A Bright Future: Innovation Transforming Public Health in Chicago

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Big cities continue to be centers for innovative solutions and services. Governments are quickly identifying opportunities to take advantage of this energy and revolutionize the means by which they deliver services to the public. The governmental public health sector is rapidly evolving in this respect, and Chicago is an emerging example of some of the changes to come. Governments are gradually adopting innovative informatics and big data tools and strategies, led by pioneering jurisdictions that are piecing together the standards, policy frameworks, and leadership structures fundamental to effective analytics use. They give an enticing glimpse of the technology's potential and a sense of the challenges that stand in the way. This is a rapidly evolving environment, and cities can work with partners to capitalize on the innovative energies of civic tech communities, health care systems, and emerging markets to introduce new methods to solve old problems.

KEY WORDS: big data, Chicago Department of Public Health, innovation, predictive analytics, public health, technology

From ensuring clean water supplies to delivering polio vaccines, the most effective public health activities are typically preventive interventions and policies that help avert crises before they start. However, predicting what problem will emerge as the next public health crisis has always proven a challenge for public health officials, even preventive measures such as distributing vaccines are reactive and are often initiated after an outbreak or incident.

The City of Chicago (City) is emerging as an exemplar in this arena and is developing ground-breaking approaches to delivering public health services. Using innovative policy, systems, and environmental

approaches, our team at the Chicago Department of Public Health (CDPH) is contributing to the forefront of public health practice by innovating age-old public health workflows and methods of analysis.

In this commentary, we describe challenges faced by public health departments and how, in response, CDPH is moving from one-time programmatic interventions to sustainable system-level innovations that have scalable and meaningful impact. In this commentary, we articulate the impetus for the development of an innovation agenda. Then we describe the pillars of the innovation agenda that include informatics, application development, and predictive analytics, which can lead to policy, systems, and environmental change.

● Background

Introduced in August 2011 by Mayor Rahm Emanuel and CDPH, *Healthy Chicago*, is the city's first comprehensive public health agenda with more than 200 strategies within 12 priority areas. *Healthy Chicago* is a plan for improving the health of city residents that uses neighborhood-level information and real-time data to track, monitor, and protect the health of Chicagoans.

Over the last 2 years, CDPH has been working internally and with partners to build new technologies

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that help local government offices collaborate with local residents to identify and address health problems that impact the public at large. Because these technologies are digital and utilize Web-based platforms, they have the potential to extend information to wider, more diverse audiences than some traditional public health interventions.

Public health departments are facing extraordinary challenges that include the prospect of future budgetary challenges, the uncertainty of a future public health workforce, and the emergence of informatics and big data, as well as the questions surrounding integration with health systems that have new emerging payment and delivery models. Furthermore, increased patterns of trade and travel pose new threats for health departments. In addition, legacy systems that are not interoperable, and numerous silo information technology systems pose budgetary, operational, and workforce challenges for health departments.

The Chicago Department of Public Health, like other government entities, is following the lead of the business sector, which for decades has used data to drive decision making and strategy. Government, like business, is beginning to use data to test new ideas and to measure and respond quickly to what works, as well as to develop ways to revise and improve interventions that are less effective. Like businesses, governments are starting to engage customers through social networks, Web sites, and blogs and are learning to use technology to function more effectively. Because of its potential to reach larger swaths of the public with fewer resources, digital strategies have shown to support government in becoming lean, advancing priorities, and engaging residents. That—in a time of shrinking resources—delivers better services, faster.

● Data Liberation

Liberating data is an important component of Chicago's innovation strategy. Liberating data is making data accessible, discoverable, and usable by the public so that it can spur entrepreneurship, innovation, and discovery. For several years, the federal government has issued calls for increased transparency of operations. As a result, government agencies are releasing data that the public can access to generate awareness that can foster more ideas for potential solutions and efficiencies. In May 2013, President Obama established a historic executive order that outlines steps to make government-held data more accessible to the public and to entrepreneurs and others as fuel for innovation and economic growth.¹ The goal of open data is

to make data underutilized in government available and placed in the hands of people who can unlock its potential value.

