Presented as a Zoom Public Lecture at BrisScience, July 6, 2020

Estimation and control of epidemics via Safe Blues

Yoni Nazarathy

Based on joint work with Raj Dandekar (MIT), Shane Henderson (Cornell), Marijn Jansen (UQ), Sarat Moka (UQ), Chris Rackauckas (MIT), Peter Taylor (Melbourne), and Aapeli Vuorinen (UQ, Melbourne).

safeblues.org
@ynazarathy
Deaths: \( p = \frac{532,691}{11,367,743} \approx 4.5\% \)

Number of people you love: \( n \approx 10 \)

Assumed proportion infected: \( F = 0.75 \)

Chance to lose a loved one: 
\[
1 - (1 - F \times p)^n \approx 30\%
\]

If \( p = 1\% \): 
\[
1 - (1 - F \times p)^n \approx 7.3\%
\]

If \( n = 20 \): 
\[
1 - (1 - F \times p)^n \approx 50\%
\]
We are fighting back…
But social distancing hurts…
So governments are doing their best* to find the sweet spot...

* With the exception of some governments across the Americas
How?

Clinical aspects…

Economic aid…

Modelling to inform policy…
Spanish Flu

SIR Model
(Kermack–McKendrick theory)

Computational Statistics
(ML/DS/AI)

1918-1920
Spanish Flu

1928-1933
SIR Model
(Kermack–McKendrick theory)

1955 - 2015+
Computational Statistics
(ML/DS/AI)

2000+
Smart Mobile Devices

2019-2020+
COVID-19 Pandemic

Modelling to inform policy…
1918-1920
Spanish Flu

1928-1933
SIR Model
(Kermack–McKendrick theory)

1955 - 2015+
Computational Statistics
(ML/DS/AI)

2000+
Smart Mobile Devices

2019-2020+
COVID-19 Pandemic
1918-1920
Spanish Flu

1928-1933
SIR Model
(Kermack–McKendrick theory)

1955 - 2015+
Computational Statistics
(ML/DS/AI)

2000+
Smart Mobile Devices

2019-2020+
COVID-19 Pandemic
1918-1920
Spanish Flu

1928-1933
SIR Model
(Kermack–McKendrick theory)

1955 - 2015+
Computational Statistics
(ML/DS/AI)

2000+
Smart Mobile Devices

2019-2020+
COVID-19 Pandemic

Spanish Flu
SIR Model
Computational Statistics
Smart Mobile Devices
COVID-19 Pandemic
Spanish Flu
(1918-1920)

SIR Model
(1928-1933)
(Kermack–McKendrick theory)

Computational Statistics
(ML/DS/AI)
(1955 - 2015+)

Smart Mobile Devices
(2000+)

COVID-19 Pandemic
(2019-2020+)

Safe Blues
Quantifying an epidemic with a single number, the reproductive number: $R$

$$R = \text{The number of secondary infections induced by an infected individual}$$

$R < 1 : \text{Exponential Decay}$

$R > 1 : \text{Exponential Growth}$

What is $R$ for COVID?
What affects $R$?

- biology
- environment
- conduct
- contact

Social distancing level
Illustration: SIR Toy Model
Illustration: SIR Toy Model
Illustration: SIR Toy Model
Illustration: SIR Toy Model
Illustration: SIR Toy Model
Illustration: SIR Toy Model with Social Distancing
Illustration: SIR Toy Model with Social Distancing
But how does social distancing work for non-toy models?
Big Problem: COVID measurements are noisy, partial, and delayed!

safeblues.org
Safe Blues is about injecting many virtual safe viruses... to get real time measurements.
Safe Blues = virtual safe viruses

\[ R = f \left( \begin{array}{c}
\text{biology} \\
\text{environment} \\
\text{conduct} \\
\text{contact}
\end{array} \right) \]

\[ R^1 = f^1 \left( \begin{array}{c}
\text{bluetoothology}^1 \\
\text{contact}
\end{array} \right) \]

\[ R^2 = f^2 \left( \begin{array}{c}
\text{bluetoothology}^2 \\
\text{contact}
\end{array} \right) \]

\[ R^N = f^N \left( \begin{array}{c}
\text{bluetoothology}^N \\
\text{contact}
\end{array} \right) \]
Infected
Projection with SafeBlues
Latest Infection Observations

Day
Proportion Infected

Strong Social Distancing ON

About to turn Social Distancing OFF

Infected
Projection with SafeBlues
Latest Infection Observations
Proportion Infected vs. Day

- Infected
- Previous Projection
- Projection with SafeBlues
- Latest Infection Observations

Y-axis: Proportion Infected
X-axis: Day
The graph shows the proportion of infected individuals over time. Key lines represent:
- **Infected** (red dots)
- Previous Projection (green)
- Projection with SafeBlues (blue)
- Latest Infection Observations (black)

The x-axis represents days, while the y-axis represents the proportion of infected individuals.
How we tested Safe Blues…

Model I

Model II

Model III
Understanding the effect of various social distancing regimes

\[ S' = -C\beta(p)\delta SI, \]
\[ I' = C\beta(p)\delta SI - \gamma(p)\delta I, \]
\[ R' = \gamma(p)\delta I, \]
\[ \tilde{S}' = -C\beta(p)\tilde{S}\tilde{I}, \]
\[ \tilde{I}' = C\beta(p)\tilde{S}\tilde{I} - \gamma(p)\tilde{I}, \]
\[ \tilde{R}' = \gamma(p)\tilde{I}. \]
Safe Blues is not a contact tracing app

... but can be added to such an app

Currently working towards an Android App and an experiment based on “Trace Together”...
Thank you

If you think Safe Blues is a good idea, then please let your government know about it.

safeblues.org
@ynazarathy