BioMosaic of Globalization: Big Data Meets Public Health

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Division of Global Migration and Quarantine
About BioMosaic

The US is currently made up of a diverse population with varied health outcomes and disease risk. Approximately 12% of the US population is foreign-born, defined as being born abroad and neither parent a US citizen. Known health disparities between US- and foreign-born populations are affected by differing rates of endemic disease, obesity, travel patterns, and infectious disease exposure. The BioMosaic project aims to help public health practitioners better understand and assist foreign-born populations through the use of interactive maps containing demographic information as well as data on socio-economic status, migration and infectious diseases.
Bio.Diaspora
Our Partners

- Bio.Diaspora (St. Michael’s Hospital, University of Toronto)
  - BioDiaspora provides an internet-based application that enhances situational awareness of infectious disease threats in the world
  - Uses geographic visualization to communicate geographic patterns and trends and disseminate public health and travel information to the public
  - Combines mapping technology, commercial aviation data and real time epidemic intelligence
Our Partners

- **HealthMap (Children’s Hospital, Harvard University)**
  - HealthMap is an interactive website designed for use by public health professionals and others.
  - It is publicly available and mines over 50,000 sites hourly 24/7.
  - The system extracts over 1,800 disease patterns and categorizes them to identify diseases that could potentially indicate a significant health event.
Demography

Foreign Born

Health

Migration
U.S. Foreign Born Picture

Who is Waldo?
Where’s Waldo?
All African Born Persons

Number Foreign Born: 1,428,127
% US FB Population: 3.74%

Born: All Africans By PUMA

- 0
- 1 - 49
- 50 - 99
- 100 - 249
- 250 - 499
- 500 - 999
- 1,000 - 4,999
- 5,000 - 9,999
- 10,000 - 19,999
- 20,000 - 29,999
- 30,000 or more

Seattle, Chicago, Boston, New York City, Washington D.C., San Francisco, Los Angeles, Houston, New Orleans, Miami, Honolulu, Hilo, Alaska, Juneau, Puerto Rico
New England: African-born

African Born Persons

Number African in New England: 244,645

% African in Total Foreign Born Population: 4.4%

Born: Africa by PUMA

- 0
- 1 - 9
- 10 - 19
- 20 - 29
- 30 - 49
- 50 - 99
- 100 - 499
- 500 - 999
- 1,000 - 4,999
- 5,000 - 9,999
- 10,000 or more

Map showing distribution of African-born population in New England by PUMA.
Mobile Tablet
BioMosaic Web Application
• Focuses on the characterization and response to international health events esp. infectious diseases.
• Provides access to relevant contextual information in the country of origin, global airline transportation data and at-risk foreign-born populations in U.S.
• Provides complex analytical capability
How Can BioMosaic Help?

1. **Surveillance**
   - Sort through event based surveillance from HealthMap or other sources

2. **Evaluation of Source Conditions**
   - Measure human population around event source
   - Assess environmental conditions (e.g. rainfall, temperature, animals etc.)
   - Analyze deviations from historic averages

3. **Evaluation of transportation networks from event source into U.S.**
   - Analysis of flight schedule and capacity
   - Analysis of passenger level flight data and final passenger destinations

4. **Evaluation of conditions in the U.S.**
   - Map of risk areas
   - Visualize distribution of foreign born – identify top counties of settlement
   - Perform demographic analysis (English proficiency, education level etc.)

5. **Analysis to determine where CDC intervention is needed**
1. Surveillance
Public and proprietary data sources
Human Cases H7N9 Flu in China

N = 102 cases / 20 deaths (~20%)

2. Evaluation of Source Condition
Domestic Air Travel within China from Shanghai, Hangzhou, Nanjing, and Wuxi (April - June) With Poultry Density

Passenger Volumes:
- 1,000 - 50,000
- 50,001 - 100,000
- 100,001 - 500,000
- > 500,000

Poultry Density:
- Highest
- Lowest

Data Source: FAO 2007, IATA 2010
3. Transportation Networks

Direct international flights from Port au Prince, Haiti to:

<table>
<thead>
<tr>
<th>City</th>
<th>Country</th>
<th>Distance (km)</th>
<th>Fly Time</th>
<th>Seats</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aruba</td>
<td>Aruba</td>
<td>741</td>
<td>3h 50m</td>
<td>1,178</td>
<td>16</td>
</tr>
<tr>
<td>Montreal</td>
<td>Canada</td>
<td>3,603</td>
<td>4h 20m</td>
<td>10,972</td>
<td>8</td>
</tr>
<tr>
<td>Santo Domingo</td>
<td>Dominican Republic</td>
<td>271</td>
<td>45m</td>
<td>35,346</td>
<td>5</td>
</tr>
<tr>
<td>Santiago</td>
<td>Dominican Republic</td>
<td>211</td>
<td>45m</td>
<td>2,489</td>
<td>11</td>
</tr>
<tr>
<td>Punta Cana</td>
<td>Dominican Republic</td>
<td>442</td>
<td>2h 45m</td>
<td>2,147</td>
<td>12</td>
</tr>
<tr>
<td>Paris</td>
<td>France</td>
<td>9,579</td>
<td>8h 50m</td>
<td>5,744</td>
<td>10</td>
</tr>
<tr>
<td>Pointe-a-Pitre</td>
<td>Guadeloupe</td>
<td>1,229</td>
<td>1h 45m</td>
<td>56,134</td>
<td>4</td>
</tr>
<tr>
<td>Kingston</td>
<td>Jamaica</td>
<td>501</td>
<td>1h 30m</td>
<td>1,200</td>
<td>15</td>
</tr>
<tr>
<td>Fort de France</td>
<td>Martinique</td>
<td>1,334</td>
<td>2h 30m</td>
<td>1,870</td>
<td>14</td>
</tr>
<tr>
<td>St Maarten</td>
<td>Netherlands Antilles</td>
<td>1,037</td>
<td>1h 40m</td>
<td>15,600</td>
<td>7</td>
</tr>
<tr>
<td>Panama City</td>
<td>Panama</td>
<td>1,359</td>
<td>2h 14m</td>
<td>22,140</td>
<td>6</td>
</tr>
<tr>
<td>Providenciales</td>
<td>Turks &amp; Caicos Islands</td>
<td>384</td>
<td>45m</td>
<td>1,980</td>
<td>13</td>
</tr>
<tr>
<td>Miami</td>
<td>United States</td>
<td>1,235</td>
<td>2h 15m</td>
<td>331,516</td>
<td>1</td>
</tr>
<tr>
<td>New York</td>
<td>United States</td>
<td>2,876</td>
<td>4h 15m</td>
<td>166,092</td>
<td>2</td>
</tr>
<tr>
<td>Fort Lauderdale</td>
<td>United States</td>
<td>1,262</td>
<td>2h 10m</td>
<td>152,416</td>
<td>3</td>
</tr>
<tr>
<td>Atlanta</td>
<td>United States</td>
<td>2,323</td>
<td>3h 22m</td>
<td>5,784</td>
<td>9</td>
</tr>
</tbody>
</table>
4. Evaluation of Conditions in the U.S.

Map of foreign born population from Haiti by County
Passenger Volumes to US & Canada from Shanghai, Hangzhou, Nanjing, and Wuxi (April - June) With Chinese-Born Population by County and Direct Flights from Shanghai

- Vancouver: 16,664 passengers
- Toronto: 14,007 passengers
- Chicago: 14,295 passengers
- New York: 27,565 passengers
- San Francisco: 20,653 passengers
- Los Angeles: 27,204 passengers

Chinese-Born US Population By County:
- 1,000 - 10,000
- 10,001 - 100,000
- > 100,000

4. Evaluation of Conditions in the U.S.
Identifying Vulnerable FB Populations

FB Income

% of FB living at or below poverty line

FB Education

% of FB above 25 with less than HS diploma
4. Evaluation of Conditions in the U.S.

- The Census estimated there were 478,477 Haitians living in 33 states (138 counties) and the District of Columbia.
- Florida (15 counties) and New York (14 counties) had 384,760 Haitians (79%).
- Median income for Foreign Born in those counties was $26,121 compared to overall county median income of $30,969.
- In the counties with Haitians, there were 33,178,994 children less than 18 living below poverty.
- Of the children living below poverty, 20% were living with 2 foreign born parents.
5. Analysis to Determine CDC Intervention

- Increase the awareness of clinicians to identify cases
- Perform targeted surveillance and screening activities to selected communities based on their demographics.
- Provide medical treatment and pre-travel consultation when applicable
USA County TB rates / 100K  2006-2010
Haiti 2010-2012
Earthquake & Cholera Outbreak
In February 2012 DGMQ received a request from the states asking where Haitians lived in the United States.

