# Dengue Fever Cases Prediction

**Presented By:**
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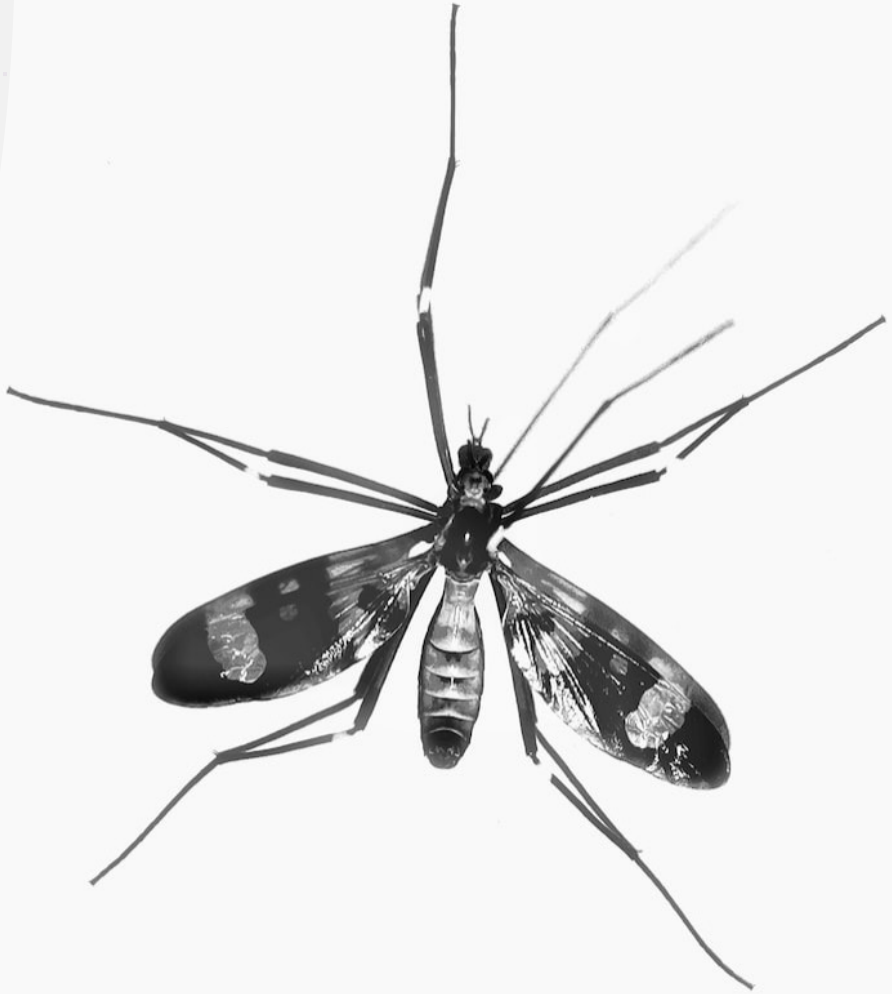


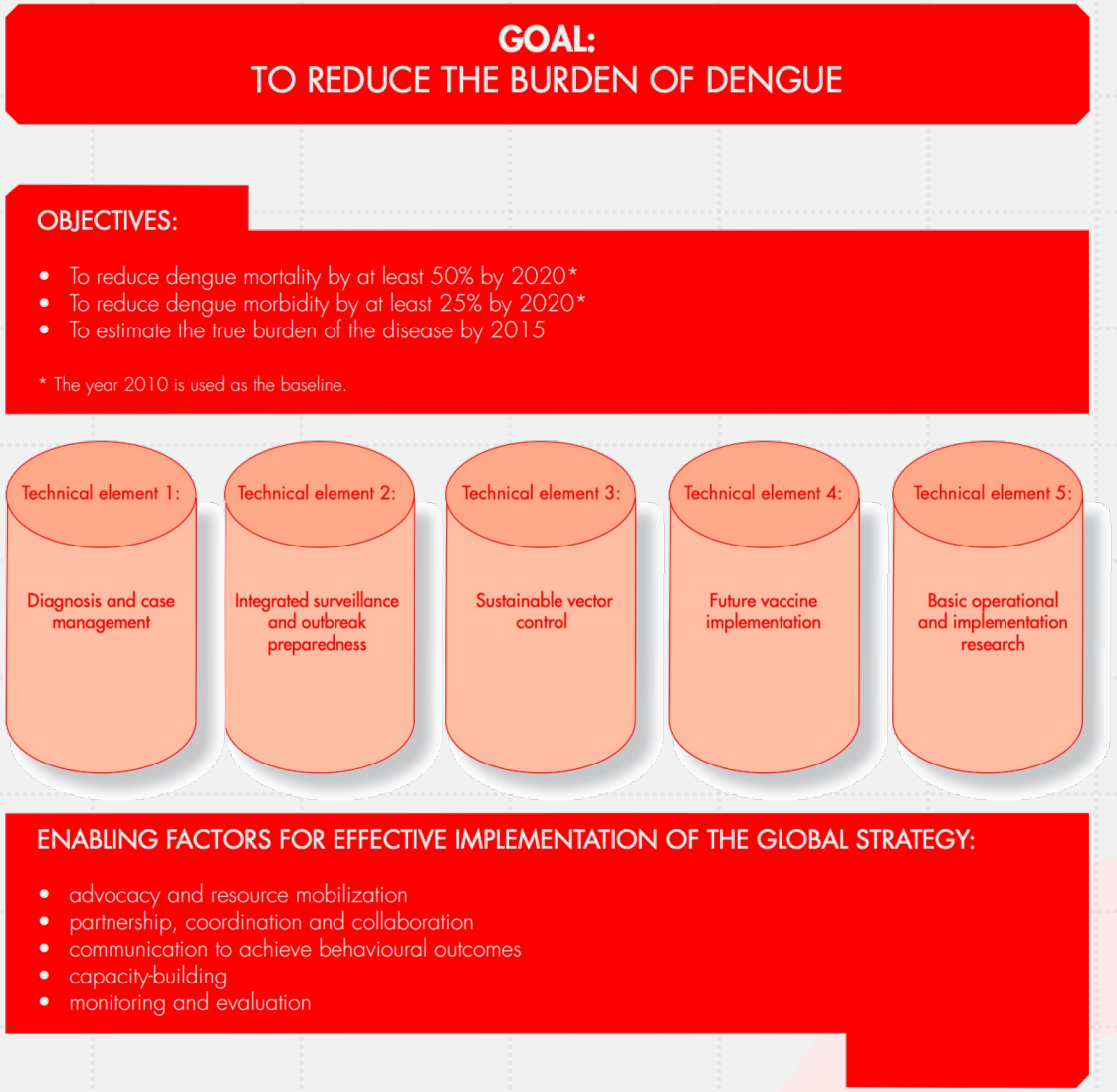
# Presentation Outline

- **Background**
- Data Science Approach
- Cost-Benefit Analysis

# Background

- Dengue cases are on the rise globally, including Singapore.
- More budget is being allocated to hospitals for tackling dengue fever.
- The WHO has implemented a strategic approach to address the issue.
- Urgent mitigation efforts are needed to combat the spread of dengue fever in Singapore.

Figure 4. The global strategy for dengue prevention and control, 2012–2020



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- **Data Science Approach**
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# Data Science Approach

Problem Statement → Data Collection → Data Cleaning & Exploratory Data Analysis → Diagnostics and Modelling → Conclusion & Recommendation

# Problem Statement

## Situation

**The Ministry of Health (MOH) has observed an increase in hospital visitations for dengue cases in the recent years.**

## Complication

**The increase in visitations has resulted in high healthcare costs for hospitals and increased financial burden on citizens.**

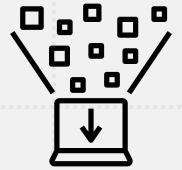
