Emerging Treats: Old Dogs Learn New Tricks, What Were You THINKING and Zebras (Or Camels or Bats)

Donna C. Sullivan, PhD
Division of Infectious Diseases
Department of Medicine

Infectious disease is one of the few genuine adventures left in the world. The dragons are all dead and the lance grows rusty in the chimney corner . . . About the only sporting proposition that remains unimpaired by the relentless domestication of a once free-living human species is the war against those ferocious little fellow creatures, which lurk in the dark corners and stalk us in the bodies of rats, mice and all kinds of domestic animals; which fly and crawl with the insects, and waylay us in our food and drink and even in our love.

- (Hans Zinsser, 1934 quoted in Murphy 1994)
Antimicrobial Resistance

- Worldwide problem
- Dramatic increase in antimicrobial-resistant community-acquired and nosocomial pathogens
- Major risk factors:
  - Antimicrobial use (misuse)
  - Infection control practices (noncompliance)

WHO Priority Antimicrobial Resistant (AMR) Pathogens

- *Escherichia coli*: resistance to 3rd generation cephalosporins and to fluoroquinolones
- *Klebsiella pneumoniae*: resistance to 3rd generation cephalosporins and to carbapenems
- *Staphylococcus aureus*: methicillin resistance, or MRSA
- *Streptococcus pneumoniae*: resistance (non-susceptibility) to penicillin
- *Non-typhoidal Salmonella (NTS)*: resistance to fluoroquinolones
- *Shigella species*: resistance to fluoroquinolones
- *Neisseria gonorrhoeae*: reduced susceptibility to 3rd generation cephalosporins

Bacteria Rapidly Adapt

Problem Gets Bigger, Solutions Fewer

CDC Antibiotic Resistance Solutions Initiative: A $264M Comprehensive Response

CDC's Antibiotic-Resistant Threats in the United States, 2013: Urgent threat level

- *Clostridium difficile*
- *Carbapenem resistant Enterobacteriaceae*
  - *K. pneumonia, E. coli*
- *Neisseria gonorrhoeae*
Clostridium difficile

- C. difficile deaths increased 400% between 2000-2007 because of the emergence of a strain resistant to a common antibiotic class (fluoroquinolones).
- Almost half of infections occur in people younger than 65, but more than 90% of deaths occur in people 65 and older.
- Half of C. difficile infections first show symptoms in hospitalized or recently hospitalized patients, and half show symptoms in nursing home patients or in people recently cared for in doctors’ offices and clinics who received antibiotics.

Carbapenem-Resistant Enterobacteriaceae

- ~140,000 healthcare-associated Enterobacteriaceae infections per year.
- 44 States have had at least one type of CRE confirmed by CDC testing.
- CRE are resistant to nearly all antibiotics including carbapenems—the antibiotic of last resort.

CRE’s: Superbugs

Neisseria gonorrhoeae (Notifiable to CDC)

- The 2nd most common reportable infection in the US, and is developing resistance to the cephalosporin antibiotics, the last line treatment option for this infection.
- 30% (246,000) now demonstrate resistance to at least one antibiotic.

CDC’s Antibiotic-Resistant Threats in the United States, 2013: Serious threat level

- Multidrug-Resistant Acinetobacter
- Drug-Resistant Campylobacter
- Fluoroquinolone-Resistant Candida
- Extended Spectrum β-Lactamase (ESBL) Producing Enterobacteriaceae
- Vancomycin-Resistant Enterococcus
- Multidrug-Resistant Pseudomonas aeruginosa
- Drug-Resistant Non-Typhoidal Salmonella (Notifiable to CDC)
- Drug-Resistant Salmonella typhi (Notifiable to CDC)
- Drug-Resistant Shigella* (Notifiable to CDC)
- Methicillin-Resistant Staphylococcus aureus
- Drug-Resistant Streptococcus pneumoniae* (Notifiable to CDC)
- Drug-Resistant Tuberculosis* (Notifiable to CDC)
- Drug-Resistant Shigella* (Notifiable to CDC)

Drug-Resistant Campylobacter

- Campylobacter causes ~1.3 Million infections, 13, 000 hospitalizations and 120 deaths each year; 310,000 (25%) drug resistant Campylobacter infections are found each year.
- Campylobacter drug resistance increased from 13% in 1997 to 25% in 2011.
- Campylobacter spreads from animals to people through contaminated food, particularly raw or undercooked chicken and unpasteurized milk. Antibiotic use in food animals can result in resistant Campylobacter that can spread to humans.
Serious Threat Level

- Fluconazole-Resistant Candida
  - Out of 46,000 Candida yeast infections per year, 3,400 (30%) of patients with bloodstream infections and drug-resistant (DR) Candida die during their hospitalization.
  - CDC estimates that each hospitalization of Candida infection results in 3-13 days of additional hospitalization and a total of $6,000-$29,000 in direct healthcare costs per patient.

