Monitoring epidemic precursors of disease

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Infectious disease threat events (IDTE) in Europe

• What are IDTE?
• What leads to IDTE?
• What are the underlying drivers of IDTE?
• Can we monitor these drivers to prevent IDTE?
• Can we build robustness and resilience to the impacts of IDTE?
IDTE drivers and plausible scenarios

Key drivers
- Globalization and environmental change
- Social and demographic change
- Public health systems

Environmental / climate change
- Travel and tourism
- Migration
- Global trade

Globalization and environmental change
- Social and demographic change
- Public health systems

Social and demographic change
- Demographic change
- Social inequality
- Prevention and treatment
- Lifestyles

Public health systems
- Healthcare system structures & changes
- Animal health and food safety
- R&D / Innovation in new medicines
- Surveillance and reporting

Surveillance and reporting

Scenarios
- Extensively drug-resistant bacteria
- Vector-borne diseases: introduction and shifts in the transmission patterns
- Sexually-transmitted infections
- Food-borne infections
- Resurgence of vaccine-preventable diseases
- Healthcare associated infections: nursing homes
- Multi-drug resistant tuberculosis
- Pandemic influenza

Disease and event monitoring at ECDC

TESSy\textsuperscript{1} Disease monitoring

- capture
- filter
- validate
- assess
- investigate

communicate and control

EWRS\textsuperscript{2} Event monitoring

- capture
- filter
- validate
- disseminate

\textsuperscript{1} The European Surveillance System – a database system
\textsuperscript{2} Early Warning Response System
Every working day at 11:30, a roundtable meeting in ECDC’s Emergency Operations Centre assesses threats, official alerts and epidemic intelligence from around the EU and the world.
Number of drivers for infectious disease threat events (IDTE), Europe 2008-2013

Cluster dendrogram from hierarchical cluster analysis of drivers of IDTE, Europe 2008-2013.
Early warning system

Climate change → Environmental consequences → Indirect exposures (vector-borne diseases, other infectious diseases) → Socio-economic impacts (homelessness, refugees...) → Health outcomes

Direct exposures (heat stroke, drowning...) → Surveillance

Early warning system
Environmental/climatic precursors of disease

- Active Surveillance
- Response

Environ Signal, First Cases, Cases

Without Early Warning, With Early Warning

Time
E³: European Environment and Epidemiology network

Epidemic intelligence and surveillance (ECDC, WHO)

Environmental and climatic data (e.g. EEA, SEIS, EDEN)

Demographic and socio-economic data (Eurostat)

Integrate

Interpret

Merge

Analyze

Welcome to the E3 Geoportal. The E3 Geoportal has been designed by ECDC to collect and make available a wide range of information for anybody interested in infectious disease epidemiology in Europe.

The objective of E3 Geoportal is to promote geospatial infectious disease modelling in Europe and its integration in Public health. There are many different determinants of infectious disease transmission but they are often highly dispersed and/or difficult to obtain. The E3 Geoportal will facilitate the collection and exchange of these datasets in a user-friendly manner. It is an inventory of information and resources which are collected, maintained, and managed by a collaborative effort under the European Environment and Epidemiology Network.

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Airport-level final destination of international travellers from dengue affected areas, 2010

Semenza JC, et al., *PlosNTD* 2014;8(12):e3278
Hierarchical multivariate model: Risk of dengue importation into Europe, by month, 2010

<table>
<thead>
<tr>
<th>Variables</th>
<th>Incidence rate ratio</th>
<th>P-Value</th>
<th>Confidence Interval (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travellers from dengue affected areas (per 10,000)</td>
<td>1.09</td>
<td>0.02</td>
<td>[1.01-1.17]</td>
</tr>
<tr>
<td>Month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>0.83</td>
<td>0.19</td>
<td>[0.63-1.1]</td>
</tr>
<tr>
<td>March</td>
<td>1.15</td>
<td>0.28</td>
<td>[0.89-1.48]</td>
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<tr>
<td>April</td>
<td>0.87</td>
<td>0.30</td>
<td>[0.65-1.14]</td>
</tr>
<tr>
<td>May</td>
<td>1.03</td>
<td>0.81</td>
<td>[0.78-1.36]</td>
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<tr>
<td>June</td>
<td>0.85</td>
<td>0.25</td>
<td>[0.64-1.12]</td>
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<tr>
<td>July</td>
<td>0.72</td>
<td>0.07</td>
<td>[0.51-1.02]</td>
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<tr>
<td><strong>August</strong></td>
<td><strong>1.70</strong></td>
<td><strong>0.001</strong></td>
<td><strong>[1.23-2.35]</strong></td>
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<tr>
<td><strong>September</strong></td>
<td><strong>1.46</strong></td>
<td><strong>0.04</strong></td>
<td><strong>[1.02-2.1]</strong></td>
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<tr>
<td><strong>October</strong></td>
<td><strong>1.35</strong></td>
<td><strong>0.04</strong></td>
<td><strong>[1.01-1.81]</strong></td>
</tr>
<tr>
<td>November</td>
<td>1.17</td>
<td>0.30</td>
<td>[0.87-1.58]</td>
</tr>
<tr>
<td>December</td>
<td>1.06</td>
<td>0.66</td>
<td>[0.82-1.37]</td>
</tr>
</tbody>
</table>