## Resolution

**MOH engaged NEA's data science team to develop a precise predictive model for dengue outbreaks in Singapore. This helps NEA take proactive measures to prevent and control dengue outbreaks, reducing healthcare costs and citizens' financial burden.**

# Data Science Approach

Problem Statement | Data Collection | Data Cleaning & Exploratory Data Analysis | Pre-processing and Modelling | Conclusion & Recommendation

# Data Collection



**Data was collected through 3 sources:**

**1) Climate historical data from weather.gov.sg**

- **Dataset downloaded directly from the website**

**2) Weekly dengue fever cases in Singapore from 2014-2018 from data.gov.sg**

- **Dataset downloaded directly from the website**

**3) Google trends data based on search term**

- **Accessed from Google Trends website and downloadable directly.**

# Data Science Approach

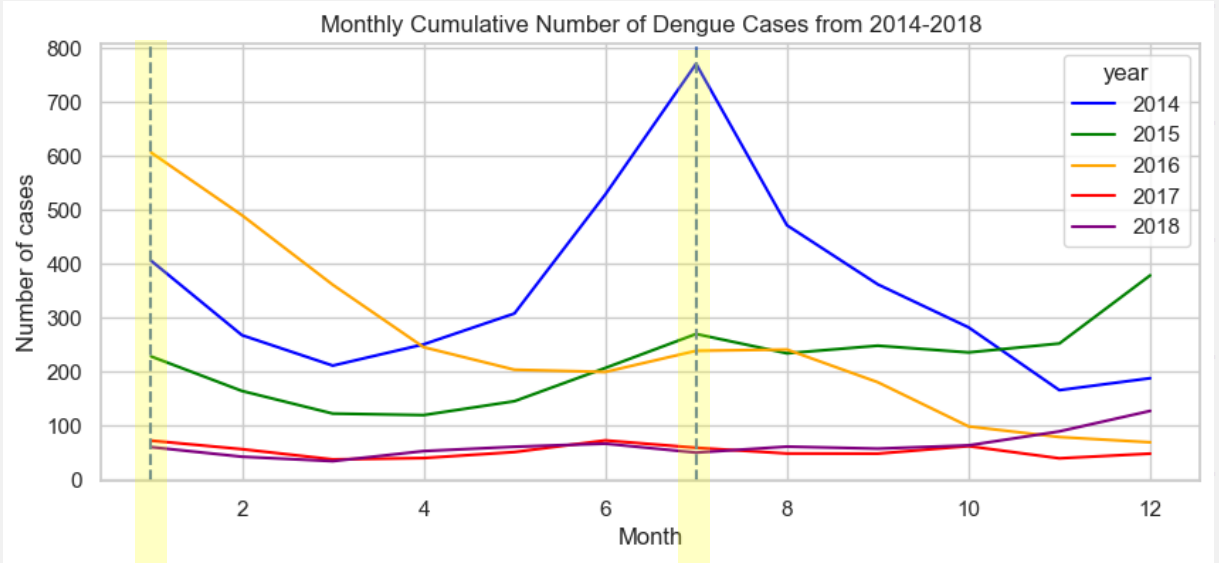
Problem Statement → Data Collection → **Data Cleaning & Exploratory Data Analysis** → Diagnostics and Modelling → Conclusion & Recommendation

