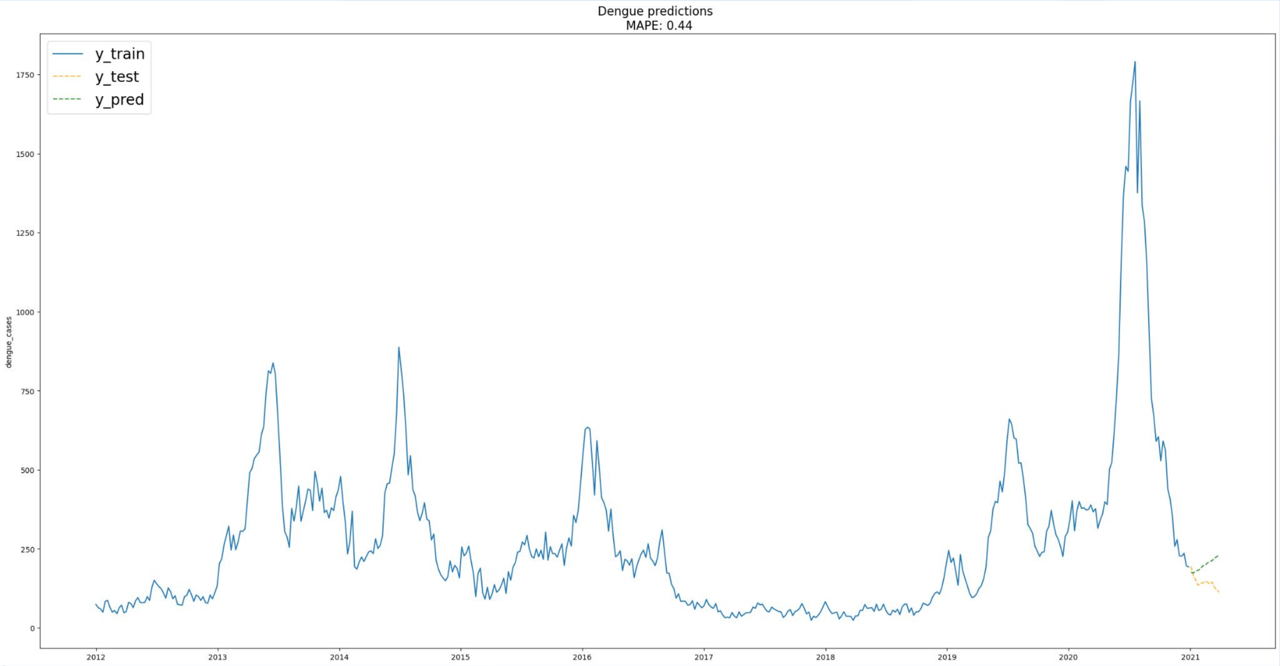
SARIMA

Score:

- MAPE: 0.442
- MAE: 58.87
- RMSE: 66.40

From the graph :

- Not much better



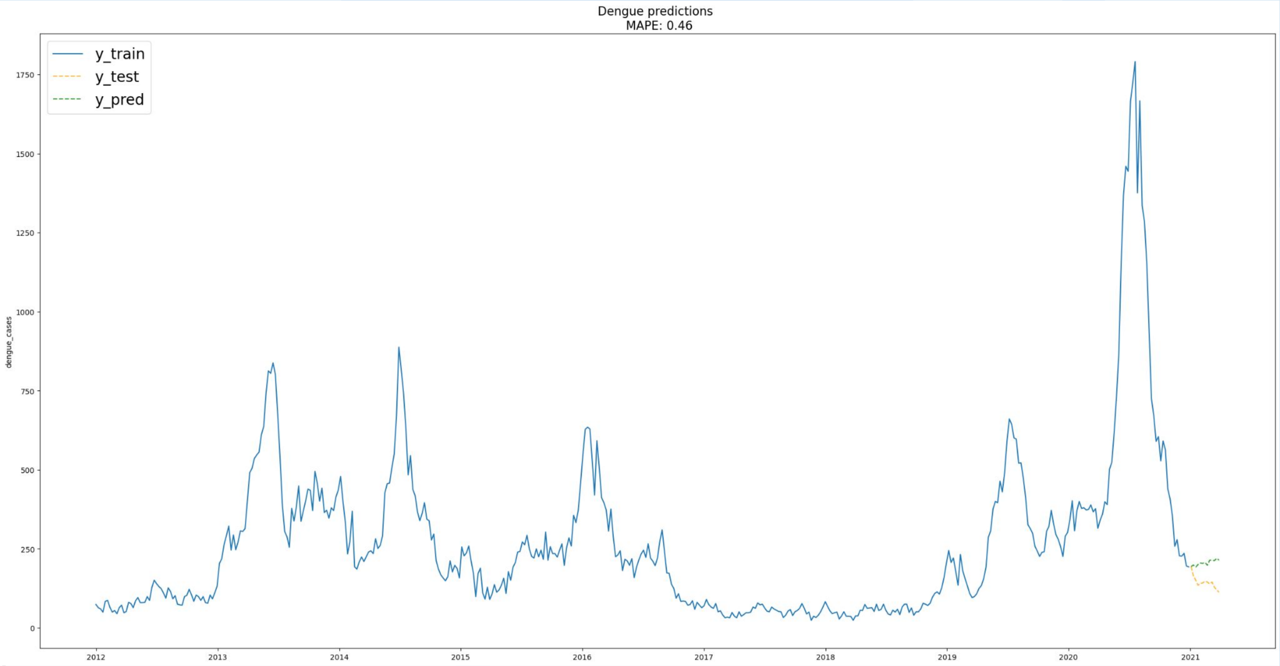
SARIMAX (weather only)

