Of love, death and money: perspectives on the ecology of fear during the covid19 epidemic

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Panel Post COVID19
“Disease, it turns out, is largely and environmental issue”
Definition

“...the ecological study of host-pathogen interactions within the context of their environment and evolution...” (Kilpatrick and Altizer 2010)

**Interdisciplinary science:** population ecology, epidemiology, parasitology, geography, mathematics and statistics

**Purpose:** understand transmission and disease spread over space and time and its impact on host dynamics.
Interdisciplinary approach

Mathematical Modeling

Covid19 Dynamics

Ecology

Human Behavior

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SIR models

- **S**: Susceptibles
- **I**: Infective
- **R**: Removed (immune or dead)

\[
\begin{align*}
\Delta S &\rightarrow \beta SI \\
\Delta I &\rightarrow \Upsilon I \\
\end{align*}
\]
SIR models

\[ \frac{dS}{dt} = -\beta SI \]
\[ \frac{dI}{dt} = \beta SI - \gamma I \]
\[ \frac{dR}{dt} = \gamma I \]
SIR Model

A “simple” model for contact diseases

\[
\begin{align*}
\frac{dS}{dt} &= -\beta SI \\
\frac{dI}{dt} &= \beta SI - \gamma I \\
\frac{dR}{dt} &= \gamma I
\end{align*}
\]

- $S$: susceptibles, $I$: Infectious, $R$: Recovered
- $\beta$: transmission rate
- $\gamma$: recovery rate, $1/\gamma$: infectious period
A threshold condition... $R_0$

For a disease to spread we need $\frac{dI}{dt} > 0$, or in other words $\frac{\beta}{\gamma} \geq 1$. We denote the threshold condition $R_0$ as

$$R_0 = \frac{\beta}{\gamma}$$

$R_0$ is the average number of secondary infections by a single infected individual. If $R_0 \geq 1$ we have an epidemic.
### $R_0$

<table>
<thead>
<tr>
<th>Disease</th>
<th>$R_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diptheria</td>
<td>6-7</td>
</tr>
<tr>
<td>Measles</td>
<td>12-18</td>
</tr>
<tr>
<td>Smallpox</td>
<td>6-7</td>
</tr>
<tr>
<td>Polio</td>
<td>5-7</td>
</tr>
<tr>
<td>Malaria</td>
<td>1-18</td>
</tr>
<tr>
<td>HIV</td>
<td>2-5</td>
</tr>
<tr>
<td>Influenza</td>
<td>2-3</td>
</tr>
<tr>
<td>Ebola</td>
<td>1-4</td>
</tr>
<tr>
<td><strong>covid19</strong></td>
<td><strong>2–3</strong></td>
</tr>
</tbody>
</table>

**Table:** $R_0$ estimates for various diseases

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The main goal to manage an epidemic is to get to $R_0 < 1$. 
Social distancing reduces transmission rate

Define $C_\beta$ as the proportion of transmission rate reduced by social distancing

$$R_0 = \frac{\beta(1 - C_\beta)}{\gamma}$$
Social distancing and $R_0$

Without social distancing $R_0 > 1$

$$R_0 = \frac{\beta}{\gamma} = \frac{0.25}{0.1} = 2.5$$

With social distancing $R_0 < 1$

$$R_0 = \frac{\beta(1 - C\beta)}{\gamma} = \frac{0.25(1 - 0.3)}{0.1} = 0.75$$
With social distancing $C_\beta = 0.3$ starting in day 70

No Social Distancing

Social Distancing
Starting at day 70
When do you start social distancing matters

Social Distancing
Starting at day 70

Social Distancing
Starting at day 30

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Adding quarantine to social distancing

Define $C_\gamma$ as the proportional effect of quarantine decreasing the length of the infectious period $(1/\gamma)$

$$R_0 = \frac{\beta(1 - C_\beta)}{\gamma(1 + C_\gamma)}$$
Combining social distancing and quarantine

Social Distancing Starting at day 30

Social Distancing and quarantine

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In sum...

- Social distancing can be used to decrease $R_0$
- When do you start social distancing matters
- Combined with quarantine increases the duration of epidemic but significantly reduces prevalence
This model is wrong!!
Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.

Statistician George Box in his 1987 book, Empirical Model-Building and Response Surfaces (which was co-authored with Norman Draper).
Assumptions of the basic SIR model

- Closed population
- No demographics (no births or natural deaths)
- Large naive population
- Quick epidemic (demographics are not important)
- **Homogeneous mixing**

**Homogeneous mixing**: Every individual has the same probability of infection
Probability of infection is often driven by risk behavior

How much risk are you willing to take? Trade-off between survival and resources.
Ecology of Fear: Predator-Prey

**Prey:** Needs to balance level of vigilance in response to their perceptions of a predator’s whereabouts.
Ecology of Fear: Host-Pathogen

**Host:** Needs to balance level of vigilance in response to their perceptions of a pathogen’s whereabouts.

Decision is made based on *information*
In animals life is a balance between...

**Survival vs. food and mates**

How are humans gathering information to inform this balance during covid19? What are human perceptions changing?
Google trends

How are humans gathering information to inform this balance during covid19? What are human perceptions changing?
Money, love and death this period last year...

Google Search Volume In 2019

Interest

Love

Death

Money

Day

Jan Feb Mar Apr May Jun

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Money, love and death this period last year...

Google Search Volume in 2019

Google Search Volume in 2020

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Variability in human behavior, driven by available information and individual perspectives, results in variability in disease risk and management response.
The future of covid19 research is interdisciplinary

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