- Extended Spectrum β-Lactamase (ESBL) Producing Enterobacteriaceae
  - ESBL is an enzyme that allows bacteria to become resistant to a wide spectrum of penicillins and cephalosporins.
  - 26,000 healthcare-associated Enterobacteriaceae infections are caused by ESBL-Enterobacteriaceae.

- Vancomycin-Resistant Enterococcus
  - Enterococcus strains resistant to vancomycin leave few or no treatment options.

- Multidrug-Resistant Pseudomonas aeruginosa
  - 13% of severe healthcare-associated infections caused by Pseudomonas are multidrug resistant, meaning nearly all or all antibiotics no longer cure these infections.

- Drug-Resistant Non-Typhoidal Salmonella (Notifiable to CDC)
  - Of 21.7 M Salmonella typhi infections worldwide, 5,700 illnesses in the U.S. with 3,800 (67%) of infections are drug-resistant resulting in 620 hospitalizations each year.
  - Before the antibiotic era or in areas where antibiotics are unavailable, Salmonella typhi results in up to 20% deaths.

- Drug-Resistant Salmonella typhi (Notifiable to CDC)
  - Of 21.7 M Salmonella typhi infections worldwide, 5,700 illnesses in the U.S. with 3,800 (67%) of infections are drug-resistant resulting in 620 hospitalizations each year.
  - Before the antibiotic era or in areas where antibiotics are unavailable, Salmonella typhi results in up to 20% deaths.

- Drug-Resistant Staphylococcus aureus (Notifiable to CDC)
  - Severe MRSA infections most commonly occur during or soon after inpatient medical care.
  - Between 2005 and 2010, overall rates of invasive MRSA dropped 31% predominantly due to appropriate medical procedures implemented in central line maintenance.
  - Methicillin-Resistant Staphylococcus aureus (MRSA)*
    - Severe MRSA infections most commonly occur during or soon after inpatient medical care.
    - Between 2005 and 2010, overall rates of invasive MRSA dropped 31% predominantly due to appropriate medical procedures implemented in central line maintenance.

- Drug-Resistant Streptococcus pneumoniae (Notifiable to CDC)
  - Of 4 million disease incidents and 22,000 deaths; 1.2 M are drug-resistant (to amoxicillin and azithromycin (Z-Pak) resulting in 19,000 excess hospitalizations and 7,900 deaths.
  - In 30% of S. pneumoniae cases, the bacteria are fully resistant or near resistance causing complications in treatment and death.
  - Pneumococcal pneumonia accounts for 72% of all direct medical costs for treatment of pneumococcal disease and in excess of $96 million in medical costs per year.
  - Pneumococcal conjugate vaccine (PCV) prevents disease, reduces antibiotic resistance by blocking the transmission of resistant bacteria, pneumococcal pneumonia, and death against 13 strains of Streptococcus.
Serious Threat Level

- Drug-Resistant Tuberculosis (Notifiable to CDC)
- Tuberculosis is among the most common infectious diseases and cause of death worldwide.
- CDC manages 5 TB Regional Training and Medical Consultation Centers (RTMCCs) and ongoing surveillance for drug resistant Tb in all 50 states and DC using the National Tuberculosis Surveillance System (NTSS).