Score:

- MAPE: 0.463
- MAE: 62.18
- RMSE: 62.43

From the graph :

- Weather flattening the curve a little



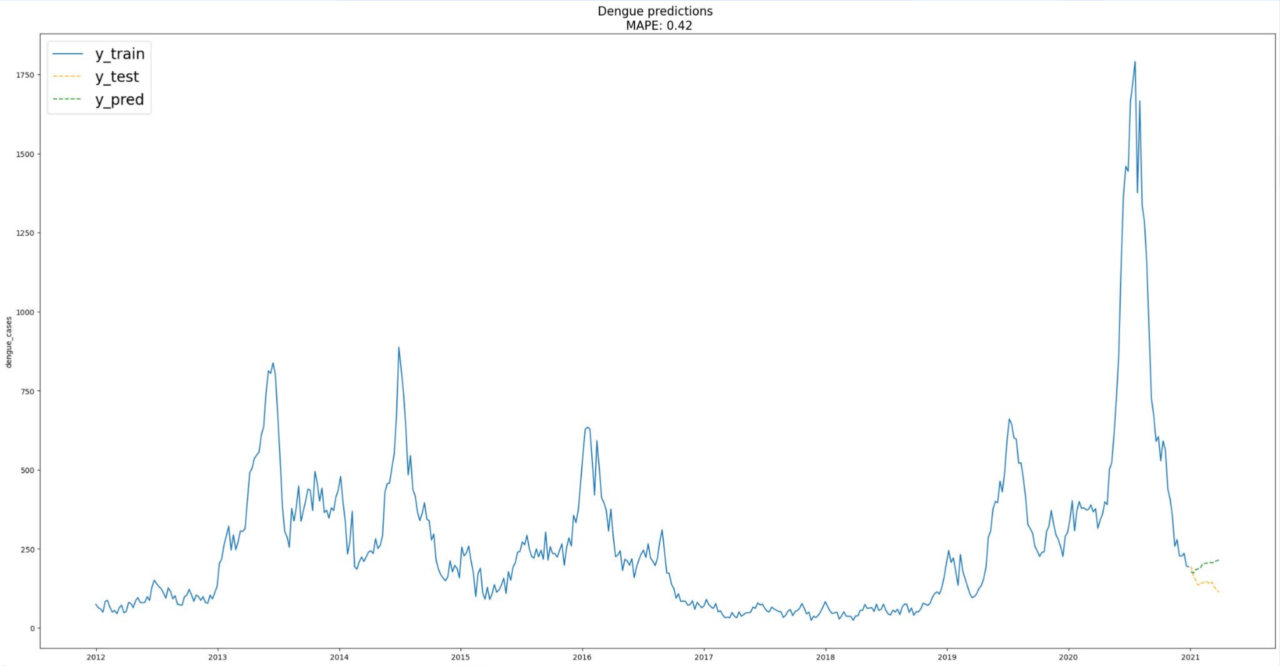
SARIMAX (Google search only)