DGMQ monitored reports of diseases in Haiti to determine what may be introduced into Haiti or brought back to the states from travelers to Haiti.
Kamran Kahn et al.
"Potential for the International Spread of Middle East Respiratory Syndrome in Association with Mass Gatherings in Saudi Arabia"
PLOS Currents Outbreaks: July 17, 2013
Saudi Arabia: Historic Trends in International Passenger Traffic

Source: BIOMOSAIC

* Doesn't include Medina
Methods

- Worldwide analysis of final city-level destinations of travelers departing any domestic or international airport in Saudi Arabia, Jordan, Qatar and UAE between June and November 2012 using flight itinerary data from International Air Transport Association.

- Time frame corresponds to approximately one month before Ramadan and one month after Hajj (Eid-al-Adha) in 2013.

- Includes travelers on all commercial and scheduled charter flights but not unscheduled charter flights (often used by Hajj pilgrims).

- Hajj pilgrim volumes derived from Saudi estimates in published literature and Ministry of Hajj national Muslim population estimates.

Final Destinations of Air Travelers Departing Saudi Arabia, Jordan, Qatar & UAE from June to November 2012 and Origins of Foreign Hajj Pilgrims by World Bank Income Classification

Destinations of Air Travelers (N=16.8 million)
- Low Income: 27.8%
- Lower-Middle Income: 47.4%
- Upper-Middle Income: 17.3%
- High Income: 7.5%

Origins of Foreign Hajj Pilgrims (N=1.75 million)
- Low Income: 27.3%
- Lower-Middle Income: 56.4%
- Upper-Middle Income: 7.6%
- High Income: 8.7%
Final Destinations of Air Travelers Departing Saudi Arabia, Jordan, Qatar, UAE from June to November 2012, Estimated Hajj Pilgrims by Country, and National Healthcare Expenditures per Capita in 2011

Note: Bubble size represents healthcare expenditure per capita (World Bank, 2011)
Global Passenger Volumes Departing Saudi Arabia
October - December 2010

Passenger Volumes
- 1 - 10,000
- 10,001 - 50,000
- 50,001 - 100,000
- 100,001 - 250,000
- 250,001 - 500,000
- No data

USA: 27,454
Pakistan: 299,685
Egypt: 353,093
India: 415,583

Data Source: IATA 2010
Final City Destinations of Air Travelers Departing Saudi Arabia, Jordan, Qatar, and UAE from June to November 2012 & Estimated Hajj Pilgrims by Country

Passenger Volumes (2012)
- 1,001-5,000
- 5,001-10,000
- 10,001-50,000
- 50,001-250,000
- > 250,000

Number of Hajj Pilgrims (2012)
- < 1,000
- 1,001-10,000
- 10,001-50,000
- 50,001-100,000
- > 100,000
- No data available

- CAIRO, Egypt: 1,340,536
- LONDON, United Kingdom: 530,543
- NEW YORK, United States: 97,055
- LAGOS, Nigeria: 69,691
- MUMBAI, India: 477,829
- JAKARTA, Indonesia: 350,516
- SAO PAULO, Brazil: 12,591
Key Findings

- Of all travelers departing Saudi Arabia, Jordan, Qatar and UAE from June to November 2012 on commercial flights
  - 51.6% had final destinations in 8 countries
  - 27.2% had final destinations in India, Pakistan or Bangladesh, more than 10 times the air traveler volume to Indonesia
  - 54.9% had final destinations in low or lower-middle income countries

- Of all Hajj pilgrims in 2012 an estimated
  - 60.7% had final destinations in 8 countries
  - 65.1% had final destinations in low or lower-middle income countries
  - 400,000 originated from India, Pakistan or Bangladesh, nearly twice the number of pilgrims from Indonesia (world’s largest Muslim nation)
The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge.

–Stephen Hawking
Value Simplicity

Any fool can make things bigger, more complex, and more violent. It takes a touch of genius—and a lot of courage—to move in the opposite direction.

$E=mc^2$
BioMosaic Web Application Demo