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**Applying Public Health Informatics to Developing an Interoperable
Communication System for Emergency Preparedness and an Active Chronic
Kidney Disease Surveillance System**

By

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Degree to be awarded: Master of Public Health

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An abstract of

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Abstract

Applying Public Health Informatics to Developing an Interoperable Communication System for Emergency Preparedness and an Active Chronic Kidney Disease Surveillance System

By Robert Larbi-Odam

Public Health Informatics (PHI) is a growing field in the practice of public health that promotes the use of information and information technology to improve population health outcomes. This portfolio developed and applied methodologies that can be used in the selection and implementation of information technology solutions for a public health need.

The aim of the first project was to develop a technology solution that will ensure continuous and interoperable communication between jurisdictions and the citizen population during a public health emergency. The second project focused on developing an active surveillance system for chronic kidney disease. This disease has a high morbidity and mortality in addition to a high cost of care.

A process and system methodology to guide the selection of an information technology solution was developed. For the selected public health need a technology solution that could be funded and implemented within the enterprise and business architecture of a public health agency was completed.

There are significant technology solutions that public health informaticians can lead and introduce into public health practice to improve population outcomes. The set of skills demonstrated in the portfolio have produced results that can be scale up into funding and implementation.

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Introduction and rationale:

Information systems are an innovative tool that continues to transform how all industries conduct business and get results. The Public Health arena continues to adopt information systems applications to address its needs. Public health informatics activities help agencies at the Federal, State, and local levels collect, store, and use data to improve public health outcomes. [1] There are multiple ways to acquire a technology product to meet the agencies' information needs. One option will be to create from scratch the information technology solution inhouse. The second option will be to obtain an already developed product from a vendor. The first option is time-consuming and expensive as the quality of the human capital to achieve that may not be available within the organization. If the agency develops a policy and methodology process, then the second option of using an already developed product may be better for the organization. This vendor designed products can significantly contribute to the incorporation of information technology to enhance public health practice. This thesis's rationale is to show the methodology that will enable the identification of a public health need and select a technology solution to address it. It will be applied in the areas of public health emergency preparedness and chronic disease kidney surveillance.

Problem Statement:

There are many areas of need in public health activities that will benefit from the deployment of technology to enhance data collection for decision making. As we migrate from manual reporting with traditional data sources to automated data collection from new data sources such as social media and electronic health records, public health agencies will need to update its institutional process to benefit fully from new and

evolving technologies. Technology solutions in public health informatics create many and better opportunities for interacting with current and new stakeholders. The availability of Electronic health records, health information exchanges, mobile smartphone apps, georeferencing tools, social media, data visualization systems, and cloud-based software solutions to solve technology needs in public health are enormous. Public health informaticians' trained formally or informally can make these future implementations possible. The Center for Disease Control and Prevention called for this urgent upgrade in its paper "CDC's Vision for Public Health Surveillance in the 21st Century" (2012). [2] In the future, these technologies will help integrate the whole information systems platforms of the United States healthcare enterprise through interoperability protocols that are inherent in applications. Public health needs can be addressed with technology solutions to generate the outcomes that support the mission and objectives of public health agencies.

Purpose Statement:

A systematic process of decision support is needed to help public health agencies evaluate and rank a technology application that will be used in solving a public health need. The practice of public health informatics can be divided into three categories. "The first involves the study and description of complex systems. The second is identifying opportunities to improve the efficiency and effectiveness of public health systems through innovative data collection and use of information. The third is the implementation and maintenance of processes and systems to achieve such improvements." [2] With current trends, there is no reasonable alternative but for public health to fully embrace the use of information technology in its business cases.

Such regulation and the policy-driven processes must also consider interoperability with the current business information technology architecture. [3]

Methodology for selecting informatics solution for a public health need:

As stated by Yasnoff et al., Public health Informatics needs to use a "systematic and informed approach to the application of information science and technology to take full advantage of its potential to enhance and facilitate public health activities." [4]

The methods applied to these projects will be organized into four main steps.

Step 1: Public Health agency internal needs assessment.

Step 2: Information technology project preparation.

Step 3: Considerations for selection of informatics applications.

Step 4: Interoperability considerations.

Public Health agency internal needs assessment [5]:

- Identify the set of requirements of the public health need.
- Gather the public health user's perspectives to determine which requirements are essential for the need to be addressed.
- Ranking the importance of the requirements.