Score:

- MAPE: 0.424
- MAE: 56.83
- RMSE: 62.33

From the graph :

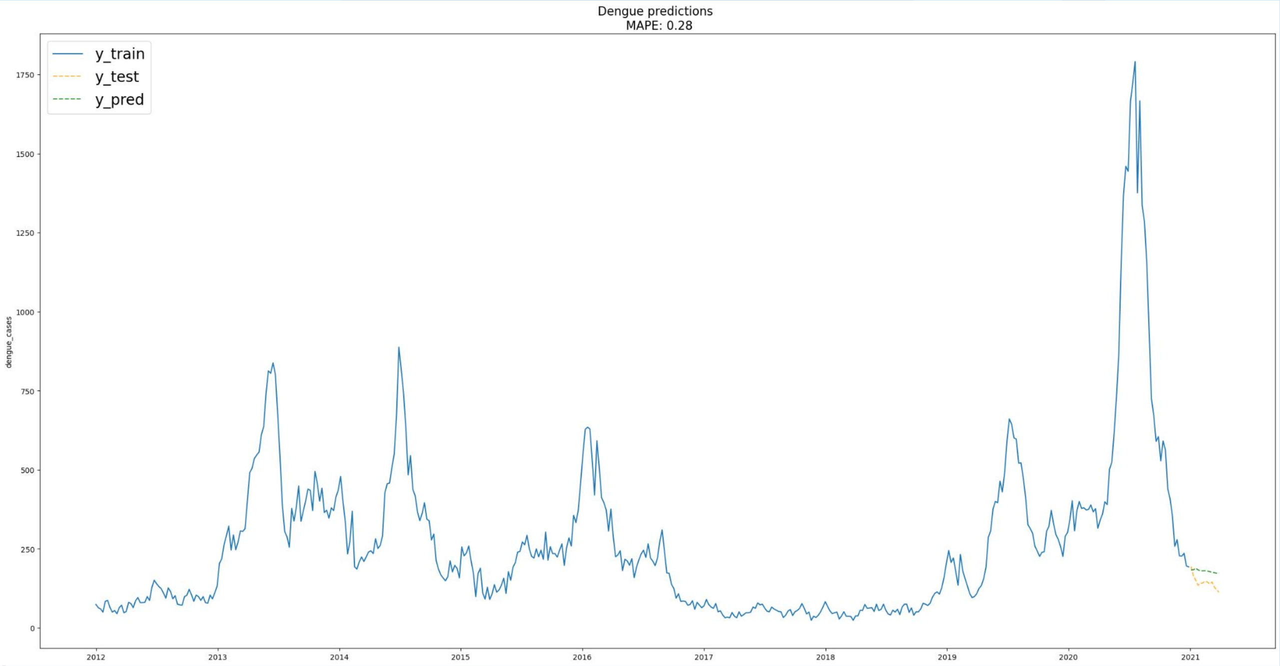
- Seems to be trying to pushing for the spike



SARIMAX (Weather and Google trends)

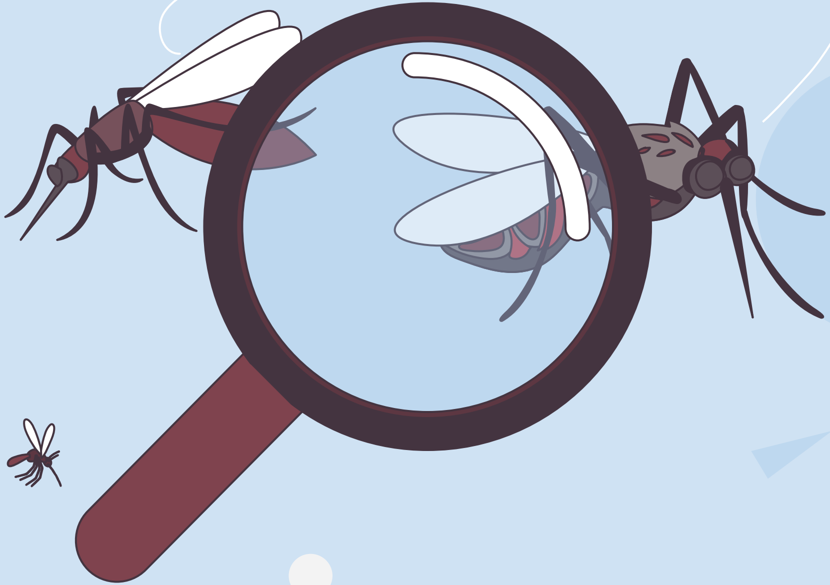
Score:

- MAPE: 0.279
- MAE: 37.76
- RMSE: 39.88



From the graph :

- Improved MAPE

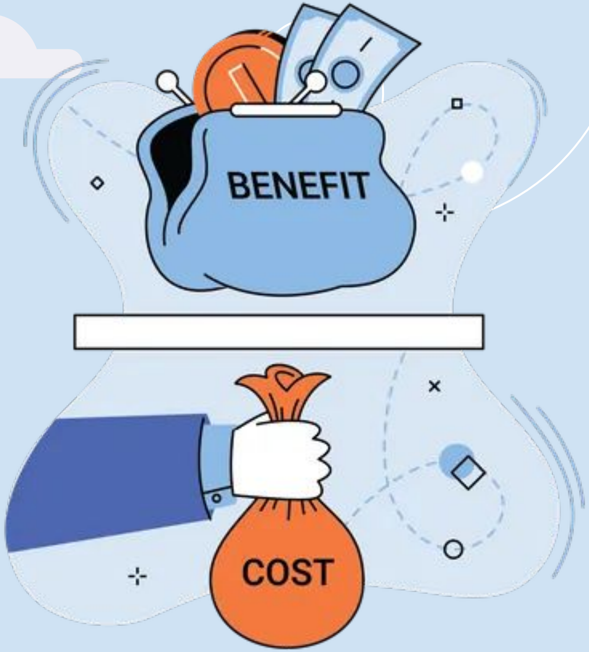


05

Evaluation

Evaluation of Models

Model	MAPE	MAE	RMSE	Best
ARIMA	Train: 0.175 Test: 0.414	Train: 34.922 Test: 55.026	Train: 55.116 Test: 61.699	
SARIMA	Train: 0.178 Test: 0.442	Train: 34.960 Test: 58.870	Train: 54.974 Test: 66.402	
SARIMAX (Weather Data)	Train:0.183 Test: 0.463	Train:36.571 Test: 62.178	Train:57.988 Test: 62.426	
SARIMAX (Google Search)	Train: 0.160 Test: 0.424	Train:33.740 Test: 56.829	Train: 52.956 Test: 62.334	
SARIMAX (Weather + Google)	**Train: 0.162 Test: 0.279**	**Train:33.833 Test: 37.760**	**Train: 53.142 Test: 39.878**	✓



06

Cost-Benefit Analysis

Economic cost

Economic impact of dengue in Singapore from 2010 to 2020 and the cost-effectiveness of Wolbachia interventions

**Stacy Soh[1☯], Soon Hoe Ho[1☯], Annabel Seah[1], Janet Ong[1], Borame Sue Dickens[2], Ken Wei Tan[2], Joel Ruihan Koo[2], Alex R. Cook[2], Kelvin Bryan Tan[3], Shuzhen Sim[1], Lee Ching Ng[1,4], Jue Tao Lim[1,2]*

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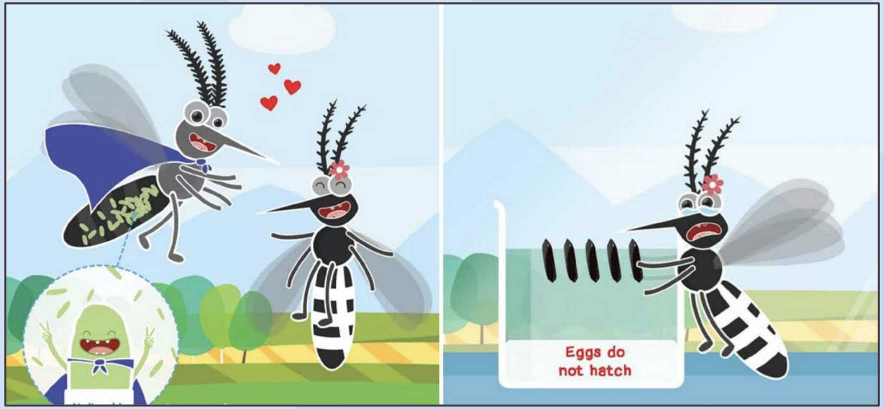
a high income nation where dengue is hyper-endemic. The hypothetical cost effectiveness of a national Wolbachia suppression program was then evaluated historically from 2010 to 2020. We estimated that the average economic impact of dengue in Singapore from 2010 to 2020 in constant 2010US$ ranged from $1.014 to $2.265 Billion. Using empirically derived disability weights, we estimated a disease burden of 7,645–21,262 DALYs from 2010–2020. Under an assumed steady-state running cost of a national Wolbachia suppression program in Singapore, we conservatively estimate that Wolbachia would cost an estimated $50,453–

SGD 223.4 mil/yr!!