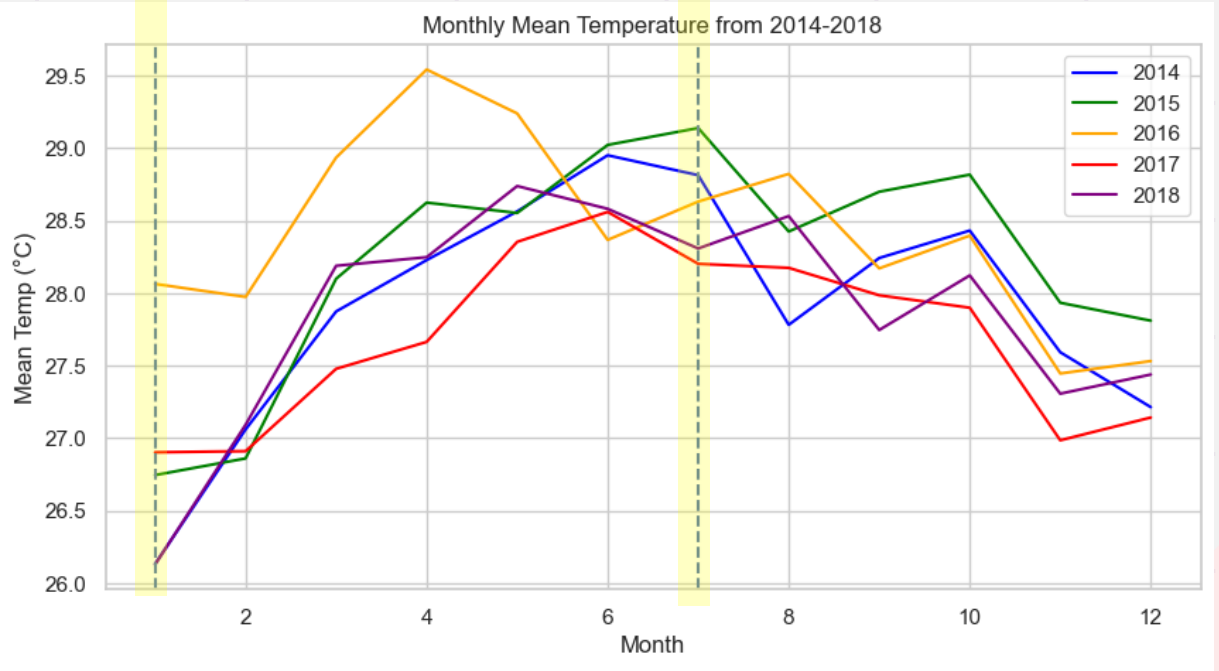
# Mean monthly cases peaked in mid-2014 and early 2016

Dengue cases are thought to go up during seasons with high temperature which encourages aedes mosquito breeding

**Data does support this trend:**

- **2014's peak was during SG's hottest mid-year period**
- **2016's peak at the start of the year was due to El Nino in late 2015.**