Since then, thousands of data sets have been released in usable format, giving all types of organizations the tools to develop new products and services to help millions of Americans, and creating jobs of the future in the process. "Open data" has increased the flow of information, and in doing so, it has created an opportunity for government leaders and their teams to analyze it to improve outcomes, look for inefficiencies, and communicate better with their constituents. The City of Chicago, for instance, is using its open data platform to collect, measure, visualize, and communicate performance data to its residents.²

Chicago has been at the forefront of the data liberation movement in cities. The strategy involves many players including City of Chicago departments and agencies, technology companies, entrepreneurial hubs for digital startups, and civic organizations, such as the Smart Chicago Collaborative. To begin, Mayor Emanuel asked each city agency to focus on innovation with guidance from the Digital Excellence Initiative.³ One of the inaugural efforts to leverage technology was the Open 311 project. Open 311 grew from a partnership between the Mayor's office, the Chicago Department of Innovation and Technology (DoIT), and Code for America, a not-for-profit group that helps residents and governments harness technology to solve community problems. This project used phone-based technologies to foster open communication about issues related to public space and public services, making 311 calls transparent to the public. The project also included a response tracker so that residents could identify how the call was resolved.

Our innovation framework is supported by 3 pillars: informatics, application development, and predictive analytics (PA), each of which is anchored in the unique use of data. Data liberation spurs innovation by allowing developers the flexibility to freely utilize the open data in application development, analysis, data visualization, and so forth, to serve the residents of Chicago. Applications are often adopted by the City or by civic communities that share their knowledge to develop open-source projects for the city. Predictive analytics uses many variables that are often derived from open data sources, such as weather, 311 complaints, business licenses, and so forth.

Our goals include improving the use of scarce resources, being smarter with data, fostering engaged citizenship, spurring economic development, leveraging nontraditional partners, and evolving departmental culture. To achieve these goals, we use informatics, application development, and PA (Figure 1).

FIGURE 1 ● The 3 Pillars: Projects in Informatics, Application Development, and Predictive Analytics

Abbreviations: EHR, electronic health records; GIS, geographic information systems.

● Informatics

Public health informatics, defined as the systematic application of information and computer science and technology to public health practice, research, and learning.⁴ In its infancy in 2001, public health informatics focused primarily on better disease surveillance and outbreak detection systems. Public health informatics then evolved to ensure that there was a connection between public health systems and clinical systems.⁵ Now the impetus is to identify ways to leverage informatics to merge structured and unstructured data to generate valuable insights to advance health.

A major driver of the informatics revolution is certainly the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act (Title XIII of Pub. L. 111-5), which has led to incentive payments tied to meaningful use requirements. Much has been written about meaningful use implications for public health because of the requirements supporting modifiable electronic laboratory reporting, syndromic surveillance, and reporting to immunization registries. The commentary has been positive and negative.⁶ There are potential consequences for population health if the proposal of removing public health measures in stage III proceeds as proposed. Public health measures provide an additional profile for health departments about communities that guide interventions and education campaigns. Beyond the public health reporting requirements, population health stands to gain considerable advantages by establishing chronic disease surveillance systems.

One of our key partners, the Chicago Health Information Technology Regional Extension Center (CHITREC), led by Drs. Kho and Rachman, are working with us to move forward electronic health record surveillance for population health. HealthLNK is a database of de-identified health record data for Chicagoans. It encompasses inpatient and outpatient visits spanning 5 years. Furthermore, individual patient records are matched across institutions. This work resulted in support from the Patient Centered Outcomes Research Institute (PCORI) to 20 institutions across Chicago to build a clinical data research network (CDRN) to advance population health. This CDRN is part of a larger PCORI network effort. This endeavor will drive new insights in population health for Chicago. We actively work with CHITREC and their partners to enhance public health surveillance.

