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Best Practices: A Network Approach of the Mandatory Influenza Vaccination Among Healthcare Workers

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Abstract

A network simulation was applied to hospital social networks improve the influenza vaccination rate of healthcare workers in a healthcare system. Social network methods can be used to develop an understanding of structures of social relations. Over 200,000 U.S. patients are hospitalized annually for influenza, which attributes to 36,000 deaths and is the sixth leading cause of death in adults. The best way to prevent influenza each year is by receiving the influenza vaccination. The typical influenza vaccination rate among healthcare workers is 40-50%. A Healthy People 2020 objective is to increase the percentage of healthcare workers who are vaccinated annually against influenza from 45.5% in 2008 to 90%. This simulation used hypothetical questionnaire results regarding demographic, vaccination status and network focused data. Pajet Matrix Maker and NodeXL were used to analyze and create a visual representation of the hypothetical data. Our resulting sociogram illustrated that some nodes were very influential with many ties and some nodes had few ties. Complexity can be used to analyze and measure a network. The study of complexity can advise health officials to use nonlinear models, accept unpredictability, and respond to emerging patterns. The Social Network Theory, Health Belief Model, and Diffusion of Innovation were used to approach the study of influenza vaccination strategies. Previous studies focus on social network methodologies, but omit the application of social networks on real world situations. The core ideas of social network analysis have potential to enrich our understanding of fields outside the social sciences.

Keywords: complexity, immunization, prevention, simulation, application

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healthcare workers

Many healthcare institutions recommend that their employees receive the seasonal

influenza vaccination to reduce the risk of transmission of the influenza virus from a patient to

the healthcare worker (HCW) as well as to prevent the transmission of the influenza virus from a

health worker to a patient. Since the 1980s, the Centers for Disease Control and Prevention

(CDC) has suggested that HCWs receive the influenza vaccination (Hofmann, Ferracin, Marsh,

& Dumas, 2006). Healthy People 2020 have also made increasing the number of HCWs

receiving the influenza vaccination one of its goals. Healthy People 2020 objective IDD 12.9

looks to increase the percentage of HCWs who are vaccinated annually against influenza

(Healthy People 2020, 2011). In 2005, the Virginia Mason Medical Center was the first to

mandate an influenza vaccination program for HCWs, which led to vaccination rates of greater

than 97% (Quan, Tehrani, Dickey, Spiritus, & Hizon, 2012). In 2010, the Advisory Committee

on Immunization Practices (ACIP) recommended annual influenza vaccination for all people

over 6 months old (Couto, Pannuti, Paz, Fink, & Machado, 2012). Overall, in the United States,

HCWs influenza vaccination rates averaged to be 45% before 2008 and were 65% after the

H1N1 influenza epidemic. By 2020, the U.S. Department of Health and Human Services set a

goal of immunizing 90% of HCWs (Quan et al., 2012).

Healthcare is often referred to as a "system." However, do we really measure the

systemic things happening in the healthcare system? A social network approach allows analysis

using the strength of ties, structural holes, and many other variables within a network. Strength

of ties refers to the emotion, time, intimacy, and reciprocal services that are shared generally

between two people (Granovetter, 1973). Structural holes identify gaps between nodes in a

network, which may influence communication between nodes (Hanneman & Riddle, 2005).

These variables promote better visualization and understanding of a network when applied to

real world applications.

The social network approach is connected to broader fields of analysis such as

engineering, linguistics, and other fields that are a rich source of new ideas for analysts focusing

on social relations. The core ideas of social network analysis have that potential to enrich our

understanding of fields outside the social sciences. Social network methods are tools that can be

used to develop understanding of structures of social relations. Previous studies focus on social

network methodologies but omit the application of using social networks on real world situations

to see the problems and possibilities in a new way (Hanneman & Riddle, 2005). This best

practice will discuss the use of social network practice and look at how it can be applied to

improve the influenza vaccination rate of HCWs in a healthcare system.

Literature Review

Epidemiology

Influenza.

Influenza, more commonly known as the flu, has been recorded since the middle of the

18th century. It is caused by different strands of a contagious virus that infects the nose, throat

and lungs that can cause mild to severe illness which has the potential to lead to death. Influenza

symptoms include fever or chills, cough, sore throat, runny or stuffy nose, muscle or body aches,

headaches, fatigue and vomiting or diarrhea (Centers for Disease Control and Prevention [CDC],

2013). Complications from influenza include ear and sinus infections, bacterial pneumonia and

dehydration. The virus can also worsen chronic disease such as diabetes, congestive heart failure

or asthma.