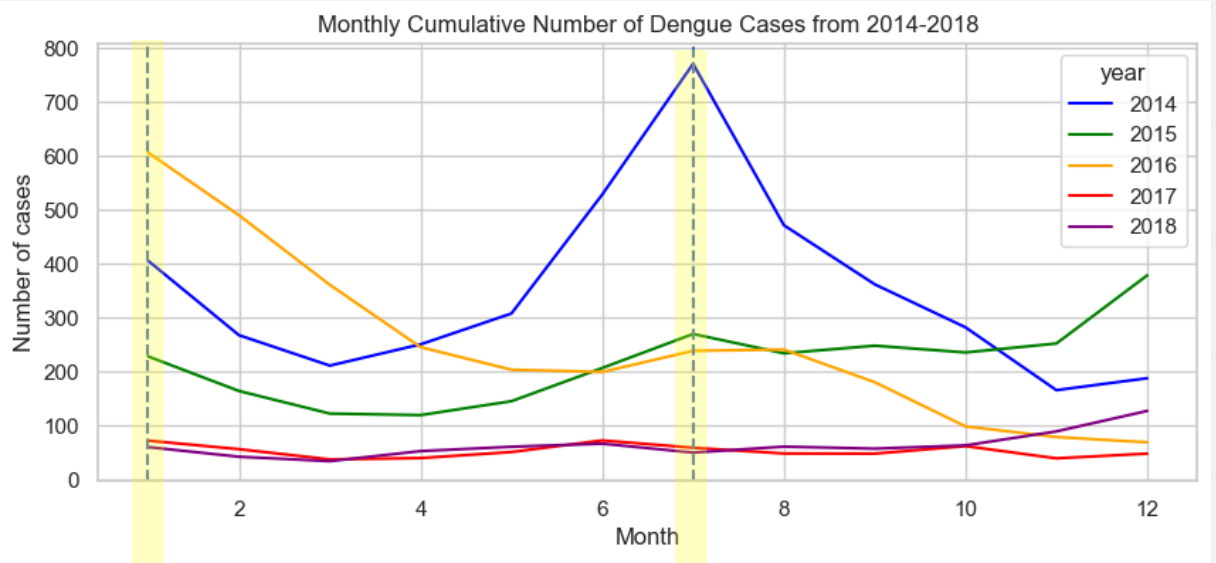


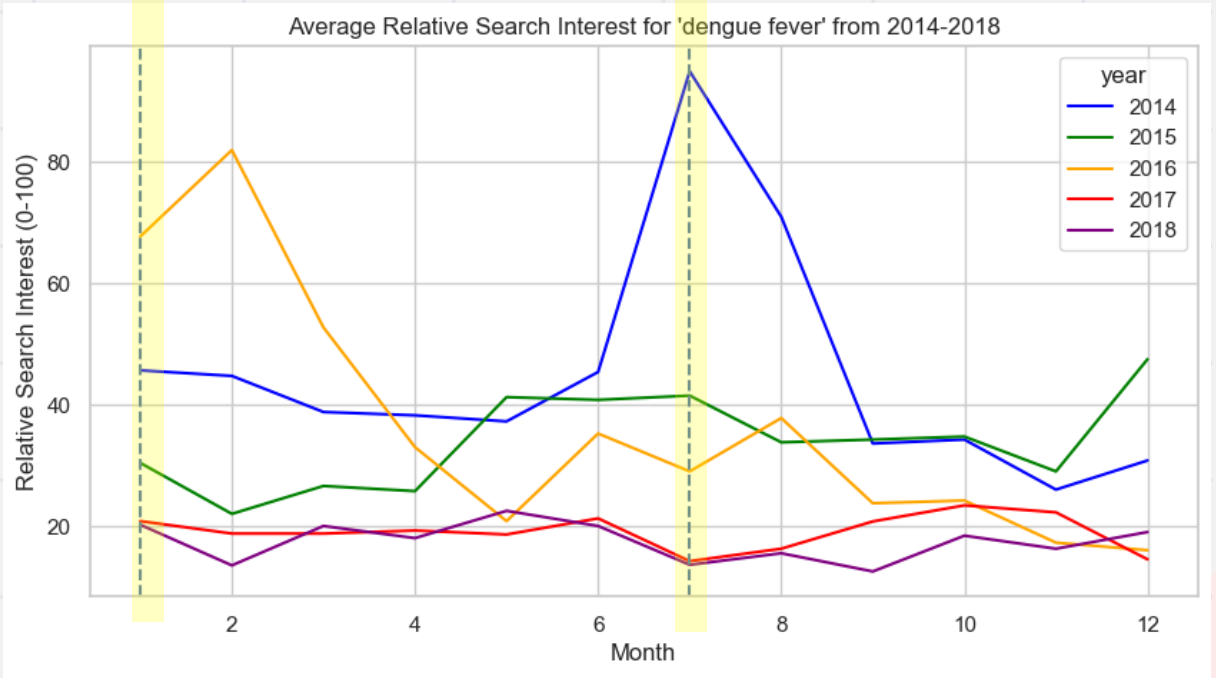



# Google searches for ‘dengue fever’ track case numbers closely

- **Searches for “dengue fever” go up when actual caseloads increase**

- This is likely due to higher media coverage and more people experiencing the symptoms of dengue, thus going online to look for solutions and medical advice



# Timing matters: NEA's campaigns have historically preceded high case volumes (except for Jan 2016)

- Our model aims to predict the best time to start the mozzie wipeout in 2019

***Campaigns***

2014: NEA conducts 3.5M inspections and destroys over 18K mosquito breeding habitats mostly in homes

Late 2015: NEA's Gravitrap data shows rise in Aedes mosquito population

Aug 2016: Wolbachia small-scale trial

Oct 2016: HSA approves dengue vaccine

Sep 2018: Wolbachia phase 2

***Interventions***

**Jun 2014: 'Do the Mozzie Wipeout' Campaign 2014**

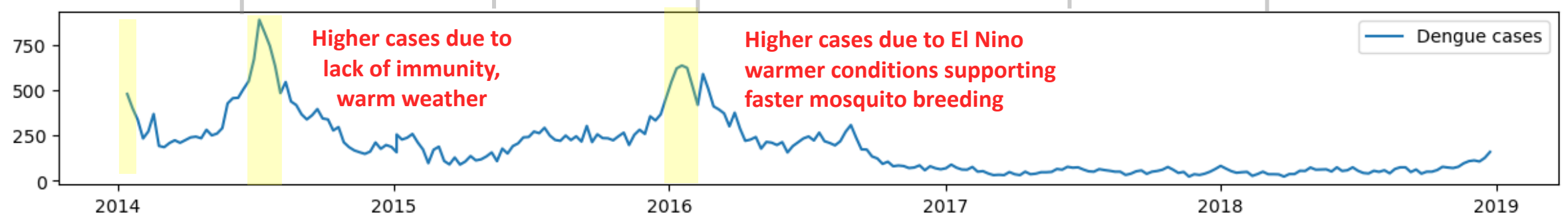
**Apr 2015: 'Do the Mozzie Wipeout' Campaign 2015**