PROJECT WOLBACHIA
SINGAPORE



Project started in 2016

- Currently has been deployed to 8 housing estates, covering 300, 000 HDB households (*June 2022*)
- Reduced *Aedes* population by up to 98% in deployment area[*]
- Reduced dengue fever cases by up to 88%[*]

Estimated steady state cost of SGD 40mil/year for full deployment[#] (SGD3.33mil/month)

**Wolbachia-mediated sterility suppresses Aedes aegypti populations in the urban tropics (https://www.medrxiv.org/content/10.1101/2021.06.16.21257922v1)*
#Economic impact of dengue in Singapore from 2010 to 2020 and the cost-effectiveness of Wolbachia interventions (https://journals.plos.org/globalpublichealth/article?id=10.1371/journal.pgph.0000024#references)

Assumptions:

- Reduction in economic in direct proportion to reduction in dengue fever cases.
- Efficacy of project Wolbachia to reduce dengue fever cases by 80%.
    - Project runs for the entire year.
- Best prediction model has MAPE of 27.85% with forward prediction of 3 months.
- Reduction from Wolbachia project will have a lag period of 1 month based on the life cycle of the mosquitoes

Baseline benefit cost ratio:

Economic cost * efficacy of project Wolbachia / steady state cost of project Wolbachia

= 223.4mil * 0.80 / 40mil = **4.468**

We assume that we deploy project Wolbachia 4 months per year based on the 3 months forward prediction

- Cost of 4 months of deploying Wolbachia mosquitoes = SGD 13.32mil
    - Assuming 1 peak in each three months prediction
- Cost of 1 month of deploying Wolbachia mosquitoes = SGD 3.33mil
    - Assuming only 1 peak entire year.

Economic impact reduction from project Wolbachia based on model prediction

= 223.4mil * 0.8 * (1-0.2785) = SGD 128.95mil

Hypothetical minimum benefit cost ratio = 128.95 mil/13.32 mil = **9.681** (2.2 times improvement from baseline)

Hypothetical maximum benefit-cost ratio = 28.95 mil / 3.33 = **38.724** (8.7 times improvement from baseline!)

07

Conclusion & Recommendations

Conclusion and Recommendations

Best model

SARIMAX (with weather and Google data) - MAPE of 0.279

CBA

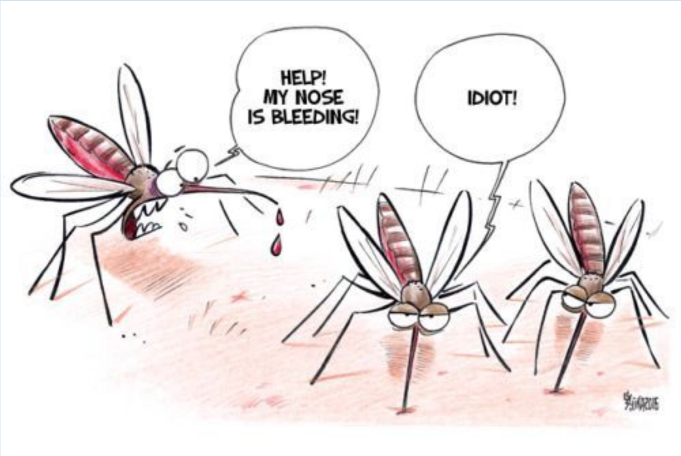
Our model allows us to accurately continue to monitor dengue cases in Singapore while we trial 'Targeted Project Wolbachia'.

By continuing our monitoring (and increasing our model's performance), we will be able to improve our hypothetical benefit-cost ratio over time.

Future Consideration

- Gather more data / more granular data (daily)
- Running more complex models with more data (LSTM performed badly)
- Exploring the efficacy vaccination although not in the scope of NEA.

Thanks!



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