Information technology project preparation [1]:

- Define a conceptual view and project scope, especially in the form of a diagram or graphic to explain the agency's goals and scope.
- Complete identification of key stakeholders.

- Develop a project charter to build a capable project team, preempt project risk, and guide the creation of deliverables.
- Highlight context drivers for interoperability and modernization of the agency's information systems to decision-makers.
- Make the business case to justify that the use of technology is an integral part of a solution to the public health need.

Consideration for selection of software applications [6]:

Organizations in public health will need to set goals in selecting applications that will be used in public health informatics solutions. Use of the application must help achieve:

- *Specific* goals of the project. These are the defined needs of the project.
- *Measurable* outcome that can be quantified and compared to the previous status quo.
- *Attainable* outcomes, even if the needs are on the outlines of the organizational goals.
- *Relevance* in the light of current standards thereby making it a useful business process within the enterprise architecture.
- *Timeliness* in the project completion process.

The selection of the applications for the solution must be “SMART”.

Interoperability consideration for the current system and the new application to eliminate siloed systems of the past [7]:

- General systems requirements.
- Technical design.

- Data exchange and integration.
- Data analysis, visualization, and reporting.

There are logical benefits to using such methods to address informatics in public health issues. In this process, applications are most often platform neutral. They often have incorporated industry set standards and may have been used previously in many corporate environments. These methods will be used in two scenarios of public health needs in this thesis.

Application to public health emergency preparedness:

Developing and Implementing a New Technology for communication during Disaster and Public health Emergencies in Hennepin County: Introducing the iDAWG emergency communication system.

The public health need:

The Center for Disease Control Public Health Preparedness Capabilities: National Standards for State and Local Planning outlines the development of needed capabilities to smooth coordination of Public Health officials with other leaders with jurisdiction in preparedness response. Fourteen capabilities are needed to support emergency preparedness effectively. One of the capabilities includes Emergency Public Information and Warning. Messaging and communication are critical to the effective management and reduction of harm and destruction. [8]

Disasters of current times suggest the need to find better ways to communicate with systems that provide access to information that is timely and useful when needed. All

the lessons suggest the need for a communication and messaging system that is interoperable across the communications system between jurisdiction authorities and the citizen population. Current communication is over multiple communication frequencies bands.

Technology Solution:

In current existence is software that connects devices and information exchange systems through machine to machine communication with no needs for a wired system. The innovative technology called Innovative Deployable Augmented Wireless Gateway (iDAWG) is an emerging technology for emergency preparedness. (Figure 1) This informatics technology solution works with a new class of software called Edgeware that connects devices and transmits information and data with the help machine-to-machine communication. [9] The Edgeware software is paired with another communication technology called cognitive radio technology to create this adaptable tool for public health preparedness communication across jurisdictions. [10] The Federal Communication Commission defines cognitive radio and the public safety application as a radio that can change its transmitter parameters based on interaction with the environment it operates. [11] When deployed, iDAWG enables interoperability across diverse Radio Frequency bands used in public safety mobile communications. The common channels are 700/800 MHz, Industrial Scientific and Medical (IEEE 802.11), 4.9 GHz (IEEE 802.11, VoIP, UMTS/TDD), walkie-talkie, citizen band radio, and cellphones. (Figure 2)

The selection criteria are based on the outlined process in the methodology section. It is interoperability with current local and federal communication systems, it is ease to

adoption by jurisdictions without disruption of the current organization processes, and capable of reaching the public during a public health emergency.

Deliverable:

The critical components of this solution are Wireless grid network, the Edgeware software, and the Cognitive radio technology.

Wireless grid network:

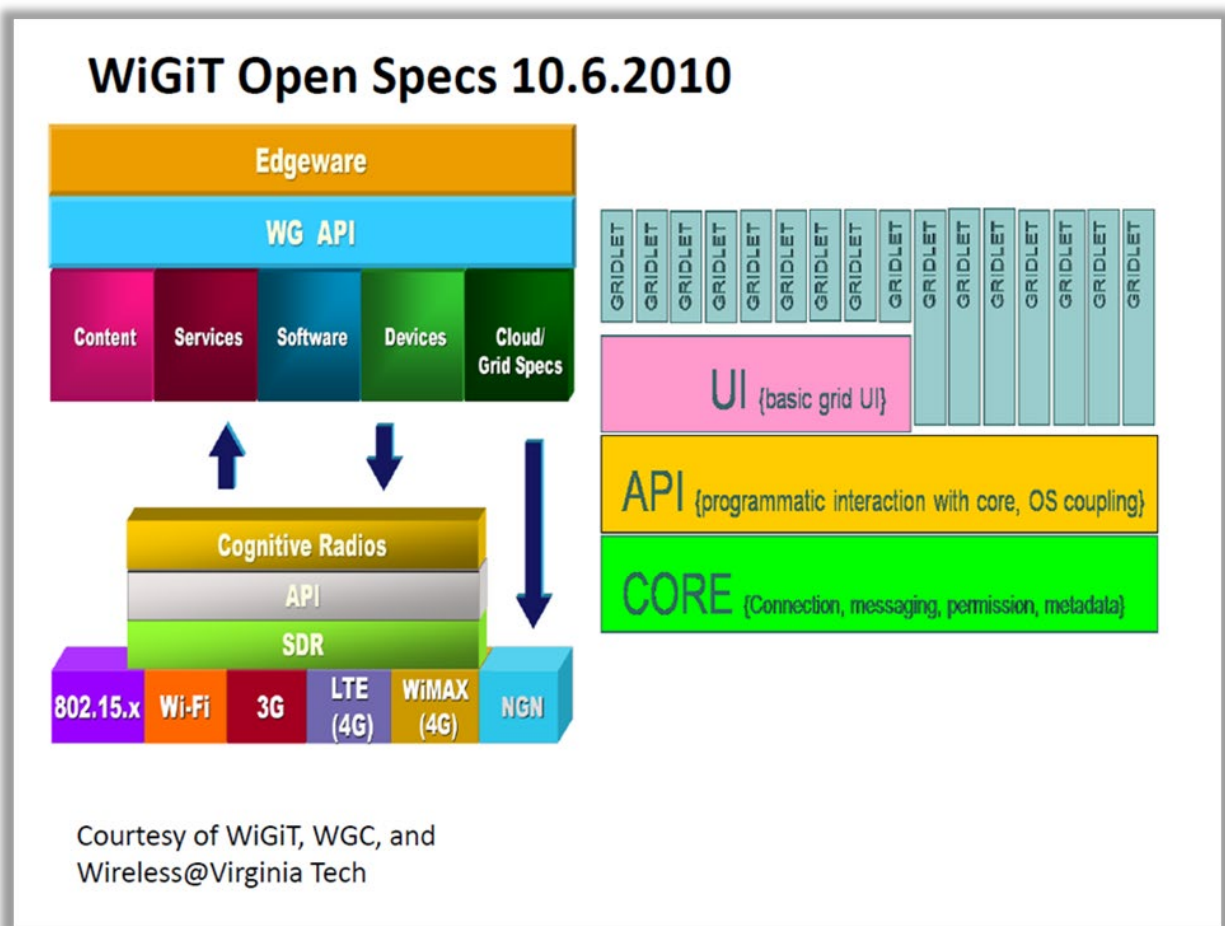
The wireless grid network are computing resources that are enabled to allow resources on one device to be securely shared and manipulated by another authorized device or service on the same network thus creating a mesh of devices, content, and users. [10]

How will it be deployed:

1. A portable device which will act as a controller can be carried in a standard police cruiser.
2. It has a 5,000-foot operating radius.
3. It implements survivability in that if the primary node fails other nodes can take over
4. With its cognitive engine, it can optimize channel allocation, duty distribution, and switch between radio frequency bands base on spectrum availability and traffic conditions.
5. Security: User authentication and access control, data confidentiality, integrity and data freshness and network availability are included in iDAWG's security protocol.

Figure 1 below shows the software integration of iDAWG system for Public safety. It demonstrates the relational location of Edgeware, the Cognitive Radio, and the link to communication frequencies of WiFi, 3G, 4G and 802.15 MHz used by many public safety jurisdictions.