**Feb 2016: 'Do the Mozzie Wipeout' Campaign 2016**

**May 2017: 'Do the Mozzie Wipeout' Campaign 2017**

**Feb 2018: Public Advisory**

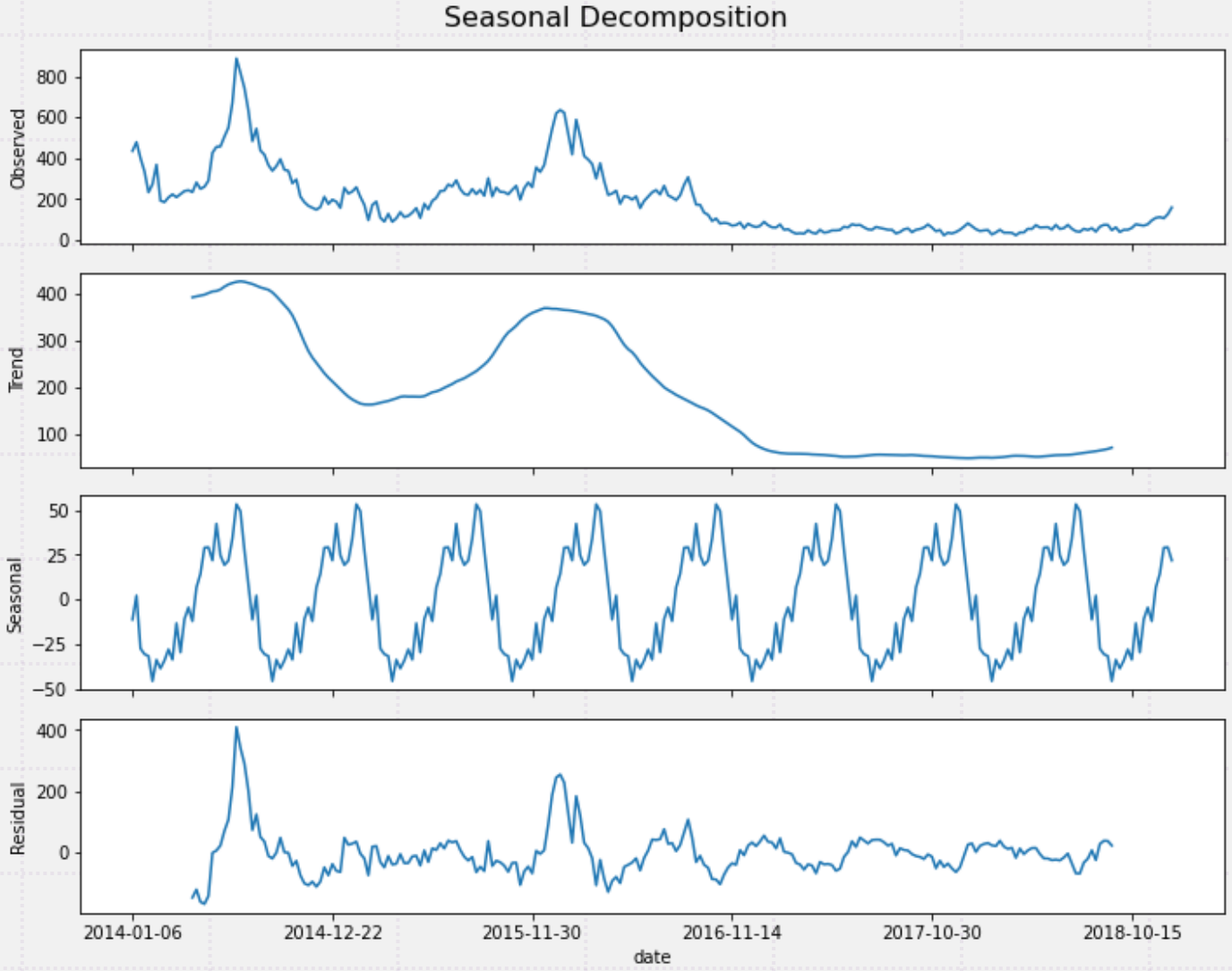
***Cases***



# Data Science Approach

Problem Statement → Data Collection → Data Cleaning & Exploratory Data Analysis → **Diagnostics and Modelling** → Conclusion & Recommendation

# Diagnostics and Modelling



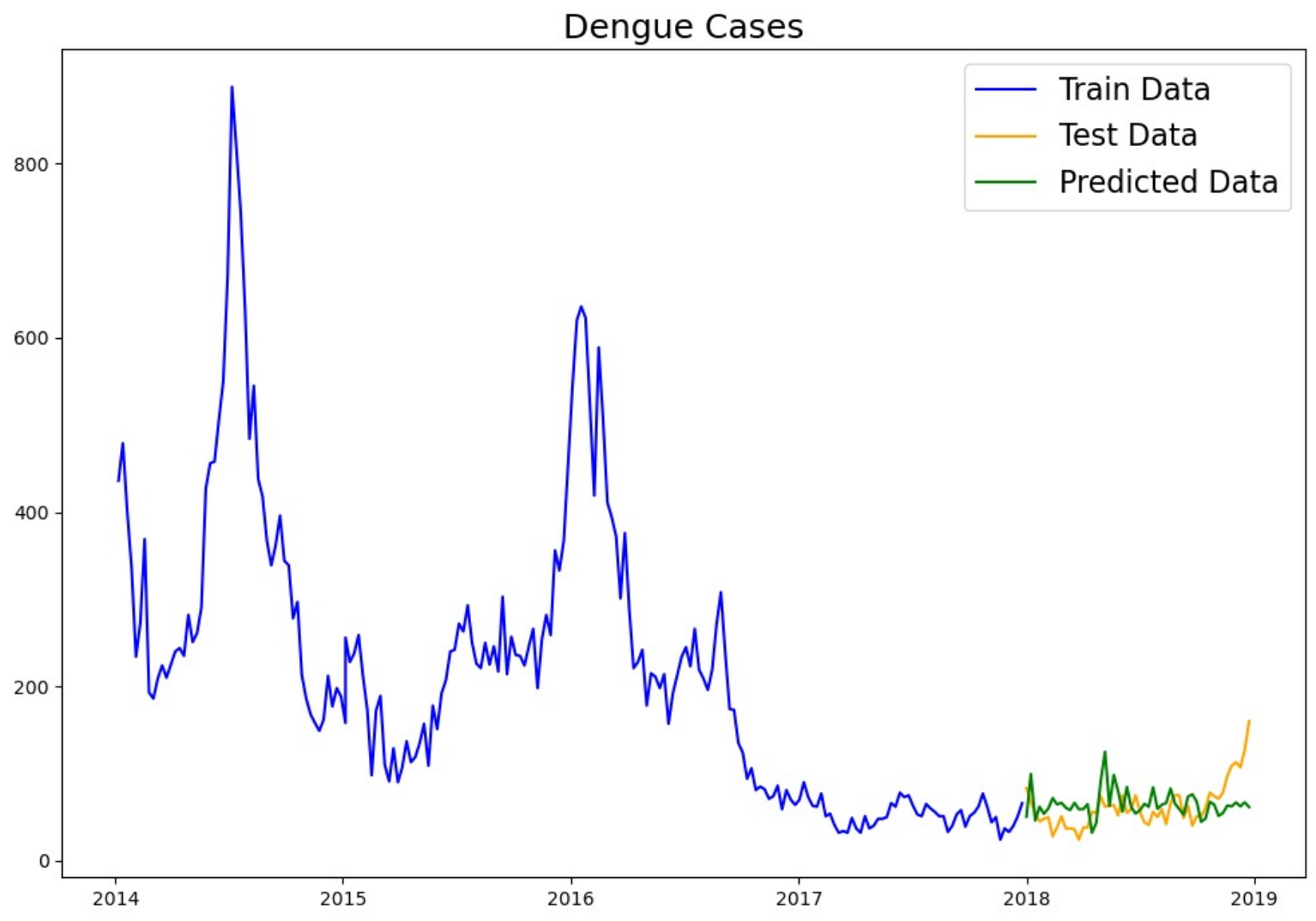

## Inference:

- Downward Trend, flatten from end 2016.
- Seasonal 6 months.
- Residual – mean & variance not constant.

