IBM Health Corps – Taiwan Centers for Disease Control
Executive Summary

Introduction

Dengue fever is a major cause of morbidity and mortality across the tropics and subtropics. Globally, it is the most rapidly spreading mosquito-borne virus, and global incidence has increased 30-fold over the past 50 years.[1]

In Taiwan, from 2003 to 2013, the annual number of domestic dengue cases was less than 2,000. During 2014, a large dengue outbreak occurred in Kaohsiung with 15,492 cases. In 2015, southern Taiwan suffered an even larger outbreak, with a total of 43,419 cases and 228 deaths.

The Taiwan Centers for Disease Control's (CDC) Epidemic Intelligence Center (EIC) is responsible for risk monitoring and risk assessment for infectious disease in order to inform early warning and intervention. EIC serves as the data center for the CDC, gathering data from different sources and maximizing the utilization of the data by providing platforms for partners, such as local governments and scholars, to access it.

In October and November 2016, IBM Health Corps partnered with the Taiwan CDC to help improve their capability and capacity to evaluate the potential impacts of intervention policies to fight dengue fever. The ultimate objective was to promote CDC's ability to make efficient, data-driven, practical decisions to protect the public's health from a serious infectious disease.

Methodology

The IBM Health Corps team took a design thinking approach to frame and address the challenges CDC and Taiwan was facing around dengue control. Through interviews and workshops, the IBM Health Corps team engaged stakeholders across different government agencies to explore their pain points and desired outcomes for tackling dengue in the field and from a policy perspective.

The IBM team also collected and examined data on vectors (mosquitos), human cases, population demographics, socioeconomic factors, environment and weather, and the built environment. Using SPSS Modeler, the team cleansed and curated the data, allowing them to better understand what indicators existed in the data to use in the model. The team also conducted statistical modeling to interpolate where there were gaps in the data (most notably with accurate mosquito counts). They also focused on constructing a proxy for mosquito count.

The EIC asked the IBM team to build an intervention model to examine the impact of introducing Wolbachia-carrying mosquitoes into areas at risk for dengue. The key questions the IBM team aimed to answer through the mechanistic model were:

1. How effective would a Wolbachia release be in Taiwan on human case counts and the mosquito population?
2. Where should a pilot introduction be conducted?
3. How should the mosquitoes be released? (e.g. number, duration, frequency)
4. What is the projected cost and value for a pilot?

[1] World Health Organization. "Global Strategy for Dengue Prevention and Control: 2012-2020."

Throughout the engagement, the IBM team adopted a practice of "co-creation" with the CDC, which was demonstrated through side-by-side work sessions and regularly occurring "playbacks" to solicit feedback and gain buy-in on project direction.

Key Challenges Facing Taiwan CDC

- Data collection: Dengue fever surveillance of human cases is highly dependent on people reporting symptoms, physicians reporting the diagnosis, and the length of time between disease onset and case reporting. For vector surveillance, CDC faces challenges in the manpower needed to investigate breeding sites, and the accuracy of mosquito counts. CDC employees highlighted the desire for automating data collection.
- Analytics & Modeling: The process for analytics is not standardized at the CDC. Further, working with imperfect data makes it challenging to analyze and correlate data and do predictive modeling on the impact of interventions to fight dengue fever.
- Decision making: Without great confidence in the disease and intervention models, it is difficult for CDC to 1) convince local governments to comply with policy for dengue control, and 2) obtain funding to implement new strategies/policies.
- Organizational Barriers: Collaboration between government agencies (at the national level, and between local and national) is irregular, impeding data sharing and shared decision making.

Critical Assets

- CDC is open to embracing new ways of framing and solving problems
- Cross-sector interest and desire to serve the individual
- CDC leadership supportive of developing analytical capabilities of employees
- Rich source of data available
- EIC already on a trajectory to act as an Analytics Center of Excellence through its practices in data collection and analysis
- CDC is bent towards transparency, demonstrated through regular press conferences and creation of open source data platforms

Deliverables Created by IBM Health Corps Team

- **Cleansed and curated data set** comprised from 13 original data files.
- **Statistical models** built to examine correlation between various factors (for example, the correlation between education level of village and mosquito egg ratio in same geography, or the correlation between temperature and larva level) in order to refine the mathematical model and improve predictive capability.
- **Mechanistic model** built to predict the impact of introducing Wolbachia-carrying mosquitoes on the case counts for dengue fever and the mosquito population. The model enabled interactive ("what if") scenarios to evaluate the changes in case counts and mosquito population based on different input parameters entered for number of Wolbachia mosquitoes released, the frequency and duration of the release. Intervention effectiveness was explored via the model for 261 villages that were affected by dengue fever in 2015.
- **Decision support interface**: The interface helps CDC visualize the mechanistic model outputs and see the impacts of the interventions, including an estimate of cost of the intervention (available here).

- **Analytics agenda** developed to show CDC how they can move from descriptive to predictive to prescriptive analytics in order to enhance their capacity to prevent and control infectious disease.

Recommendations for CDC

<table>
<tr><td colspan="2">Ongoing</td></tr>
<tr><td colspan="2">• Design Thinking: Incorporate human-centered problem framing and solving into common practices of decision making
• Collaboration: Institutionalize interagency collaboration and utilize the analytics framework to drive shared insights</td></tr>
<tr><td>Near-Term</td><td>Long-Term</td></tr>
<tr><td>• Data & Models:
1) Establish a strong data management discipline to ensure common data sharing across agencies
2) Refine models based on continuous learning
• Workforce Skills Planning: Identify critical skill requirements and establish cross training programs for the analysts (e.g. modeling, optimization, Python)
• Analytics Maturity: Assess organizational analytics maturity and develop a strategic development plan
• Monitor & Measurement:
1) Collaborate cross-organization to monitor & measure the intervention impact
2) Use technology to share performance metrics and accomplishments</td><td>• Automation: Leverage Internet of Things (IoT) to automate data collection and analysis from the field to improve the efficiency of interventions
• Cognitive Capabilities:
1) Automate the literature search function by incorporating cognitive
2) Apply cognitive forecasting methods</td></tr>
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Conclusion

In addition to the tangible assets (mathematical model for Wolbachia and decision support interface) the IBM Health Corps team delivered to enhance the CDC's ability to fight dengue fever, the IBM team focused on empowering CDC to take the work forward. Through side-by-side skills transfer, trainings on modeling, analytics, and design thinking, and regular collaboration, the EIC can use the model for Wolbachia as a proof of concept to develop predictive models, not only for other dengue interventions but also for other serious infectious diseases facing Taiwan.