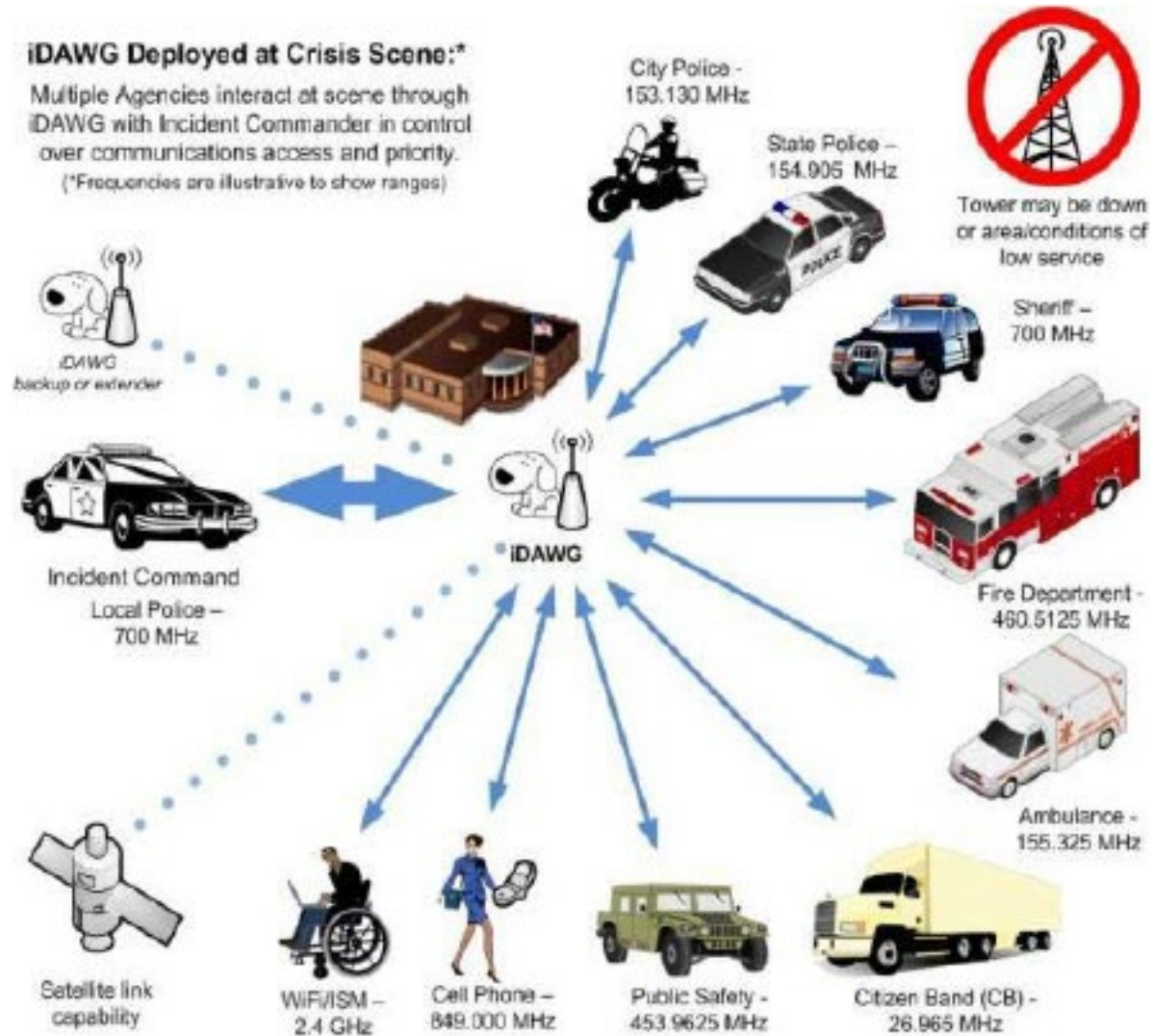
Figure 1. Integrated Diagram of iDAWG.[12]



Source: McKnight, Lee Warren and Lehr, William and Meyerrose, Dale. "Cloud to Internet of Things: Wireless Grids Edgeware Panel and Tutorial" (2014).

Figure 2 below shows an example of a communication platform in a disaster situation using iDAWG with links to the 10 jurisdictions and their communication frequencies.

Figure 2. Proposed Disaster Communication Platform using iDAWG. [13]



Source: Marsden, Janet & Treglia, Joseph & McKnight, Lee. “Dynamic emergency response communication: The Intelligent Deployable Augmented Wireless Gateway (iDAWG)”. (2012).

Implementing the informatics solution for the Public Health Emergency Preparedness Communication System:

The core backbone of disaster and emergency preparedness is the ability to message and communicate across multiple platforms and systems currently used by command and control.

We assume that a communication system's safe operation is a critical system that will support the mission of existing National, State, and County and city jurisdiction to communicate and inform citizens adequately.