## Conclusion:

- Seasonal in nature.
- Non-stationary.

# Diagnostics and Modelling

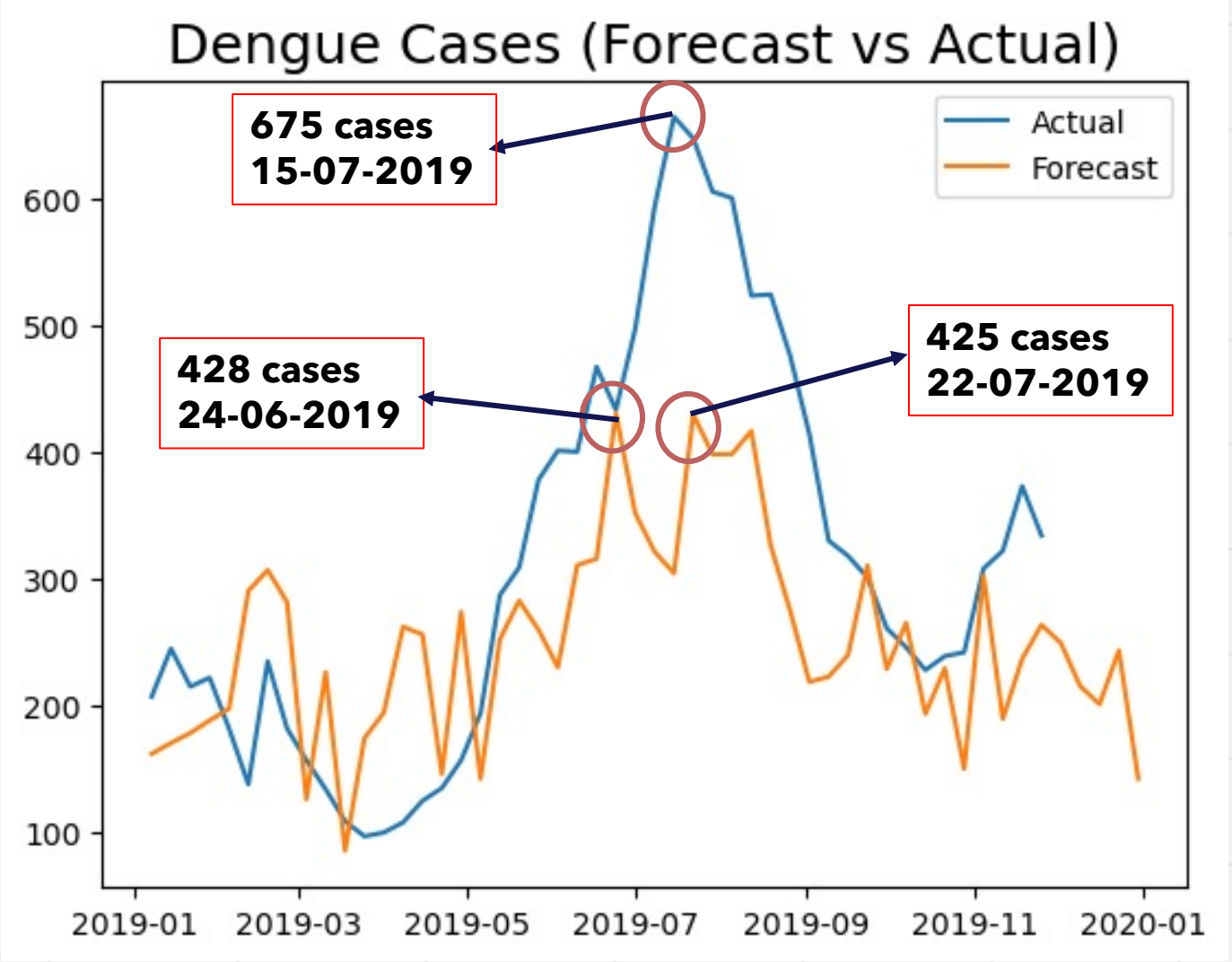



**Model: SARIMAX**
**(p,d,q):(0,1,1)**
**(P,D,Q,s):(0,0,0,26)**
**Exo - Google Trends**
**- Climate**

| Seasonal Order | AIC | Log Likelihood | RMSE |
|---|---|---|---|
| **(0,0,0,26)** | 2229.573 | -1089.786 | 29.44 |

- **AIC lowest.**
- **Log Likelihood highest.**
- **RMSE within the range of different models.**

# Diagnostics and Modelling



# Data Science Approach

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- **Cost-Benefit Analysis**

# Cost-Benefit Analysis

| | | Our forecast: **13,068 cases** | 40% Efficacy: **7,841 cases** |
|---|---|---|---|
| Direct Costs | Hospitalization costs | $ 3.9mil | $ 2.3mil |
| | Treatment costs | $ 39.2mil | $ 23.5mil |
| Indirect Costs | Productivity lost (friction cost method) | $ 172mil | $ 103mil |
| Government intervention | Education program | | $ 5mil |
| | Vector reduction | | $ 20mil |
| | **TOTAL COSTS** | $ 215mil | $ 154mil |

*28% of the cost is reduced*

# Our recommendation: Educate and Eradicate

**Focus vector control efforts from June – July:** the highest number of dengue cases

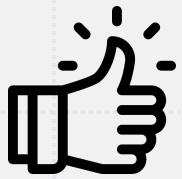
Timing matters: drive **education** campaigns from **April - August**