Currently at CDPH, we are working to create an informatics data tool that enables providers to generate community-profiles public health data to understand the social, environmental, and economic context of their patients, and to support clinical decision making in real time. This coupled with geographic information systems provides a map of the community ecosystem visually. The Institute of Medicine has recently argued for embedding social determinants of health data into the electronic health records (EHRs), a move we believe aligns with the larger goals of improving patient care, advancing population health, and reducing health care costs.

Tobacco cessation is a revealing example of how an integrated EHR can be used to prevent

cardiovascular disease. Currently, in many health systems and federally qualified health centers across Chicago, patients who are ready to quit smoking tobacco are advised to call the Illinois Tobacco Quitline, a resource for tobacco cessation. However, we have anecdotal evidence that patients require additional support in taking this step, and we are losing a critical opportunity to engage ready-to-quit smokers by asking them to call for help themselves. In an effort to quickly engage ready-to-quit patients, we have been working with federally qualified health centers, and the Illinois Department of Public Health as well as the American Lung Association, to develop an electronic referral system that will allow care providers to directly inform the Quitline about patients who are ready to quit. With patient information in hand, the Quitline staff can then proactively reach out to these patients to provide guidance and support. This project, created in partnership with the Illinois Department of Public Health and the Illinois Tobacco Quitline, shifts the follow-up responsibility for tobacco cessation to experts with the proper resources to support patients at a critical juncture when they are ready to quit.

Big data has been leveraged extensively in commercial industries and by companies such as Amazon to generate insights that can lead to more informed, targeted, and successful marketing efforts.⁷ Health care “big data” is a branch of health care informatics that pools large and disparate data sets and applies a suite of mathematical approaches that derives associations, facilitates comparisons, and generates insights that are not otherwise possible using standard analytics. “Big data” is a term used to describe a collection of data sets with the following 3 characteristics: volume—large amounts of data generated; velocity—frequency and speed of which data are generated, captured, and shared; and variety—diversity of data types and formats from various sources.⁸ The public health community is just starting to emerge as a user of data in unique ways, taking a page from the commercial playbook.⁹ As the focus on innovative uses of data in health strengthens, there will be an increasing need for cross-sector relationships anchored by local and state health departments to maximize the benefits achieved from appropriately using these data. Neither health departments nor health systems can navigate this terrain alone—nor should they. Working together—governments, health plans, academic delivery systems, community-based organizations, and the private sector—these organizations have the potential to leverage data and technology to transform public health. To evaluate the success of open data, a city can be accountable for the number of data sets, the number of applications developed, and the economic multiplier effect of small businesses created as a result of open data. Increased economic

development through civic innovation is most often viewed through the lens of open data.¹⁰

● Application Development

One of the success stories in Chicago’s civic innovation community is the rapid spread of health-related Web sites and applications (apps) that have come out of both the volunteer civic technology community and critical public-private partnerships. The Chicago Health Atlas is one illustrative example.

The creation of the Chicago Health Atlas is a direct result of community partnerships. Initially, the site was built by an existing partnership by informatics researchers at seven health systems in Chicago; University of Illinois at Chicago, Stroger Hospital, The University of Chicago, Northwestern University, and Rush University. Since the initial formation of the partnership, the atlas has been expanded by the Smart Chicago Collaborative (a civic organization devoted to improving the lives of Chicago residents) to include data and research from the CDPH and other agencies.

The Chicago Health Atlas illustrates data from a diverse range of sources including the City of Chicago data portal, CDPH programs, EHR data from academic health centers in Chicago, data from partners such as Purple Binder on local community and social resources, and City of Chicago Web portal aggregate data; which contribute to profiles that present intersecting health outcome data, demographic information, and community assets for each Chicago community area.