Semenza JC, et al., *PlosNTD* 2014;8(12):e3278
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Malaria
Historical malaria foci in Greece

Environmental suitability for malaria

- Area with autochthonous cases 2009-2011

Potential areas of environmental suitability

Significant variables (NLDA):
- **Warmer temperatures**
- **Low elevation** (low-range in DEM)
- Permanently **irrigated land**
- Complex **cultivation pattern**

Malaria: Public health interventions

- Delineate areas **environmentally suitable** for transmission
- Targeted epidemiological and entomological **surveillance**
- **Indoor residual spraying** and the provision of long-lasting insecticide-treated **nets**
- **Aerial sprayings** over extensive water bodies (difficult access)
- **Active case detection**: house visits for fever screening
- **Mass Drug Administration** (MDA) to immigrants from malaria-endemic regions
- Immediate case **investigation**
- Use of **EU Structural Funds**
- **Transmission interrupted** 2013 and 2014

Vibrio infections
With its low salinity and rising water temperatures, the Baltic Sea is becoming prime habitat for Vibrio species. During the exceptionally hot summer of 2006, at least 66 people developed vibrio infections after visiting Baltic beaches. © Kacper Kwiatkki/Paros Pictures.
Pathogenic vibrios present in the marine environment

**V. vulnificus**

Gram negative bacteria – common in marine and estuarine environments.

**V. parahaemolyticus**

All these species proliferate in warm (>15 °C) and low salinity (<30 ppt NaCl) seawater.

**V. alginolyticus**

Complex life cycle: planktonic and attached to marine organisms.

**V. cholerae**

[Slide courtesy of Jaime Martinez-Urtaza]
Different clinical manifestation of vibriosis

1. Wound infections. Caused by a range of different *Vibrio* spp. including *V. vulnificus*, *V. alginolyticus*, *V. cholerae* – normally caused by exposure of cut, wound or abrasion to contaminated seawater. Seriousness of infection is partly determined by species in question – *V. vulnificus* probably the worst ~25% mortality rate (Oliver 2005).

2. Gastroenteritis. Nausea, vomiting, diarrhoea - again, caused by a range of different *Vibrio* spp. – most commonly *V. vulnificus*, *V. parahaemolyticus* and *V. cholerae* – normally caused by consumption of raw/undercooked seafood and/or exposure to contaminated water sources.

3. Septicaemia (blood poisoning). Most serious clinical manifestation associated with vibriosis. Often fatal, depending on pathogen involved (*V. vulnificus* > 50% of cases). 100 *Vibrio* fatalities a year in the USA, mostly septicaemia-associated, numerous recent cases in Europe.
Cluster dendrogram from hierarchical cluster analysis of drivers of IDTE, Europe 2008-2013

Early warning system: ECDC *Vibrio* map viewer

- Designed to delineate retrospective, current, and short-term forecasts of **environmental suitability** for vibrio growth at a global scale

- Monitor **sea surface temperature** (SST) and **sea surface salinity** (SSS), especially in coastal regions where human exposure is more likely to occur

- Global model data inputs are SST fields from **remote sensing and models**, as well as SSS from models, **in situ** data and climatological data

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Daily Suitability Index
- Daily Vibrio Risk

Suitability Index (last 7 days)
- Weekly Maximum
- Weekly Mean

Forecast (next 5 days)
- Forecast

Time range selection
From: 2013-06-12
To: 2018-05-08

Colour palette: boxfill/vibrio

Colour bands: 10
Scale method: linear
Legend range: Min. value: 0, Max. value: 20

Legend:
- 0: Very Low
- 1-10: Low
- 11-20: Medium
- 21-30: High
- 31+: Very High

Daily Suitability Index (Daily Vibrio Risk)
2013/06/12
Current: 2014/07/26

Map showing the distribution of Vibrio risk across Europe with different color intensities representing varying risk levels.
Annual frequency of total *Vibrio* infections notified in Sweden from 2006-2014

Exposure–response relationship of *Vibrio* infections in response to sea surface temperature (SST), Sweden 2006 - 2014

Mean IHR core capacities and infectious disease threat events in Europe, 2010–2016
IDTE drivers with plausible and actual scenarios

Plausible

Actual

Conclusion

- The most important **category** of drivers of Infectious Disease Threat Events (IDTE) was **global environmental change**, contributing to 61% of all IDTE in Europe.

- **Trade and travel** was the most important single driver of IDTE in Europe but climate is also an important driver.

- By **monitoring** these climatic and environmental **precursors of disease** it might be possible to **predict** and **intercept** outbreaks.

- Improvements in IHR **core capacities** can help reduce the incidence of cross-border IDTE in Europe.
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IDTE
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