        The influenza virus is believed to spread from an infected individual through droplets that

are passed from person to person through coughing, sneezing or talking. Droplets from an

infected influenza patient travel through the air and land in the mouths or noses of people in

close proximity. Though it is not as common as a source of transmission, the influenza virus can

be spread by touching objects that have the virus on them then touching their eyes, nose or

mouth subsequently infecting themselves with the virus (CDC, 2013).

        The severity of influenza is unpredictable and can change from year to year due to

different prevalences of virus strains. Historically, there are groups of people that are at a higher

risk for more serious complications. These groups include children, older adults, pregnant

women and people with pre-existing chronic health conditions that include diabetes, congestive

heart failure or asthma (CDC, 2013). The Spanish flu of 1918-1919 was one of the most

devastating and severe pandemics in human history that caused an estimated 20 to 50 million

deaths worldwide (World Health Organization [WHO], 2005). Influenza occurs each year in

every country, seasonally and sporadically. In the past three centuries alone, there have been at

least ten global influenza pandemics. Over 200,000 U.S. patients are hospitalized annually for

influenza, which attributes to 36,000 deaths (Quan et al., 2012). The possibility of another

catastrophic outbreak and the devastating toll of seasonal flu has made influenza the world's

second most studied virus, only behind HIV (Patrick, 2012). The influenza virus is related to

one in twenty deaths to persons greater than 65 years of age and is the sixth leading cause of

death in adults in the U.S. (Ottenberg, Wu, Poland, Jacobson, & Koening, 2011).

        After all of the advances made possible by new technologies, our understanding of the

fundamental epidemiology of influenza remains far from complete. The question of where

seasonal strains come from is still a puzzle. It was previously thought that the source of seasonal

flu epidemics come from south-east and eastern Asia. However, the viral migrations between

seven different temperate and tropical regions were studied and none of the flu strains could be

traced back to a single region (Patrick, 2012). Inactivated and live attenuated influenza vaccines

are available. Live attenuated vaccines are based on genetic reassortment and are formulated as

a nasal spray. This type of vaccination appears to be safe, efficacious and technically developed

for mass vaccination campaigns. However, live attenuated influenza vaccines should not be

given to immunosuppressed individuals or contacts close to them in their social network or those

caring for them, such as HCWs, as a precaution. Several analyses have demonstrated the cost

effectiveness of inactivated influenza vaccines in adult as well as in children (WHO, 2005).

Mandatory influenza vaccination of healthcare workers.

The best way to prevent influenza each year is by receiving the seasonal influenza

vaccination. IDD 12.9 is the Healthy People 2020 objective that specifically focuses on HCWs

and the influenza vaccination. This objective focuses on increasing the percentage of healthcare

workers who are vaccinated annually against influenza from 45.5% in 2008 to 90% (Healthy

People 2020, 2011).

The focus of the mandatory influenza vaccination is HCWs. HCWs can be defined as all

medical and non-medical personnel in contact with patients (Hofmann et al., 2006). There has

been longstanding difficulty in achieving high influenza vaccination rates for HCWs despite the

fact that they are at a higher risk for exposure to patients with influenza and are potential vectors

for exposing high-risk patients to influenza.

History of social networks.

The study of structural analysis and networks connects back to post World War II

developments in British social anthropology (Wellman, 1988). In the 1950's, anthropologists

shifted their attention away from cultural systems and began focusing on social network concepts

and the structural systems of ties and networks. Complete network studies began to describe the

comprehensive structure of role relationships in a social system by analyzing matrixes,

connectivity and cleavage (Wellman, 1988).

Current practices requiring mandatory influenza vaccination.

The enforcement of a mandatory influenza vaccination policy is needed in order for

vaccination rates to increase. Non-mandatory campaigns include education, incentives, e-mail

and pager reminders, after-hours vaccination, mobile vaccination carts, mandatory declinations

and peer-to-peer vaccinations. Nevertheless, the cumulative use of these campaigns, even over a

two year period, was unable to increase HCW vaccination rates beyond 60%. Only the addition

of a mandatory vaccination policy enabled instantaneous gains in vaccinations to levels above

90% (Quan et al., 2012). Low HCW influenza vaccination rates have led to a variety of

strategies to increase vaccination levels. The involvement of hospital leadership and human

resources personnel is necessary to achieve near-complete vaccination rates. The introduction of

a noncompliance tracking tool is crucial to ensuring participation because staff members have to

be held accountable to their supervisors. Reminders directly from chief medical officers aided in

this process by instilling the importance of the mandatory vaccination policy for HCWs. The

successful implementation of such policy requires substantial resources, administrative support

and cooperation of HCWs (Quan et al., 2012).

