Unlikely disasters

Pandemics, prevention and public health

Christopher Dye
“The world knows an apocalyptic pandemic is coming but nobody is interested in doing anything about it”

L. Garrett, *Foreign Policy*, 20 September 2019
4000 years of diarrhoea

4.5bn of 7.6bn people still do not have safe sanitation
>5 million preventable deaths in children each year
### $7 trillion on health – 4% on prevention

<table>
<thead>
<tr>
<th>Preventable risk</th>
<th>% spend SHA</th>
<th>Prevention</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% deaths</td>
<td>4%</td>
<td>96%</td>
</tr>
<tr>
<td>Environment</td>
<td>&gt;17%</td>
<td><img src="image1.png" alt="Environment Image" /></td>
<td><img src="image2.png" alt="Treatment Image" /></td>
</tr>
<tr>
<td>Metabolism</td>
<td>&gt;30%</td>
<td><img src="image3.png" alt="Metabolism Image" /></td>
<td><img src="image2.png" alt="Treatment Image" /></td>
</tr>
<tr>
<td>“Behaviour”</td>
<td>&gt;41%</td>
<td><img src="image4.png" alt="Behaviour Image" /></td>
<td><img src="image2.png" alt="Treatment Image" /></td>
</tr>
</tbody>
</table>
National Health or Sickness Service?

Prevention is better than cure

Our vision to help you live well for longer

“Prevention will be embedded into every part of the NHS over the next decade. State, society, business and people.”

05 November 2018
“Prevention is better than cure” means...

Aspirational
“Highest attainable standard of health” (WHO)

Conditional
Benefit/Cost (prevention) > Benefit/Cost (treatment)
Prevention more likely to be favoured when...

**Benefit**
- Large avoidable threat (hazard, $H$)
- Certain reward (risk, uncertainty, $p$)
- Immediate result (time discount, $d$)

**Cost**
- Low cost ($ and non-$, $C$)
- High efficacy ($e$)

**Maximize**
\[
\frac{\text{benefit}}{\text{cost}} = \frac{e \times p \times d \times H}{C}
\]

**Choice**
- Rational - testable $H_0$
- Contingencies
- Values - measured & perceived
## Perceived value of a future threat

<table>
<thead>
<tr>
<th>Element of threat</th>
<th>Lower value</th>
<th>Higher value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voluntary</td>
<td>Imposed</td>
<td></td>
</tr>
<tr>
<td>Known precisely</td>
<td>Not known precisely</td>
<td></td>
</tr>
<tr>
<td>Trusted source</td>
<td>Distrusted source</td>
<td></td>
</tr>
<tr>
<td>Controllable</td>
<td>Uncontrollable</td>
<td></td>
</tr>
<tr>
<td>Pleasurable</td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td>Delayed</td>
<td>Immediate</td>
<td></td>
</tr>
<tr>
<td><strong>Hazard</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familiar</td>
<td>Novel</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>Acute</td>
<td></td>
</tr>
<tr>
<td>Nonthreatening</td>
<td>Dreaded</td>
<td></td>
</tr>
<tr>
<td>Adults affected</td>
<td>Children affected</td>
<td></td>
</tr>
<tr>
<td>Natural</td>
<td>Man-made</td>
<td></td>
</tr>
<tr>
<td>Benign</td>
<td>Severe</td>
<td></td>
</tr>
</tbody>
</table>
Modelling with the big wigs
Value, utility and the St Petersburg paradox (1713-38)

Decision theory: expected value of a win (or loss), \( E = p \times V \)

Utility theory: toss a coin; heads win until coin shows tails; for \( n \) heads, player wins \( 2^n \). How much would you bet?

\[
E = \frac{1}{2}2 + \frac{1}{4}4 + \frac{1}{8}8 + \frac{1}{16}16 + \cdots
\]

\[
E = 1 + 1 + 1 + 1 + \cdots = \infty
\]

Cramer (1728): "mathematicians estimate money in proportion to its quantity, and men of good sense in proportion to the usage that they may make of it."
Hazard
Risk
Time
Ebola
Public Health Emergency
PHEIC
West Africa
2014-16
Different values of Ebola and Tuberculosis
Deaths, expenditures and economic costs, 2014-15

<table>
<thead>
<tr>
<th></th>
<th>Ebola (West Africa 2014–15)</th>
<th>Tuberculosis (Global 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure (US$ bn)</td>
<td>5.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Economic cost (US$ bn)</td>
<td>53</td>
<td>41</td>
</tr>
<tr>
<td>Deaths</td>
<td>11,310</td>
<td>9,700 (W Africa) 1.33 million (Global)</td>
</tr>
</tbody>
</table>
Civil-Military Engagement on Ebola

OPERATION
Western Area Surge
LANDSCAPE OF EMERGING INFECTIOUS DISEASE RESEARCH AND DEVELOPMENT: PREVENTING THE NEXT PANDEMIC
Hazard
Risk
Time
All the “X” in one basket
1483 epidemic events 2011-18 in 172 countries

Pool assets: risky
Pool threats: insurance

Risk sharing for predictability
narrow range of 154-213 events/year
Avian influenza... Zika

© WHO 2019
Risk and the power (laws) of R&D
drugs > vaccines

Kremer & Snyder, Q J Econ (2015)

Population risk of disease = power curve
Zipf distribution = even revenue curve
More revenue from drugs than vaccines
HIV risk (US), drug revenue 4× vaccine
Drugs $930bn/yr, vaccines $60bn/yr
Breakthrough of the Year 2015

Runners-up: new vaccine protects against Ebola

“Breakthrough therapy” still not licensed by Merck Feb 2019
Preclinical to phase 2a $319–469 million per vaccine

Portfolio MERS, Lassa, Nipah, RVF, Chikungunya, Ebola...

Generic technologies for rapid vaccine development - “Disease X”

Risk sharing among investors
Sharing risk through platform technologies

Pandemic influenza preparedness Framework 2011 for the sharing of influenza viruses and access to vaccines and other benefits

GISAID GenBank

www.pnas.org/cgi/doi/10.1073/pnas.1701410114
COVAX

Vaccine R&D success ≈ 7% after preclinical trial

Vaccine nationalism and/or Vaccine equity
Place your bets
Buy your insurance
UK 340m doses, 6 Cos
Diverse portfolio
EU €2.4bn, 1 Co
170 countries
US 800m doses, 6 Cos
92 LMICs
Favourable price
COVAX: GAVI/CEPI/WHO
Insurance for catastrophes?
Betting against hurricanes: gambling with the odds in your favour

“Wall Street is a machine for turning information nobody cares about into information people can get rich from.”

In Nature’s Casino
Michael Lewis
NYT 26 Aug 2007
World Bank’s $500m pandemic scheme accused of ‘waiting for people to die’

Bonds designed to provide fast funding for poor countries branded ‘obscene’ because of complex payout criteria

Pandemic bonds: designed to fail in Ebola

The World Bank’s funding scheme for disease outbreaks drained potential resources from the Democratic Republic of the Congo, says Olga Jonas.
International Health Regulations
"prevent, protect against, control and respond to international spread of disease..." 1969

Newsweek
SARS
What You Need to Know
The New Age of Epidemics
2005
The RITE way to contain an epidemic
Rapid response to Ebola outbreaks in Liberia

Kateh MMWR 2015; 64: 188-92
“Everything we do before a pandemic will seem alarmist. Everything we do after a pandemic will seem inadequate”

St Petersburg paradox: loss vs gain

- 84% chance of $1 loss
- 16% chance of $64 win