Addressing vaccination access & coverage through Big Data

Michael Greenberg, MD, MPH
Global Medical Strategy, Sanofi Pasteur

WHAT HAPPENS IN 1 SECOND OF THE INTERNET

- Amazon gets an average of $3400 worth of transactions
- eBay gets an average of $686 worth of transactions
- 28,935 Instagram Photos sent
- 721 Instagram Photos Uploads
- 1286 Netflix Hours of Videos Streamed
- 23 Uber Rides
- 24,88,887 Emails
- 35,069 of Internet traffic
- 6 New Facebook Profiles Created
- 6 Million
- 48 Million
- 2 Billion
- 0
The "FOUR Vs"

Volume
SCALE OF DATA

Variety
DIFFERENT FORMS OF DATA

Velocity
ANALYSIS OF STREAMING DATA

Veracity
UNCERTAINTY OF DATA

Why Big Data?

- Google
  - Flu – 50 million flu queries weekly
  - Daily behavior of >57 000 diabetic patients

- evidation
  - Thousands of publications

- DOCTOR EVIDENCE
  - VAXITREND – Internal Market Researches
    - 20 countries; 17 000 patients, 3000 HCPs

- Activity trackers
- Daily Behavior information
- Daily searches

Google

- Graphs / Tables
- Internet queries & posts
- Publications

GRADE Evaluation:
- Evaluate the quality of medical evidence
- Methodological rigor
- Data cleaning
- Internal data controls

SANOFI PASTEUR
Why Flu & Diabetes?
We need deeper understanding to increase flu vaccine coverage

- **Metabolic complication:** Decompensation, ketoacidosis, deaths
- **Infection complication:** Secondary infection

**HOSPITALIZATION**
- 3-6x

**DEATHS**
- 6x

Influenza vaccination is recommended (and funded)

Why do people living with Diabetes do not get vaccinated (more)?
3-Step pilot experimentation approach

1. Scientific data review - make sure we don’t find what is already known
   - Using natural language processing, machine learning, deep learning

2. Design methodology for understanding patient behavioral phenotypes
   - Run small scale real-world pilots

3. Experience building a datamart that unites google, sanofi and publicly available data
   - Emphasis on country level implementation
We used **VaxiTrends**, a proprietary dataset, to identify variables influencing vaccine uptake among adults in the U.S., China, France, Mexico, and U.K. We combined the data with National Health Interview Survey results from the CDC, which offer insights into health behaviors of Americans with diabetes.

This information was aggregated with data from **Google FluTrend**, which signals flu incidence, & Google Trends Application Programming Interface, which tracks search keyword popularity by location & date in a de-identified fashion.

Cluster analyses indicated factors most positively & negatively associated with acceptance & adherence.

factors impacting flu vaccination vary by country for people living with diabetes

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>UK</th>
<th>France</th>
<th>China</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triggers to Action</td>
<td>Doctor Relation</td>
<td>Triggers to Action</td>
<td>Chronic conditions</td>
<td>Triggers to Action</td>
<td></td>
</tr>
<tr>
<td>Vaccine Trust</td>
<td>Triggers to Action</td>
<td>Doctor Relation</td>
<td>Weak Immune condition</td>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Doctor Relation</td>
<td>Vulnerability</td>
<td>Vulnerability</td>
<td>Beliefs and Perception</td>
<td>Chronic Condition</td>
<td></td>
</tr>
<tr>
<td>Chronic Conditions</td>
<td>Chronic Conditions</td>
<td></td>
<td>Vulnerability</td>
<td>Severity of flu</td>
<td></td>
</tr>
<tr>
<td>Beliefs and Perception</td>
<td>Beliefs and Perception</td>
<td>Beliefs and Perception</td>
<td>No Chronic conditions</td>
<td>Beliefs and Perception</td>
<td></td>
</tr>
<tr>
<td>Risk Perception</td>
<td>Risk Perception</td>
<td>Doctor Relationship</td>
<td>Risk Perception</td>
<td>Risk Perception</td>
<td></td>
</tr>
</tbody>
</table>

Ordered in terms of importance from Highest influence to Lowest

Positive Factors

Negative Factors
Google Flu Trends Offers Regional Granularity

Search trends for both positive and negative terms are observed.
Using Google Cloud and Predictive Analytics to Promote Influenza Vaccination Among People with Diabetes

AIM:
To combine novel datasets and dynamic modeling techniques to identify the behavioral determinants of influenza vaccination in people living with diabetes, and to use these insights to tailor flu vaccination interventions and campaigns to the psychosocial and contextual characteristics of different populations.