CDC's Antibiotic-Resistant Threats in the United States, 2013: Of Concern threat level

- Vancomycin-Resistant Staphylococcus aureus (Notifiable to CDC)
  - Few cases thus far (13 cases in 4 States since 2002).
  - Staph a strains resistant to vancomycin leave very few or no treatment options.
- Erythromycin-Resistant Group A Streptococci
  - Group A (GAS) causes many illnesses including strep throat (up to 2.6 M cases per year), toxic shock syndrome, and “flesh-eating” disease (necrotizing fasciitis, 25-35% fatal).
- Erythromycin-resistant GAS causes 1,300 illnesses and 160 deaths.
- Current concern is the increase in bacteria that show resistance to clindamycin—which has a unique role in treatment of GAS infections.
- Clindamycin-Resistant Group B Streptococci
  - Of 27,000 Group B (GBS) cases, 7,600 illnesses are drug-resistant resulting in 440 deaths in the U.S. each year.

No New Antibiotics Coming

New applications for approval of antibiotic drugs

With fewer new antibiotics being developed, the options are shrinking for treating antibiotic-resistant infections.

Sources: CDC, Agency for Healthcare Research and Quality | Petterson Daily | The Washington

CDC's Advanced Molecular Detection (AMD) Initiative

- Slow the Development of Resistant Bacteria and Prevent the Spread of Resistant Infections
- Strengthen National One-Health Surveillance Efforts to Combat Resistance
- Accelerate Development and Use of Rapid and Innovative Diagnostic Tools for Identification and Characterization of Resistant Bacteria
- Accelerate Basic and Applied Research and Development for New Antibiotics, Other Therapeutics, and Vaccines
- Improve International Collaboration and Capacities for Antibiotic Resistance Prevention, Surveillance, Control, and Antibiotic Research and Development

Antibiotic Resistance Solutions Initiative: A $264M Comprehensive Response

- Estimated number of illnesses and deaths caused by antibiotic resistant:
  - 2,049,442 illnesses
  - 23,000 deaths

Antibiotic Resistance Solutions Initiative: A $264M Comprehensive Response
Vaccines

From Smallpox to AIDS and Ebola

Vaccines: Planned Extinction

- Already extinct:
  - Smallpox
  - Rinderpest

- Soon to be extinct:
  - Polio
  - Measles (?)

Polio’s Last Stand

Only a few countries still have wild type polio circulating in their populations.

Polio Eradication

- In 1988, when an initiative was launched to stamp out polio worldwide, 1,000 children around the globe were crippled by the infection every day.

Lest We Forget

- Whooping cough and iron lungs.
- Braces designed for children paralyzed by polio.
- Devastating birth defects.
- U.S. infant and childhood mortality rates were 20%.
- Measles, diphtheria, smallpox, and pertussis topped the list of childhood killers.

Comparison of Pre-Vaccine and Current Reported Morbidity of Vaccine-Preventable Diseases and Vaccine Adverse Events, United States

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pre-vaccine Era</th>
<th>2006**</th>
<th>% decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheria</td>
<td>175,885</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Measles</td>
<td>663,262</td>
<td>55</td>
<td>99.9</td>
</tr>
<tr>
<td>Mumps</td>
<td>152,209</td>
<td>5,584</td>
<td>95.7</td>
</tr>
<tr>
<td>Pertussis</td>
<td>147,217</td>
<td>15,632</td>
<td>89.4</td>
</tr>
<tr>
<td>Polio (paralytic)</td>
<td>16,316</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Rubella</td>
<td>47,745</td>
<td>11</td>
<td>99.9</td>
</tr>
<tr>
<td>Congenital Rubella Syn.</td>
<td>823</td>
<td>1</td>
<td>99.9</td>
</tr>
<tr>
<td>Tetanus</td>
<td>1,314</td>
<td>41</td>
<td>96.9</td>
</tr>
<tr>
<td>H. influenzae type b and unknown (&lt;5 yrs)</td>
<td>20,000+</td>
<td>208</td>
<td>99.0</td>
</tr>
<tr>
<td>Total</td>
<td>1,064,854</td>
<td>22,532</td>
<td>97.9</td>
</tr>
</tbody>
</table>

Vaccine Adverse Events

| N/A                  | 15,484         | +++    |

* Baseline 20th century annual morbidity.
** Estimated because no national reporting existed in the pre-vaccine era.
+++ Source: MMWR 2007;56(33):851-64.

The data is derived from surveillance sources, including the Vaccine Adverse Event Reporting System (VAERS).
MMR: Measles, Mumps and Rubella

- Live attenuated viruses given in a single vaccine

Diptheria, Tetanus and Pertussis

- There are four combination vaccines used to prevent diphtheria, tetanus and pertussis: DTaP, Tdap, DT, and Td.