The alternative is to continue using the existing devices with radio frequency bands, Emergency communication apps like that developed by FEMA, and Current GPS/GIS systems that are technologically less stable.

The pros of current systems are as follows. These are stable systems that have been used over the years. These systems are accessible to use and applicable. Finally, they may be more secure and free from outside threats. The cons of the current system are as follows. There is significant difficulty with interoperability over systems. The current systems are not survivable and have social and policy weaknesses as jurisdictions and citizen interaction may not be easily achieved.

iDWAG is a cost-effective system since the technology for the components already exist and can be adequately married for maximum benefits. It can also be linked to GIS, GPS, and emergency communication apps to make it more real-time to manage citizens and population response. iDAWG as designed by Syracuse University can integrate with the Federal Emergency Management Association's (FEMA) Integrated Public Alert and Warning System (IPAWS). IPAWS is the communication system used by most police and fire agencies and emergency management responders.

The system has excellent social and political benefits because it does not break the systems of authority traditionally established to allow proper jurisdiction and administration. The primary iDWAG can be managed by current command and control for better administration during an emergency as proposed in the CDC's National Public

Health preparedness plan. Locally I will consider presenting this at the State Community Health Conference to leverage County and State official interest to fund planning and development.

Application to Chronic Kidney Disease Surveillance Systems.

Chronic Kidney Disease (CKD) Surveillance System in the State of Minnesota.

The Public Health need:

Chronic Kidney disease (CKD) is a common disease and a public health problem. It affects 13.6% of the US adult population. (CDC 2019) Simulation models predict that CKD prevalence in adults aged ≥ 30 years will increase to 14.4% by 2020 and 16.7% by 2030. [10] Chronic Kidney disease (CKD) patients, even in early disease stages, carry a disproportionate burden of cardiovascular morbidity, mortality, healthcare utilization, and costs. Creating a CKD surveillance system that focuses on CKD early stages will help reduce the increasing cases of end-stage renal disease (ESRD) with its related morbidity, mortality, and high cost of care. Given that diabetes and hypertension are the leading cause of this condition, it will help evaluate intervention programs. [14]

Given the high cost, especially on Medicare resources, the building of a surveillance system will allow early detection, public health-style case management, and disease control at the local level, state level, and National level. [15]

Current surveillance systems are all passive and are listed below.

1. The United States Renal Data System, which collects data on Stage 5 CKD and ESRD.

This was established by the National Institute of Diabetes and Digestive and Kidney Disease (NIDDK) and the Center for Medicare and Medicaid Services (CMS).

(usrds.org) [16]

2. Center for Disease Control CKD surveillance. This 'passive' surveillance approach is

utilized, leveraging existing data from various disparate data sources from the

Department of Veterans Affairs—VA, or other sizeable administrative health data as well

as data obtained from non-health-care sources (National Health and Nutrition

Examination Survey— NHANES). (CDC 2020) [17]

Technology Solution:

An active system that will detect early-stage disease and leverage disease management

from all stakeholders will prevent ESRD development. There is a great benefit in

developing an active Chronic Kidney Disease Surveillance System to detect, monitor

program, optimize treatment and create a decision support system that will promote

interaction between medical providers and Local, State and Federal Public Agencies in

reducing the cost of care and improve the quality of care of the patient with risk factors

for CKD.

Most of the data needed are found in the Electronic Health Record Systems (E.H.R)

Continuity of Care Document (CCD), Laboratory results, Insurance claims data of party

payers, Medicare and Medicaid Claims data, and Social Security Disability data records.

Chronic Kidney Disease will be defined as a patient with eGFR less the 60, Urine

albumin greater than 30 and a diagnosis of any risk factor disease like Diabetes,

Hypertension, and autoimmune conditions. The project plan will be to link a Certified Electronic Medical Record system and Laboratory Information System with the Minnesota Public Health agency using the Medicare Promoting Interoperability process for Public Health Registry and Clinical Data Registry Reporting.