BACKGROUND:
Influenza vaccines protect people living with diabetes and reduce the risk of severe illness and death. The Centers for Disease Control and Prevention (CDC) recommends annual influenza vaccination for people with diabetes. However, vaccination coverage rates are often lower than those for the general population. Understanding the determinants of influenza vaccination behavior is crucial to developing effective vaccination interventions.

METHODS:
We combined data from four sources: (1) NHANES, a nationally representative sample of health-related behaviors and factors; (2) Medicare Advantage data that captures personal health information; (3) Google Flu Trends, a data-driven forecasting tool; and (4) wearable devices that track physical activity. We conducted a mixed-methods study to identify factors that influence vaccination behavior and to develop targeted interventions.

Step 1: GROUP
- We identified high-risk populations based on NHANES data. This step leverages the strengths of NHANES to select candidate intervention groups who share a combination of factors that influence vaccination behavior.

Step 2: ELIMINATE
- We categorized participant groups based on their likelihood of receiving a vaccination. This step uses data from Medicare Advantage to eliminate participants who are unlikely to benefit from vaccination.

Step 3: CALCULATE PUBLIC HEALTH IMPACT OF INCREASED VACCINATION ADHERENCE
- We projected the potential impact of increased vaccination adherence on public health outcomes. This step uses data from Google Flu Trends to calculate the potential impact of increased vaccination adherence.

Step 4: DEBATE ADDITIONAL EVIDENCE
- We synthesized evidence and considered the potential impact on public health. This step involves a detailed analysis of the potential benefits and drawbacks of increasing vaccination adherence.

RESULTS:
- We identified several high-risk populations based on NHANES data. These populations included people with type 2 diabetes, those with obesity, and individuals with a history of hospitalization.

- We found that the groups with the lowest vaccination coverage were also the groups with the highest risk of severe illness. This suggests that targeted interventions are needed to improve vaccination rates in these populations.

- The results from Google Flu Trends and wearable device data showed a strong correlation between physical activity and vaccination behavior.

CONCLUSION:
We conclude that a personalized public health strategy is needed to improve vaccination rates among people with diabetes. Our findings highlight the importance of targeting interventions to high-risk populations and leveraging data-driven approaches to inform vaccine messaging and delivery.
Google created a country specific dashboard for local users to identify behavioral drivers of flu vaccination & the most receptive subgroups to design tailored interventions to increase uptake.

Adherence Impact Calculator

- Adherence Score: 53.83%
- Intent to Vaccinate: 60%
- Affordability: 70%
- Access to Flu Jab: 80%
- Availability of Time: 90%
- Vulnerability: 50%
- Self Efficacy: 70%

- External Barriers
  - Information barrier
  - Financial barrier
  - Access barrier
  - Social barrier

- Internal Barriers
  - Perceived health risk
  - Beliefs about vaccine
  - Perceived vaccine efficacy
  - Perceived vaccine safety

- Flu Trend
  - Flu activity: Low
  - Influenza virus activity: Low
  - Vaccine effectiveness: High

- Health
  - Vaccination rate: 50%
  - Flu cases: 10%
  - Hospitalizations: 5%

- Knowledge on Flu
  - Information on flu: 70%
  - Knowledge on vaccine: 80%
  - Knowledge on symptoms: 90%

- Doctor Relation
  - Trust in doctor: 60%
  - Communication with doctor: 70%
  - Doctor's advice: 80%

- Vaccine Attitudes
  - Preference for vaccine: 90%
  - Convenience of vaccine: 80%
  - Acceptability of vaccine: 70%

- COVIDs to Action
  - Awareness of COVID-19: 80%
  - Understanding of COVID-19: 90%
  - Preparedness for COVID-19: 70%

- Sanofi Pasteur
THANK YOU