Chicago has also seen a surge in the development of public health–focused mobile apps starting, with Tom Kompare’s Chicago flu shot app, which helps Chicago residents find free flu shots located near them. The flu shot app has been adopted in other cities, including Boston and Philadelphia. Mobile apps can be designed to help residents file service requests to the city and to decrease call times to 311 centers.

At CDPH, we maintain that innovations related to food protection activities are critical to achieving better health outcomes. As the Centers for Disease Control and Prevention has reported, most cases of foodborne illness go unreported, and health agencies typically wait for customers to file official complaints. We worked proactively with partners to launch a new application, www.foodbornechicago.org, that allows us to monitor public tweets from Chicago that mention food poisoning. Foodborne Chicago uses a program designed to detect language that suggests that an individual may be suffering from food poisoning. First, we identify the local Twitter users who have posted information suggesting that a particular restaurant has been the cause of food poisoning. Then, we review

the content of the tweets more closely to identify instances that are likely to represent actual foodborne illness. We then respond to residents via Twitter and ask them to file a complaint with CDPH. The app complements the City's 311 telephone reporting system by providing an online option to report CDPH, and sends the residents a form via Twitter to complete once they report a potential foodborne illness via tweet to Foodborne Chi. Since its launch on March 23, 2013, 259 cases have been reported through the new system, resulting in 174 inspections that would not have occurred otherwise. Not only have these inspections resulted in additional health code violations, but in 1 case, the app alerted CDPH's Food Safety Division to several people with complaints, a result that prompted an investigation. These examples underscore how open data, social media, and mobile technologies can be used together to monitor and protect public health.

● Predictive Analytics

Over the last few years, the Triple Aim of reducing health care costs, improving quality, and better population health has taken center stage.¹¹ Through effective identification of individuals at higher risk, health care systems can become more strategic about resource allocation to achieve the Triple Aim. A tool called "predictive analytics" has created opportunities for customized prediction and relative risk scores to achieve this very goal.

Predictive analytics describes statistical and analytical techniques that investigate current and/or historical data to make predictions about the future. Predictive analytics utilizes these techniques to identify patterns in the data associated with a specific endpoint. Once the data are analyzed, a weighted formula is created from the recognized data patterns. These formulas can be used for the creation and application of more effective predictive risk scores that can enable health care providers to more accurately identify patients in need. Without this tool, many patients who are at an increased risk may be overlooked, and opportunities may be lost to apply preventive measures. This tool creates timely opportunities to make real change in daily patient interactions. By harnessing probabilistic prediction power from a diverse set of data sources, including homegrown, community-specific data, it is plausible to change the landscape of how we practice patient care through the lens of population health.¹²

Another innovative use of data in public health is the Smart Data Project, a PA initiative launched in 2014 in Chicago. The project works create a platform to help City employees use available data to make informed

decisions with the goal of preventing problems before they develop. The platform is connected to Windy-Grid, a data hub that houses real-time information and gathers millions of data records each day from City departments. One of the features planned for the SmartData Project is to incorporate PA. With this kind of information, public health officials may be able to better respond to possible public health issues by, for example, providing prenatal treatments to prevent birth complications, recommending dietary changes that will help manage a chronic disease, or distributing vaccines early to contain a viral outbreak. Wise use of public health data through well-designed predicative analytics could transform how government operates and how resources are allocated to serve public health. Funded with a \$1 million grant from Bloomberg Philanthropies, Chicago's SmartData project will build the first open-source, PA platform—aggregating and analyzing information to help leaders make smarter, faster decisions and prevent problems before they develop. SmartData will give leaders a tool to search for relevant data and detect relationships, analyzing millions of lines of data in real time. This will help make smarter, earlier decisions to address a wide range of urban challenges.¹³ Predictive analytics may also help public health officials concretely measure gains in efficiency by comparing health metrics before and after the analytics are used. If successful, the SmartData Project may be able to serve as a template for cities that want to build similar systems.¹⁴

Use of PA has already proven to be successful in Chicago. Brenna Berman, Commissioner of Chicago's Innovation and Technology Department (DoIT), implemented a predictive rodent control project using complaints from citizens about garbage problems as key indicators. The City found that it was possible to predict that every garbage complaint submitted would be followed within 7 days by a related rodent complaint in the same spot. Linking the 2 complaints, service crews have been able to redress rodent problems across Chicago.