Whooping Cough (pertussis)

- A highly contagious respiratory tract infection
- Most contagious before the cough manifests

Meningococcal Meningitis

- Transmission by respiratory system, particularly with overcrowding
- Risk
  - Saharan Africa
  - Saudi Arabia
  - The Hajj

Meningococcal Disease

- Table: Meningococcal Disease
- Chart: Meningococcal Disease
**True: Vaccines are Not Without Risk**

- No vaccine is 100% safe
- No vaccine is 100% effective
- All vaccines have possible side effects, most mild, rarely severe
- The risk of disease far outweighs the risk of vaccine

**Andrew Wakefield**

- A case series of 12 subjects (that is, a series of 12 anecdotes) that could not determine whether there was a causal link.
- Wakefield had undisclosed conflicts of interest (he received £50,000 in legal aid money from lawyers preparing a case against MMR – over the years he received over £434,000 from such cases).

**The Vaccines and Autism Debate**

Although the possible association with MMR vaccine has received much public and political attention and there are many who have derived their own conclusions based on personal experiences, the available evidence does not support the hypothesis that MMR vaccine causes autism or associated disorders or IBD. Separate administration of measles, mumps, and rubella vaccines to children provides no benefit over administration of the combination MMR vaccine and would result in delayed or missed immunizations. Pediatricians need to work with families to ensure that children are protected early in the second year of life from these preventable diseases. Continued scientific efforts need to be directed to the identification of the causes of ASD.

- Pediatrics 2001;107(5). URL: http://www.pediatrics.org/cgi/content/full/107/5/e84; autism, measles-mumps-rubella vaccine, autistic spectrum disorder, inflammatory bowel disease, measles, mumps vaccine, epidemiology.

**Autism and Vaccines**

- Over 40 published, peer reviewed studies have examined the rate of autism among vaccinated and unvaccinated children
- Available evidence does not indicate that Autism is more common among children who receive MMR or thimerosal-containing vaccines than among children who do not receive vaccines
- On February 12, 2009 U.S. Court of Federal Claims ruled that the measles-mumps-rubella vaccine, whether administered alone or in conjunction with thimerosal-containing vaccines, were not causal factors in the development of Autism or Autism spectrum disorders.
- See [www.uscfc.uscourts.gov/node/5025](http://www.uscfc.uscourts.gov/node/5025)

**Jenny McCarthy: Vaccine Expert?**

- Began her career in 1993 as a nude model for Playboy magazine and was later named their Playmate of the Year.
- Parlayed her Playboy fame into a successful television and film acting career.
- Has written books about parenting
- Became an activist promoting the controversial claims that vaccines cause autism and that chelation therapy helps cure it - both claims which are widely unrecognized or disputed by the medical community.
Choices and Responsibilities

- Should you choose not to have your child vaccinated?
- According to CDC, "The decision not to vaccinate is not only a decision for your child but also a decision for society."
- Refusing vaccinations risks others.
- Vast majority of kids get their shots.

Estimated Herd Immunity Thresholds For Vaccine Preventable Diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Transmission</th>
<th>R0* [N]</th>
<th>Herd immunity threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheria</td>
<td>Saliva</td>
<td>6-7</td>
<td>85%</td>
</tr>
<tr>
<td>Measles</td>
<td>Airborne</td>
<td>12-18</td>
<td>83 - 94%</td>
</tr>
<tr>
<td>Mumps</td>
<td>Airborne/droplet</td>
<td>4-7</td>
<td>75 - 86%</td>
</tr>
<tr>
<td>Pertussis</td>
<td>Airborne droplet</td>
<td>12-17</td>
<td>92 - 94%</td>
</tr>
<tr>
<td>Polio</td>
<td>Fecal-oral route</td>
<td>5-7</td>
<td>80 - 86%</td>
</tr>
<tr>
<td>Rubella</td>
<td>Airborne droplet</td>
<td>5-7</td>
<td>80 - 85%</td>
</tr>
<tr>
<td>Smallpox</td>
<td>Social contact</td>
<td>6-7</td>
<td>83 - 85%</td>
</tr>
</tbody>
</table>

*R0 is the basic reproduction number, or the average number of secondary infectious cases that are produced by a single index case in a completely susceptible population.