Prevention is better than cure: reaps cost savings of **at least 28%**

# Thank you

# Annex

# We leveraged on this report, which has a detailed cost break down



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RESEARCH ARTICLE

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

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

Published: October 13, 2021 • https://doi.org/10.1371/journal.pgph.0000024

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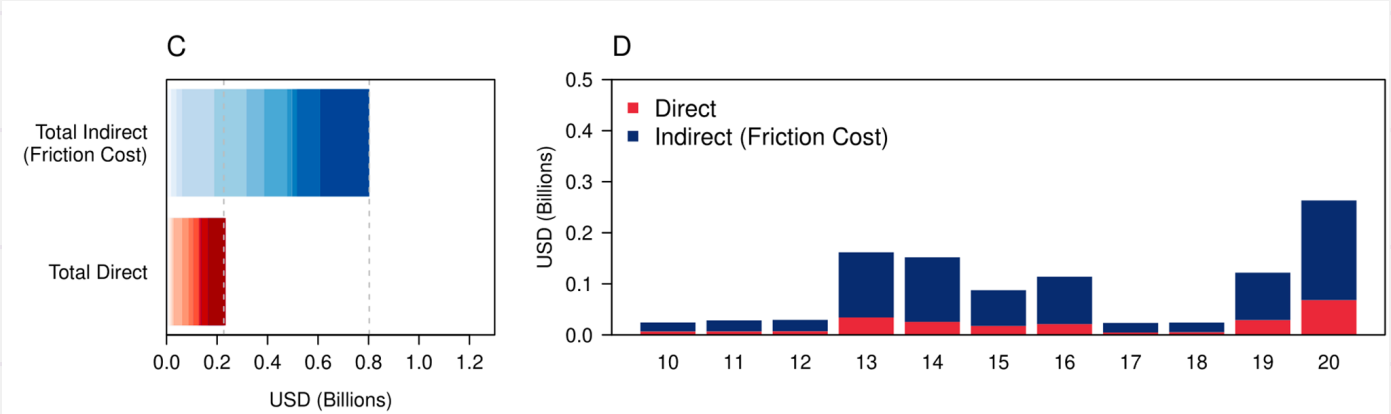
### Abstract

The release of Wolbachia-infected mosquitoes is a promising disease intervention strategy that aims to control dengue and other arboviral infections. While early field trials and modelling studies suggest promising epidemiological and entomological outcomes, the overall cost effectiveness of the technology is not well studied in a resource rich setting nor under the suppression approach that aims to suppress the wild-type mosquito population through the release of Wolbachia-infected males. We used economical and epidemiological data from 2010

# Friction Cost Approach




Friction cost approach is the measure of **actual** value of production loss due to illness. It is roughly 4 times of the direct cost

Source

# Treatment costs

We uses the average cost of $300 per case, and $3000 per hospitalization

Source

| Parameter | | Value | Source |
|---|---|---|---|
| Proportion of children that require a parent to be absent from work for care giving | | 0.43 | [33] |
| Proportion of elderly needing to hire a care giver | | 0.073 | [34] |
| Discount rate for premature deaths productivity lost | | 0.03 | [35] |
| Transport costs to seek medical care and household members visiting patients[1] | | 3.7 | [36] |
| Average household services losses per day | | 35 | [37] |
| Cost of providing primary education per student per day[2] | | 21.2–36.6 | [38, 39] |
| Cost of providing secondary education per student per day[2] | | 29.6–48.5 | [38, 39] |
| Average costs per visit (CHAS)[3], $Cost_C$ | | 32.8–56.1 | MOH |
| Average costs per visit (Polyclinic)[3], $Cost_P$ | | 58.0–74.8 | MOH |
| Average costs per visit (Public Hospitals)[3] | | 1780.9–3014.0 | MOH |
| Average costs per visit (Emergency Department)[3] | | 135.3–281.5 | MOH |
| Average productivity loss per absent day of work in individuals from 18 to 64 years[4] | | 155.4–200.0 | [40] |
| $EF_a$ | 0–24, age dependent (constant) symptomatic rates[5] | 3.8 (1.7–3.6) | [23] |
| $EF_a$ | 25–34, age dependent (constant) symptomatic rates[5] | 13.1 (3.8–8.2) | [23] |
| $EF_a$ | 35–44, age dependent (constant) symptomatic rates[5] | 24.3 (6.1–13.4) | [23] |
| $EF_a$ | 45–54, age dependent (constant) symptomatic rates[5] | 45.3 (11.1–24.2) | [23] |
| $EF_a$ | >55, age dependent (constant) symptomatic rates[5] | 50 (12.2–26.5) | [23] |
| Average number of ambulatory visits | | 4.33 | ARDENT project |
| Duration of disability, reported/unreported cases | | 4–14 | [41] |
| Hospital average length of stay | | 3.2–3.7 | MOH |
| $EFh$ [6] | | 1 | MOH |

[1] Average daily ridership and average round trip distance used to calculate weighted average transportation cost. It includes Mass Rapid Transport and Light Rapid Transport systems, bus, and taxi. An average of two family visits per day per inpatient are assumed.

[2]Estimated by dividing the average cost of one student per year by number of schooling days for each year.

[3]Estimated using average bill size per notified dengue patient in respective institution type per year.

[4]Estimated by dividing the household median income by number of calendar years.

[5]Follows [23] by estimating ambulatory expansion factors using serological information in Singapore from 2004 onwards.

[6]Conservatively sets hospitalization expansion factor to 1 by assuming perfect diagnosis.

https://doi.org/10.1371/journal.pgph.0000024.t001

# Benchmark: 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

This is the cost structure, which uses 40% Efficacy as a benchmark.