In a collaboration among CDPH, DoIT, and other civic-minded community-based organizations, City officials are also building on lessons learned from the Foodborne Chicago project previously mentioned. A new model is being developed that uses data related to food establishments including ZIP codes, business licenses, building code violations, and 311 complaints. Then the data aggregated by the model formulate a risk score to uncover critical violations more efficiently. The risk score also presents usable data to inspectors to identify potential issues before they occur. This tool complements and optimizes existing food protection processes, so resources can be better allocated and prioritized on the basis of risk.

FIGURE 2 ● Strategy for Capacity Development for Innovation and Sustainability

To test the model's effectiveness in the field under real conditions, CDPH ran a pilot trial in which the data in the model were used to determine which establishments were most at risk for health code violations. The blind, randomized, controlled trial evaluated several hundred establishments. We are currently assessing the results and refining the model. Once the model is accurately predictive, we hope to expand the program to identify health code violations, improve the quality of the food supply, and prevent instances of food poisoning. We are also hopeful that the information generated by the model will help the business community in understanding health codes and inspection requirements.

Our goal for the Chicago's analytics platform is to create tools that are transferable, scalable, and highly usable. To achieve these goals, we will continue to develop programs that not only make powerful use of open-source software and open data but also follow principles of human-centered design.¹⁵ The design of programs based on predictive analytics will continue to be based upon an explicit understanding of users, tasks, and environments. The intent is that the design will address the whole user experience.¹⁶

● The strategy for capacity development for innovation and sustainability

Creating sustainable innovation programs requires a robust and proven workflow. We believe that there are several essential steps in developing a strategy that can effectively use informatics and support the development of innovative software applications in the realm of public health. A first essential step is identifying a public health problem that already has data and resources attached to it. A second step for a successful program is to build a broad and experienced staff and external partnerships.¹⁷ Participants whose knowledge and skills could build new solutions might include informatics professionals, epidemiologists, inspectors, medical directors, public health administrators, Health

Insurance Portability and Accountability Act privacy officers, policy experts, civic and business technologists, community-based organizations, and universities. By working together, experts from different sectors can build off of each other's strengths to create innovative solutions.

Once partnerships are formed, they should begin by identifying what policy, system, and environmental strategies are working in public health instead of identifying what strategies are not. By identifying the operative ingredients of related success stories, technically referred to as "positive deviants," collaborators can build on an already proven baseline.¹⁸ Once effective ingredients are recognized, they can be incorporated into solutions built using informatics, predictive analytic models, and new software applications. The new tools all need to go through a normal development cycle: testing through proof of concept, creating and testing a prototype, rolling out a pilot program, refining tools with input from pilot, and finally building a working model to use at full scale. By using these processes, we have proven that together these steps generate one method to build capacity and sustain innovative projects (Figure 2).

● Conclusion

Governments are gradually adopting innovative informatics and big data tools and strategies. This trend in government leadership is being led by pioneering jurisdictions that are piecing together the standards, policy frameworks, and leadership structures fundamental to the effective use of data analytics. These groundbreaking initiatives provide cities across the country with an enticing glimpse of the technology's potential and a sense of the challenges we must overcome to be able to use data safely and effectively in the service of public health. In the rapidly evolving culture of merging of data sources, cities can work with partners to create new strategies to solve old problems by capitalizing on the innovative synergies of civic tech communities, health care systems, and emerging markets.

Chicago is using lessons from other industries and established techniques such as PA to drive innovation in redesigning age-old processes and contribute to citizen engagement, use of cases to an emerging open-source smart data platform, and data-driven decisions toward the journey in becoming the healthiest city in the nation.

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