Immunogenic Proteins, Polysaccharides in Vaccines

What Goes Around, Comes Around: Girolamo Frascatoro Speaking About Syphilis

“There will come yet other new and unusual ailments in the course of time. And this disease will pass away, but it later will be born again and be seen by our descendants.”

This quote was written 450 years ago.
Global Examples of Emerging and Re-Emerging Infectious Diseases

- Dengue/DHF-1970s, SE Asia, global
- HIV/AIDS-1980s-Africa, global
- Drug resistant TB-1990s, US, global
- Cholera-1991-Americas
- Plague-1994-India, global
- Foot & Mouth disease-1995,2000- Taiwan & UK
- West Nile-1990s- Mediterranean, Americas

Major Infectious Disease Epidemics since 1980

- Dengue/DHF-1970s, SE Asia, global
- HIV/AIDS-1980s-Africa, global
- Drug resistant TB-1990s, US, global
- Cholera-1991-Americas
- Plague-1994-India, global
- Foot & Mouth disease-1995,2000- Taiwan & UK
- West Nile-1990s- Mediterranean, Americas
- BSE-1990s- UK, Canada, US
- Swine fever, 1996- Netherlands
- H5N1 influenza-1997- HK, global
- Nipah encephalitis-1998- Malaysia, Asia
- SARS-2002-Asia, global
- Chikungunya-2004-Africa, Asia
- H1N1 influenza-2009-Mexico?, global
- Ebola-Liberia, Guiana, Sierra Leone, 2014-15

Some Are Old Foes

- Dengue/DHF-1970s, SE Asia, global
- HIV/AIDS-1980s-Africa, global
- Drug resistant TB-1990s, US, global
- Cholera-1991-Americas
- Plague-1994-India, global
- Foot & Mouth disease-1995,2000- Taiwan & UK
- West Nile-1990s- Mediterranean, Americas
- BSE-1990s- UK, Canada, US
- Swine fever, 1996- Netherlands
- H5N1 influenza-1997- HK, global
- Nipah encephalitis-1998- Malaysia, Asia
- SARS-2002-Asia, global
- Chikungunya-2004-Africa, Asia
- H1N1 influenza-2009-Mexico?, global
- Ebola-Liberia, Guiana, Sierra Leone, 2014-15

Plague Pandemics

- Justinian's Plague (mid-6th Century A.D.)
- Black Death (mid-14th Century A.D.)
- Modern Pandemic (1894 – mid-1900s)

Pneumonic Plague in India

- Indian outbreak was a major surprise – no plague confirmed in India since 1966
- Clinical and lab diagnosis
- Media and panic driven epidemic
- First epidemic to impact global air transportation
- Caused huge economic loss for India (> $3 billion)

It's STILL HERE!
Current Status of the Global HIV/AIDS Pandemic

- 70 million total HIV infections
- 36 million total AIDS deaths
- 35.3 million people living with HIV
- 1.6 million AIDS deaths in 2012
- 2.3 million new HIV infections in 2012

Global SARS Cases (Probable) WHO 26 September 2003

<table>
<thead>
<tr>
<th>Country</th>
<th>Cases</th>
<th>Deaths</th>
<th>Case Fatality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>251</td>
<td>43</td>
<td>1.5%</td>
</tr>
<tr>
<td>China</td>
<td>5</td>
<td>327</td>
<td>65.5%</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>17</td>
<td>55</td>
<td>299%</td>
</tr>
<tr>
<td>Singapore</td>
<td>238</td>
<td>33</td>
<td>13.5%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>346</td>
<td>37</td>
<td>12.5%</td>
</tr>
<tr>
<td>U.S.</td>
<td>75</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Vietnam</td>
<td>63</td>
<td>5</td>
<td>7.9%</td>
</tr>
<tr>
<td>Other</td>
<td>81</td>
<td>5</td>
<td>6.2%</td>
</tr>
<tr>
<td>Total</td>
<td>8098</td>
<td>774</td>
<td>9.6%</td>
</tr>
</tbody>
</table>

Disease Emergence and Re-Emergence: Causes

- Genetic/Biologic Factors
- Host and agent interactions
- Increased survival of susceptible population
- Human Behavior
- Political
- Social
- Economic
- Physical Environmental Factors
- Climatic changes
- Deforestation
- Etc.
Current Outbreak And Historical Outbreaks: Why Here? Why Now?