The following data will be needed to design the surveillance system. [18], [19]

1. ICD 10 codes for all diagnosis of Chronic Kidney Diseases. ICD 10 is the current system for disease classification in the United States
2. ICD 10 codes for all diagnosis of the diseases causing the CKD. These are Diabetes, Hypertension, Autoimmune Diseases, and Polycystic Kidney Disease
3. SNOMED-CT nomenclature related to diagnosis of CKD and risk factor condition
4. LOINC coded for lab results for chronic Kidney Disease such as GFR, Creatinine, Urine Microalbumin, Hemoglobin A1c, and complete blood counts
5. HL7 data on patient demographics (age, Date of Birth, sex, race, ethnicity, and address)
6. CPT codes for CKD test require for diagnosis, treatment, and monitoring
7. NPI numbers of medical providers caring for the patient
8. NPI numbers of medical facilities where the patient receives care
9. Electronic Health Record Systems (E.H.R) Continuity of Care Document (CCD), Laboratory results, Insurance claims data of their party payers, Medicare and Medicaid Claims data and Social Security Disability data records.

Specific Data structures used for this system:

Data from providers who see CKD patients will be sent to a digital bridge collection system based on condition definition. The goal is to trigger a report at Stage 3A CKD

that is when eGFR is below 60. Data will then transfer over to a public health system for final case definition and management. Data standards for the CKD Surveillance System includes:

SNOMED-CT:

1. Chronic Kidney Disease – 709044004
2. Chronic Kidney Disease stage 1 – 431855005
3. Chronic Kidney Disease stage 2 – 431856006
4. Chronic Kidney Disease stage 3 – 433144002
5. Chronic Kidney Disease stage 4 – 431857002
6. Chronic Kidney Disease stage 5 – 433146000

ICD 10 CODES:

1. N18.1 Chronic kidney disease, stage 1
2. N18.2 Chronic kidney disease, stage 2 (mild)
3. N18.3 Chronic kidney disease, stage 3 (moderate)
4. N18.4 Chronic kidney disease, stage 4 (severe)
5. N18.5 Chronic kidney disease, stage 5
6. N18.6 End-stage renal disease

CPT codes for CKD lab test:

1. eGFR – 82565
2. Urine Microalbumin/Creatinine – 82043/82570

LOINC codes for CKD lab results:

1. eGFR for non-African American – 88294-4
2. eGFR for non-African American – 88293-6
3. Urine microalbumin – 14957-5
4. Urine microalbumin/Creatinine ratio – 14959-1

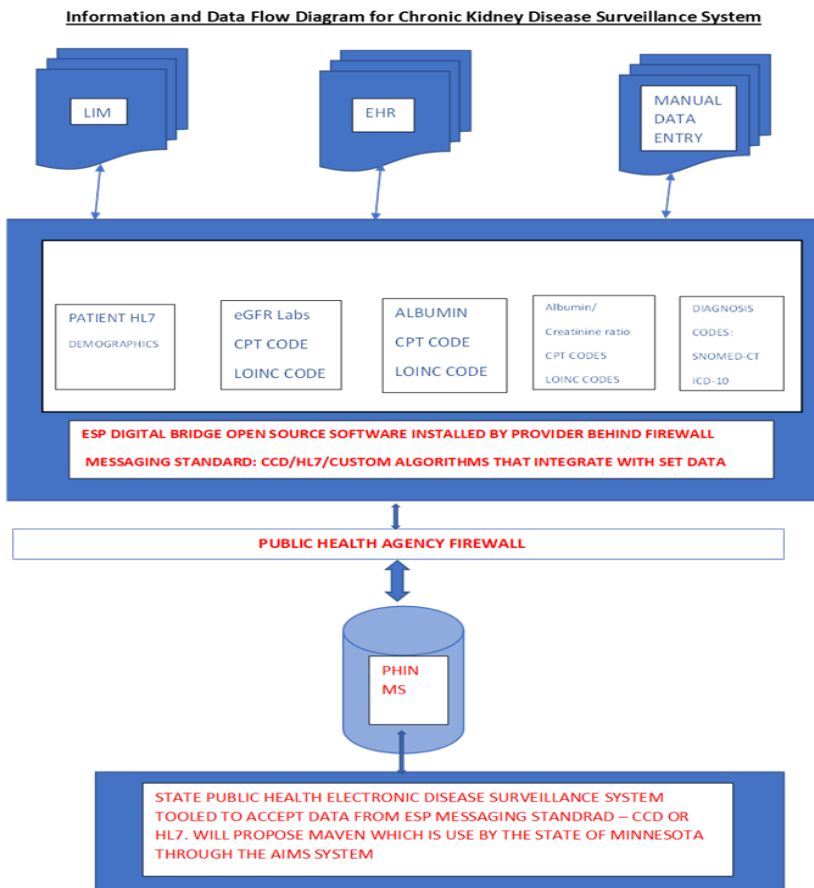
The critical components of the information and data flow diagram show in figure 3 are:

1. Electronic Health Record of stakeholder organization. This will have patient information and medical history.
2. Laboratory Information Systems of stakeholder organizations which will have laboratory data.
3. ESPHealth Digital Bridge will connect electronic health record to state public health department chronic disease registries.
4. Continuity of Care Document is a data exchange standard that can be electronically transmitted between certified health agencies on a health information exchange.
5. The Public Health Information Network Messaging System (PHINMS). This is a secure messaging system for public health organizations that is maintained by the Center for Disease Control.
6. Maven's Chronic Disease Registry Solution. This a vendor based chronic disease registry system that is design for public health agencies who will be exchanging meaningful use data from health systems with certified electronic health.

7. AIMS System. “The APHL Informatics Messaging Services platform (AIMS) provides cutting edge data management and messaging services to the public health community and its data exchange partners.” [20]

Figure 3 below shows the information and data flow for the Chronic Kidney Disease Surveillance System. It will use HL7 to encode data for electronic transmission and PHIN-MS as the messaging transport protocol across systems thus providing seamless interoperability. The AIMS platform will provide systems and resource integration.

Figure 3. Information and data flow diagram.



Implementing the informatics solution for the Chronic Kidney Surveillance System:

According to the Center for Disease Control, the use of surveillance systems has benefits for public health. It helps to better understand the extent of health risk behaviors, preventive care practices, and the burden of chronic diseases. It can monitor the progress of prevention efforts. Finally, it helps public health professionals and policymakers make more timely and effective decisions.

The current National CKD surveillance system is a passive system based on outdated data with multiple data gaps. Real-time data can be collected with current health and public health informatics technology to improve management, reduce the burden of disease and mortality, and reduce national costs.

I will plan to make this system state specific. It will help create a small startup with scaling to other state systems and then nationally. This proposed system will be presented at the State Community Health Conference and the National Association of Chronic Disease Directors conference. A collaborative partnership with stakeholders will be developed to build a business case to attract funding.

Discussion:

This thesis's objective was to show the benefit of using information technology in public health by working with all stakeholders to meet a specific public health need. It will deliver accurate, timely and actionable public health information. It will enhance the meaningful use of health information technology and the exchange of health information among health care and public health professionals.

"According to the Office of the National Coordinator for Health Information Technology's Federal Health IT Strategic Plan 2015–2020, effective communication and technology by health care and public health professionals can bring about an age of patient- and public-centered health information and services." [21] Some of the great results will be improvement in public health service delivery and improvement in the public health information infrastructure.

With the methodology applied to these two examples of public health need, it shows that there is often a cost-effective technology solution that can be used to enhance the activities of public health.

Public health organizations must develop policies and regulations in their organization to grow human resource teams capable of developing solutions for identified needs. Involving a public health informatician in a decision-making role in early management decisions will preempt what is needed sooner than later.

There are always limitations in the use of technology in public health, and much of it cost. The second limitation is how to maintain interoperability with the current systems. The third limitation is user training. The fourth limitation is privacy and security.

By having an evolving process and working with vendors, public agencies will become more comfortable using public health informatics solutions. They will also overtime become attractive to technology trained professional seek to join public health.

Conclusion:

Informatic technology solutions must improve the workflow of the user, the agency, and its stakeholder to enrich data quality and improve visualization. Health People 2020 has

objectives for Health Communication and Health Information Technology. The processes outlined in this thesis support the following objectives for Health Communication and Health Information Technology: [22]

- HC/HIT-11. Increase the proportion of interoperable systems or meaningful users of health information technology.
- HC/HIT-12. Increase the proportion of crisis and emergency risk messages intended to protect the public's health that demonstrates the use of best practices.
- HC/HIT-13. Increase social marketing in health promotion and disease prevention.

The two examples provided in this thesis demonstrate how this can be accomplished around a specific health issue. The first experience systematically follows an organization-specific methodology for identifying public health needs. The second looks for an informatics solution with the internal standards that meet the needs of the current business information technology architecture of the organization and the user.

Using an informatics solution requires strong leadership as it may involve a radical change in organizational behavior, new stakeholders, and external socio-political systems within governments. Project teams must be encouraged to be honest and consistent in interacting with users, upper management, and stakeholders.

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