HCWs must demonstrate immunity to varicella zoster virus, measles, mumps, rubella and

hepatitis B prior to employment in most U.S. hospitals. Influenza vaccination is not among these

requirements, but its morbidity and mortality exceed all of these diseases combined (Hofmann et

al., 2006). As mandatory influenza vaccination is increasingly publicized, ethical, legal and

economic impact of such a policy has generated significant debate. For example, concern for

vaccine safety remained a major reason among those who declined. This occurred even with

respected data on safety (Quan et al., 2012). Obtaining signed statements of declination have

been controversial (Bruce, Hall, Steinberg, Bornstein, & Chakkalakal, 2008). An advantage of

the use of a declination statement is that obtaining statements from HCWs who decline

vaccination can assist in identifying who might require interventions to overcome barriers to

vaccine acceptance. Collection of this information will allow healthcare facilities to determine

what proportion of their staff is reached by a vaccination program. The disadvantages of

declination statements are that the burden of requiring compliance from those who have already

chosen not to participate might tax employee occupational health resources (Bruce et al., 2008).

In addition, during the 2009 H1N1 influenza pandemic, the WHO recommended vaccination of

all HCWs worldwide to protect staff and prevent potential transmission to their patients. The

implementation of these recommendations has led to much debate (Music, 2012).

      Mandate and policy information.

      Research for policy and mandate information about mandatory influenza vaccination for

healthcare workers proved to be challenging. There are a number of healthcare organizations

that have made statements supporting the idea of HCWs being vaccinated against influenza. For

example, at the Federal level the Centers for Disease Control and Prevention recommended that

all HCWs should be vaccinated against influenza to protect themselves as well as their patients

(Douville, Myers, Jackson, & Lantos, 2010). The Advisory Committee on Immunization

Practices (ACIP) recommended that all HCWs who care for people at high risk for influenza

related complications should be vaccinated (CDC, 2012).

The state of New York took a step forward in 2009 when they issued a mandate involving HCWs and seasonal and pandemic influenza vaccinations. The mandate stated that healthcare organizations would be required to vaccinate all personnel that have direct patient contact. Receiving the influenza vaccination was to become a precondition of employment with allowable exceptions for medical reasons. Governor David Paterson halted the mandate due to vaccination shortages in 2009, but plans were set in place to reinstate the mandate during the 2010-2011 influenza season (Ottenberg et al., 2011).

There are a number of hospitals and health networks that have put mandates in place for mandatory vaccination of HCWs. The Influenza Action Coalition has a list of more than 400 Honor Roll members that have mandates in place on their website (www.immunize.org). Table 1 lists all of the hospitals and hospital networks in Ohio currently on the Honor Roll as well as the date that the mandate was implemented.

Table 1

Ohio Honor Roll Members

Hospital/ Hospital Network Implementation	Date
Children's Medical Center of Dayton, OH	September 1, 2011
Christ Hospital Health Network, Cincinnati, OH	October 1, 2012
Cincinnati Children's Hospital Medical Center	July 15, 2010
Genesis HealthCare System, Zanesville, OH	October 14, 2009
Kettering Health Network, Kettering, OH	October 1, 2012
Mercy Anderson, Cincinnati, OH	October 1, 2011
Mercy Health - Clermont Hospital, Batavia, OH	December 8, 2011
Mercy-Health, Fairfield and Mt. Airy, OH	November 15, 2011
Mercy Hospital Western Hills, Cincinnati, OH	August 12, 2011
Mercy Partners-Jewish Hospital, Cincinnati, OH	October 1, 2011
MetroHealth System, Cleveland, OH	February 22, 2012
Summa Health System, Akron, OH	October 31, 2012
Summa Western Reserve Hospital, Cuyahoga Falls, OH	September 14, 2011
TriHealth, Good Samaritan & Bethesda North Hospital, Cincinnati, OH	December 1, 2009
UC Health - Drake Center, Cincinnati, OH	June 1, 2010
University Hospital, Cincinnati, OH	October 19, 2009
Wilson Memorial Hospital, Sidney, OH	September 17, 2012

Although health networks and organizations are moving in the direction of mandatory vaccination, there is not much information available about the policies and mandates being used. This is an area that could use further research and health networks and organizations should be encouraged to share their policies and mandates. A health network or organization could have a policy, mandate or a method they are using for their mandatory influenza vaccinations that has proved highly successful and has staff backing: without dissemination and sharing, it is worthless

to others. This information could prove very useful to health networks and organizations that are

just beginning the process of mandatory influenza vaccinations.

