EPIDEMICS AND PANDEMICS: PREDICTION, PREVENTION, CONTROL?

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In the last 15 years at least 11 different viruses have emerged or re-emerged causing large epidemics or pandemics:

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- In 2016 was Zika
- Yellow Fever and Lassa are currently causing large outbreaks in Brazil and Nigeria (and monkeypox!).
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Yellow fever in Brazil: (from July 217): 1257 cases and 394 deaths.
Lassa in Nigeria: Since early 2018 more than 120 deaths
Monkeypox in Nigeria: Since September 2017, 61 cases
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Recent emergence of Ebola in the Democratic Republic of Congo: 23 deaths
## A century of epidemics

<table>
<thead>
<tr>
<th>YEAR</th>
<th>EPIDEMIC</th>
<th>DEATHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>Spanish Flu (H1N1)</td>
<td>50-100 millions</td>
</tr>
<tr>
<td>1937</td>
<td>West Nile Virus</td>
<td>&gt; 15,000</td>
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<tr>
<td>1957</td>
<td>Asian Flu (H2N2)</td>
<td>~ 100,000</td>
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<tr>
<td>1968</td>
<td>Hong Kong Flu (H3N2)</td>
<td></td>
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<tr>
<td>1976-2012</td>
<td>Ebola Virus</td>
<td></td>
</tr>
<tr>
<td>1981-2017</td>
<td>HIV/AIDS</td>
<td>~ 40 millions</td>
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<tr>
<td>1999-2000</td>
<td>Flu (H5N2 &amp; H7N7)</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>SARS coronavirus</td>
<td>774</td>
</tr>
<tr>
<td>2003-2016</td>
<td>Avian Flu (H5N1)</td>
<td>449</td>
</tr>
<tr>
<td>2009</td>
<td>Swine Flu (H1N1)</td>
<td>284,5000</td>
</tr>
<tr>
<td>2012-2016</td>
<td>MERS Coronavirus</td>
<td>&gt; 750</td>
</tr>
<tr>
<td>2013-2016</td>
<td>Avian Flu (H7N9)</td>
<td>295</td>
</tr>
<tr>
<td>2014-2016</td>
<td>West Africa Ebola</td>
<td>11,325</td>
</tr>
<tr>
<td>1981-2017</td>
<td>Zika</td>
<td>20</td>
</tr>
<tr>
<td>Ongoing</td>
<td>Yellow Fever (Brazil, Africa)</td>
<td></td>
</tr>
<tr>
<td>Ongoing</td>
<td>Lassa (Nigeria)</td>
<td></td>
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</tbody>
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Adapted from: Jonathan Quick, *The End of Epidemics*, 2018
IMPORTANT EPIDEMICS OR PANDEMICS DUE TO EMERGENT OR RE-EMERGING DISEASES (2002-2015)

- Severe acute respiratory syndrome (SARS) started in China, 774 deaths, 50 billion USD
- Chikungunya outbreaks
- Cholera, Zimbabwe
- Cholera, Haiti
- H1N1 influenza pandemic
- Measles, Democratic Republic of Congo
- Zika virus, Yap Island, Federated States of Micronesia
- Zika virus, French Polynesia
- Ebola, outbreaks in West Africa
- Chikungunya outbreaks
- Middle East respiratory syndrome (MERS) outbreaks
- Pandemic Flu, >23,000 cases, >400 deaths

Millions of cases since 2012; Microcephaly 3.5 billion USD
11,300 deaths; 2.2 billion USD
Millions of cases since 2013.
643 deaths (2012-2015); 26 countries

“Life can only be understood backwards; but it must be lived forwards”

Søren Kierkegaard (1813-1855)
Quoted by Harvey V. Fineberg (Epidemics going viral, April 27, 2018)
LESSONS LEARNED FROM RECENT EPIDEMICS AND PANDEMICS

• Emerging and re-emerging diseases can be caused by multiple different agents, especially by many different families of viruses;
• Emerging and re-emerging diseases are nothing new;
• Emerging viruses can circulate locally for years before causing epidemics or pandemics (opportunities for early detection); Some emerging and re-emerging viral epidemics will not go away; and
• The economic cost of epidemics and pandemics is enormous!

MEMBERS OF MANY VIRUS FAMILIES CAN CAUSED EMERGING AND RE-EMERGING EPIDEMICS

- Smallpox
- Crimean Congo HF
- Rift Valley Fever
- SFTS
- Nipah
- SARS
- MERS
- Influenza
- Yellow Fever
- Dengue
- West Nile
- Zika
- Chikungunya
- Lassa
- Junin
- Lujo
- HIV, HTLV I
- Ebola
- Marburg
- Noro
- Crimean Congo HF
- Rift Valley Fever
- SFTS
- Nipah
- SARS
- MERS
- Influenza
- Yellow Fever
- Dengue
- West Nile
- Zika
- Chikungunya
- Lassa
- Junin
- Lujo
- HIV, HTLV I
- Ebola
- Marburg
- Noro
- Arthropod borne
WHO PRIORITY DISEASES (2018)

- Crimean-Congo hemorrhagic fever (CCHF)
- Ebola virus disease and Marburg virus disease
- Lassa fever.
- Middle East respiratory syndrome coronavirus (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS)
- Nipah and henipaviral diseases
- Rift Valley fever (RVF)
- Zika
- Disease X

- Others: chikungunya, monkeypox, severe fever with thrombocytopenia syndrome

• New CEPI funding for vaccine development:
  • Lassa fever
  • Nipah
  • Middle East Respiratory Syndrome (MERS)

• Other needed vaccines:
  • Universal influenza vaccine
  • Highly pathogenic filoviruses (Ebola, Marburg)
  • Novel orthopoxvirus vaccines (smallpox, monkeypox)
  • Zika
  • Etc.
Why are we at risk from local outbreaks turning into global pandemics?

