FIGHTING INFECTIOUS DISEASES IN A COMPLEX WORLD

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BRIEF HISTORY OF FLU

all plagues soon eradicated from Earth
(US public health officials)
New 'Sars-like' coronavirus identified by UK officials

By Michelle Roberts
Health editor, BBC News online

A new respiratory illness similar to the Sars virus that spread globally in 2003 and killed hundreds of people has been identified in a man who is being treated in Britain.

The 49-year-old man, who was transferred to a London hospital by air ambulance from Qatar, is the second person confirmed with the coronavirus.

Another death to SARS-like virus in Saudi Arabia: DOH

SARS-Like Virus Spreads From One Person To Another

by MICHAELLEEN DOUCLEFF
February 13, 2013 1:52 PM

A mysterious illness with a striking resemblance to the one caused by the SARS virus emerged in the Middle East last year.

But the new virus behind the latest cases didn't seem to be contagious — until now.

A British resident likely caught the disease from a family member in the U.K., health officials said Wednesday. The patient was in close contact with a sick relative and had never traveled to the Middle East, where all other cases of the new illness originated.
REALITY

MODELS

UNDERSTAND
- identify key mechanisms
- obtain basic conceptual results
- build/test theories
- identify trends
- estimate parameters

PREDICT
- explore scenarios
- test/evaluate/compare interventions
- answer specific questions
- provide forecasts (?)
WHAT DO WE NEED...

people

interactions/mobility

disease
H1N1 influenza pandemic, 2009
WHAT DO WE NEED...

- people
- interactions/mobility
- disease

GLEAM - GLOBAL EPIDEMIC AND MOBILITY MODEL

- 3400 airports in 220 countries
- 20,000 connections
- Traffic data (IATA, OAG)
- >99% commercial traffic

- Population data in cells 1/4° x 1/4°

- Daily commuting data

- Customizable compartmental model
GLEaM is based on a stochastic metapopulation approach
GLEAM: HOW IT WORKS (2)

input
- demographic data
- mobility data
- epidemic model

the model
- intra-population transmission dynamics
- inter-population mobility
  - compartmental natural history of the disease
  - age structure and other determinants
  - response strategies (containment, mitigation, pharmaceutical interventions)
  - air travel: explicit stochastic simulations based on IATA/OAG data
  - ground movements: effective short-range multimodal mobility
    - time-scale separation & effective force of infection

output
- # cases (ILI, hospitalized, ICU, ...)
- # drugs & intervention efficacy
- seeding, arrival time, geotemporal spreading

GLEaMviz.org
Balcan et al. PNAS 2009
PREPAREDNESS
WHAT IF... WE USE DRUGS

antiviral (AV) drugs
GLOBAL STRATEGIES

WIN-WIN

- no intervention: ~<1% reduction
- uncooperative: ~50% reduction
- cooperative: <1% reduction

WIN-WIN

% cases

no intervention

uncooperative ~50% reduction

< cooperative < 1% reduction!!!

from PREPAREDNESS to REAL-TIME
CAN WE ACT DURING THE OUTBREAK?
2009 H1N1 PANDEMIC

[a true exercise of prediction]

Balcan et al. BMC Med 2009
COMPARISON WITH DATA

Balcan et al. BMC Med 2009
Tizzoni et al. BMC Med 2012
ZOOM TO FRANCE

predictions

surveillance data

Schools closing period: Oct 24 - Nov 5, 2009

BMC Scenario 95% RR

Normalized ILI incidence (surveillance)

\[ \text{incidence} \]

France

Ile de France
CURRENT MERS-COV EPIDEMIC

160 cases
68 deaths
[nov 26, 2013]

Poletto et al, in revision.
CURRENT MERS-COV EPIDEMIC

parameter estimation

- subcritical epidemic
- dominance of sporadic cases from zoonotic/environmental transmission
- actual number of cases 1- to 8-fold the observed number [underascertainment]
- additional regions at high risk

Poletto et al, in revision.
HOW MUCH BIG DATA?
# AIRPORT NETWORK

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<tr>
<th>reference</th>
<th># airports</th>
<th># countries</th>
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<tbody>
<tr>
<td>Rvachev &amp; Longini, 1985</td>
<td>52</td>
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<td>Grais et al, 2003; Flahault et al, 2006</td>
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<td>Cooper et al, 2006; Wu et al, 2009</td>
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<td>Epstein et al, 2007</td>
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<td>Kenah et al, 2011</td>
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<td>Hufnagel et al, 2004</td>
<td>500</td>
<td>&gt;100</td>
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<td>Colizza et al, 2006-2007</td>
<td>3,100</td>
<td>220</td>
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<tr>
<td>Balcan et al, 2009; Bajardi et al, 2011; Tizzoni et al, 2012</td>
<td>3,362</td>
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</tr>
</tbody>
</table>
ERROR ON PREDICTIONS

Tizzoni et al BMC Med 2012

ERROR ON PREDICTIONS

Tizzoni et al BMC Med 2012
INDIVIDUAL MOBILITY

UrbanMobs

Client: Orange Labs
December 2007
Designing dynamic data visualization tool displaying urban populations activity.
MOBILE PHONES VS. CENSUS

overestimation of mobility

epidemic acceleration but same rank of infection time

similar epidemic pathways

Tizzoni et al., arXiv:1309.7272
COUNTING FLU CASES

GP consultations → sentinel GPs → digital participatory surveillance
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