Source

# Vector control costs

**6. Maintenance, services and supplies**

Included in maintenance, services and supplies were:

| | 2021/2022 $ | 2020/2021 $ |
|---|---|---|
| Public area landscaping, cleaning services and supplies | 137,973,935 | 134,289,464 |
| Incineration services | 114,651,455 | 92,994,392 |
| Professional, consultancy and contract services | 48,826,999 | 54,238,672 |
| Maintenance of specialised and industrial equipment | 40,181,435 | 34,328,409 |
| Maintenance of building, markets and hawker centres and office premises | 41,783,806 | 38,029,872 |
| IT services | 44,974,717 | 39,499,526 |
| Security and enforcement services | 22,813,596 | 19,414,686 |
| Industrial supplies | 13,242,335 | 12,634,712 |
| Vector control services | 23,022,011 | 22,950,676 |
| Table cleaning services | 15,169,709 | 13,455,794 |
| Utilities charges | 12,534,978 | 7,737,394 |

This is the cost for Vector control services (~$20mil)

Source: NEA

# “Mozzie Wipe Out” education costs

## Up to $10m contract for campaign against dengue

Poon Chian Hui
Deputy Business Editor

PUBLISHED 27 APR 2013, 8:07 AM SGT

Singapore, in its fight against dengue, has awarded a contract worth up to $10 million to an advertising firm for year-round campaigns against the deadly disease.

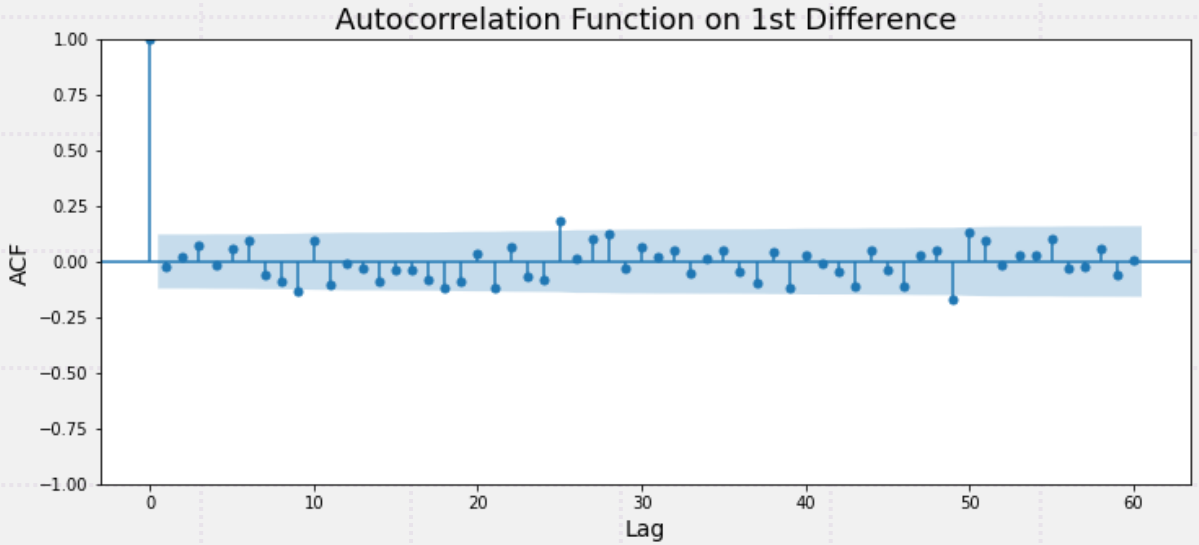
The contract from the National Environment Agency (NEA) to DDB Worldwide is made up of two parts: $5 million for campaign costs from now till next March and another $5 million should the contract be extended another year.

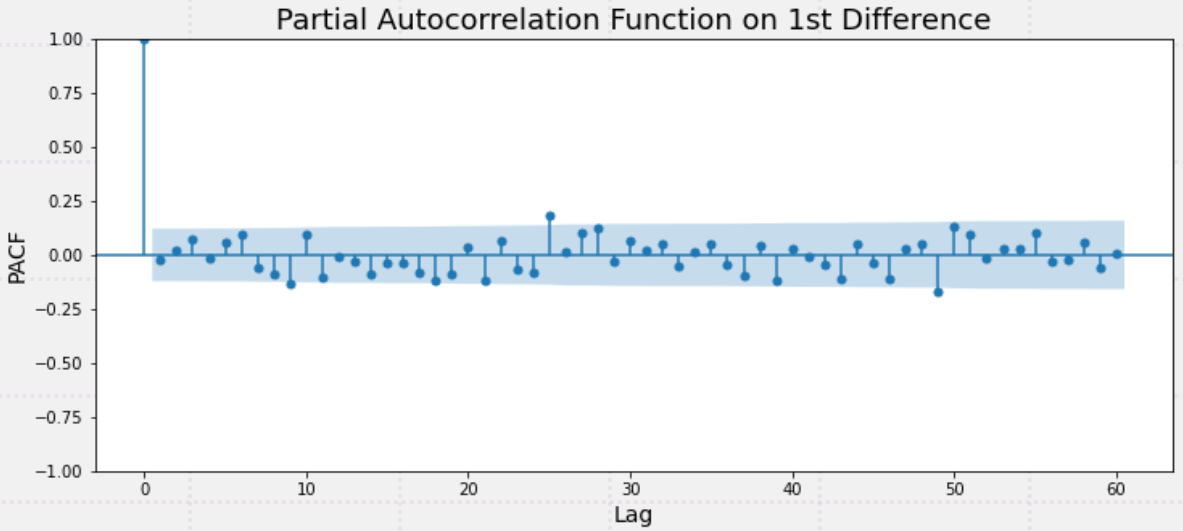
The year-round campaign against the worsening epidemic starts tomorrow and there will be no let-up even during the months when the Aedes mosquito is lying low.

This is the cost for education campaign ($5mil/year)

Source: Straits Times

# Diagnostics and Modelling



# Diagnostics and Modelling