- Population growth: urbanization and encroachment into new environments
- Spread of infectious diseases through global travel and trade
  - Increased risk of infectious pathogens “spilling over” from animals to humans (zoonosis)
- Climate change
- Development of antimicrobial resistance
- Weak public health infrastructures (few medical personnel doctors in outbreak regions)
- Civil conflicts
- Acts of bioterrorism

POPULATION GROWTH: URBANIZATION AND ENCROACHMENT INTO NEW ENVIRONMENTS

- 1800: 1 billion
- 1900: 1.65 billion
- 2000: 8 billion
- 2050: 9.7 billion

Urbanization and overcrowding facilitates transmission.
SPREAD OF INFECTIOUS DISEASES THROUGH GLOBAL TRADE AND TRADE

• 1975: 500 million
• 1990: 1 billion
• 2017: 3 billion
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ZOONOSIS: a disease that can be transmitted to humans from animals
Illustration of the relative size of the potentially unknown virosphere

known classified viruses 0.005% (4,404)

potential unknown virosphere 99.995% (~87 000 000)

human viruses 0.0003% (219)

Pathways to zoonotic spillover

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THE GLOBAL RESPONSE TO EPIDEMICS IS USUALLY TOO LITTLE TOO LATE

Prevent
Contain

PROACTIVE

PUBLIC HEALTH AGENCIES USUALLY INTERVENE AT THE TAIL END OF THE EPIDEMICS

PREDICT
PREVENT
CONTAIN
CONTROL

EPIDEMICS GOING VIRAL

OUTBREAK
EPIDEMIC
PANDEMIC

PROACTIVE
REACTIVE
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Public Health Agencies usually intervene at the tail end of the epidemics

Outbreak  Epidemic  Pandemic

Predict  Prevent  Contain  Control

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EARLY DETECTION
- Astute clinical observation
- Laboratory tests
- Event-based surveillance

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INNOVATIVE DETECTION TOOLS
- Global Surveillance and modeling
- Link with travel, climate, etc.
- Monitoring social media

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Outbreak Epidemic Pandemic
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Proactive decision: When to initiate a proactive response?

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DECISION: When to initiate a proactive response?

PREVENTIVE INTERVENTIONS
- Vaccination
- Vector control
- Antivirals
- Social isolation

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Outbreak Epidemic Pandemic

Predict Prevent Contain

PROACTIVE

REACTIVE
THE GLOBAL RESPONSE TO EPIDEMICS IS USUALLY TOO LITTLE TOO LATE

POLITICAL COMMITMENT

EARLY DETECTION
- Astute clinical observation
- Laboratory tests
- Event-based surveillance

DECISION: When to initiate a proactive response?

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Outbreak Epidemic Pandemic

Predict Prevent Contain Control

PROACTIVE REACTIVE
SOME EXAMPLES OF SUCCESSFUL CONTROL OF PREVIOUS EPIDEMICS OR PANDEMICS

• Smallpox: Vaccination
• Yellow Fever: Vaccination
• Polio: Vaccination
• HIV/AIDS: Combination prevention (a vaccine is needed)
• Influenza: Social isolation (an Universal Flu Vaccine needed.)

Vaccines is the best tool to prevent and control epidemics. But not the only one.
RECOMMENDATIONS FOR PREPARING FOR FUTURE EPIDEMICS

- The world needs to build a warning and response system for outbreaks. This system should
- be coordinated by a global institution that is given enough authority and funding to be effective,
- enable fast decision making at a global level,
- expand investment in research and development and clarify regulatory pathways for developing new tools and approaches,
- improve early warning and detection systems, including scalable everyday systems that can be expanded during an epidemic,
- involve a reserve corps of trained personnel and volunteers,
- strengthen health systems in low- and middle-income countries, and
- incorporate preparedness exercises to identify the ways in which the response system needs to improve.

“The Neglected Dimension of Global Security — A Framework for Countering Infectious-Disease Crises”
(a 2016 Report of the US National Academy of Sciences)

• Expected economic losses due to pandemics: USD 60 billion/year

• Cost of implementing NAS recommendations: USD 4.5 billion/year
  • Upgrading the public health systems in low and middle income countries: USD 3.4 billion
  • Enhancing the WHO prevention and response capabilities: USD 130-150 million
  • Incremental research and development: USD 1 billion
The next pandemic is not a matter of “if”, it’s a matter of “when”.

... and we have to prepare for it, because it will affect individuals, families, business and communities, everywhere in the world.