<table>
<thead>
<tr>
<th>Country</th>
<th>Town</th>
<th>Cases</th>
<th>Deaths</th>
<th>Fatality (%)</th>
<th>Species</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudan</td>
<td>Nzara</td>
<td>284</td>
<td>151</td>
<td>53</td>
<td>Sudan</td>
<td>1976</td>
</tr>
<tr>
<td>Dem. Rep. of Congo</td>
<td>Tandala</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>Zaire</td>
<td>1977</td>
</tr>
<tr>
<td>Sudan</td>
<td>Nzara</td>
<td>34</td>
<td>22</td>
<td>65</td>
<td>Sudan</td>
<td>1979</td>
</tr>
<tr>
<td>Gabon</td>
<td>Mekouka</td>
<td>52</td>
<td>31</td>
<td>60</td>
<td>Zaire</td>
<td>1994</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>Tai Forest</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Ivory Co</td>
<td>1994</td>
</tr>
<tr>
<td>Gabon</td>
<td>Mayibout</td>
<td>37</td>
<td>21</td>
<td>57</td>
<td>Zaire</td>
<td>1996</td>
</tr>
<tr>
<td>Gabon</td>
<td>Booue</td>
<td>60</td>
<td>45</td>
<td>75</td>
<td>Zaire</td>
<td>1996</td>
</tr>
<tr>
<td>South Africa</td>
<td>Johannesburg</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>Zaire</td>
<td>1996</td>
</tr>
<tr>
<td>Uganda</td>
<td>Gulu</td>
<td>425</td>
<td>224</td>
<td>53</td>
<td>Sudan</td>
<td>2000</td>
</tr>
<tr>
<td>Gabon</td>
<td>Libreville</td>
<td>65</td>
<td>53</td>
<td>81</td>
<td>Zaire</td>
<td>2001</td>
</tr>
<tr>
<td>Republic of Congo</td>
<td>Not specified</td>
<td>57</td>
<td>43</td>
<td>75</td>
<td>Zaire</td>
<td>2001</td>
</tr>
<tr>
<td>Republic of Congo</td>
<td>Mbomo</td>
<td>143</td>
<td>128</td>
<td>90</td>
<td>Zaire</td>
<td>2002</td>
</tr>
<tr>
<td>Republic of Congo</td>
<td>Mbomo</td>
<td>35</td>
<td>29</td>
<td>83</td>
<td>Zaire</td>
<td>2003</td>
</tr>
<tr>
<td>Sudan</td>
<td>Yambio</td>
<td>17</td>
<td>7</td>
<td>41</td>
<td>Sudan</td>
<td>2004</td>
</tr>
<tr>
<td>Uganda</td>
<td>Bundibugyo</td>
<td>149</td>
<td>37</td>
<td>25</td>
<td>Zaire</td>
<td>2007</td>
</tr>
<tr>
<td>Gabon</td>
<td>Luwero</td>
<td>7</td>
<td>4</td>
<td>57</td>
<td>Zaire</td>
<td>2012</td>
</tr>
<tr>
<td>Guinea</td>
<td>3754</td>
<td>2506</td>
<td>67</td>
<td></td>
<td>Zaire</td>
<td>2014</td>
</tr>
<tr>
<td>Liberia</td>
<td>10672</td>
<td>4807</td>
<td>45</td>
<td></td>
<td>Zaire</td>
<td>2015</td>
</tr>
<tr>
<td>Nigeria</td>
<td>20</td>
<td>8</td>
<td>40</td>
<td></td>
<td>Zaire</td>
<td>2015</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>13201</td>
<td>3946</td>
<td>30</td>
<td></td>
<td>Zaire</td>
<td>2015</td>
</tr>
</tbody>
</table>

Pathogens of Tomorrow

- From Whence They Will Come?
- From Asia
- From Animals
- Mostly Viruses

If you want to listen to celebrities.....

- [https://www.youtube.com/watch?v=QgpfN5cEd3M](https://www.youtube.com/watch?v=QgpfN5cEd3M)
- And my favorite TED Talks Speaker: Hans Rosling
  - [http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen](http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen)
  - [https://www.youtube.com/watch?v=Sm5xU-ygd](https://www.youtube.com/watch?v=Sm5xU-ygd)