Available information shows that mandatory influenza vaccination campaigns are

proving to be successful. BJC HealthCare, one of the largest non-profit healthcare organizations

in the United States (www.bjc.org), made influenza vaccinations a condition to employment in

2008 and launched a mandatory vaccination program. Information about the vaccination was

passed to employees through their managers and standardized information sheets containing

educational material and facts. Information about the program was provided on the network's

intranet site, in letters mailed to employees' homes and in Town Hall Meetings throughout the

program at which infectious disease physician, infection prevention specialists and occupational

health nurses were available to answer questions. Articles were also written in *BJC Today,*

which is a network newspaper, as well as a letter published by the networks CEO that explains

the rationale for the policy. During the entire program, the BJC HealthCare network and a

multidisciplinary implementation team met regularly before and during the vaccination program

to ensure that timely, consistent and coordinated communication was provided to any issues that

came about (Babcock, Gemeinhart, Jones, Dunagan, & Woeltje, 2010).

BJC Healthcare accepted medical and religious exemptions. Medical exemptions

required a written letter from a licensed physician be sent to human resources that explain the

medical reasoning why the employee could not receive the influenza vaccination. Medical

exemptions were predetermined and based on the CDC's Advisory Committee on Immunization

Practices (http://www.cdc.gov/vaccines/acip/). Religious exemptions required a letter from the

employee be sent to human resources explaining their religious beliefs that opposed the

vaccination. Human Resources informed the employed within five days if their requested

exemption had been accepted or not (Babcock et al., 2010).

Free influenza vaccinations were provided at all facilities within the network and

included vaccines that were thimerosal-free and intranasal. The vaccinations were offered

beginning on October 15, 2008. Vaccinations were tracked through multiple methods at each

facility. If an employee was not vaccinated or did not have an exemption by December 15, 2008

they were suspended without pay. If a suspended employee was vaccinated or exempted before

January 15, 2009 they could return to work. The employees not vaccinated or exempt by

January 15, 2009 were fired for failure to meet conditions of employment (Babcock et al., 2010).

Out of the 25,980 employees within the network, 98.4% (25,561) were vaccinated, 1.2%

(321) were granted medical exemptions and 0.3% (90) were granted religious exemptions. There

were 0.03% (8) employees terminated for failure to meet conditions of employment, as they did

not receive an exemption or a vaccination. The vaccination program effectively increased the

influenza vaccination rate throughout the network. Overall, the program compliance was

99.96% or 25,974 employees (Babcock et al., 2010).

Complexity

Complexity can be used as a measurement in complete network analysis and is described

as a system that involves several large networks with no central control, simple rules of

operation, complex collective behavior, sophisticated information processing, and adaption

(Mitchell, 2009). Complexity can be used to analyze a complete social network. A system with

complexity involves several large networks with no central control, simple rules of operation,

complex collective behavior, sophisticated information processing, and adaption (Mitchell,

2009). A new employee may feel that they do not know the "system" of how the hospital is run

when they first start their new job because they do not know who the official and unofficial

"gatekeepers" of information, access, and services are yet. A hierarchy may be used to describe

complexity and the structure of a system.

In a complex hospital system, boundaries can change because HCWs can belong to

several systems at the same time, such as a certain groups of work friends, an assigned floor,

shift, level of responsibility or pay grade. HCWs in a hospital may have allegiances to different

groups to which they belong. This adaptability allows the people within the system and the

behavior of the system to change overtime. In a hospital, systems are embedded within other

systems and co-evolve. For example, the evolution of one unit in a hospital may influence

another unit to change because they are nested within other systems, all evolving together and

interacting (Plsek & Greenhalgh, 2001).

Research involving complexity can be used to solve problems with the mandatory

vaccination of HCWs. The behavior of a complex system is nonlinear, changeable, sensitive to

small changes, and is fundamentally unpredictable over time (Plsek & Greenhalgh, 2001). An

example of this would be that a HCW may change their mind about getting vaccinated over a

period of time. The only way to know what a complex system will do is to observe it. However,

it is possible to make generally true and useful statements about the behavior of a complex

system, such as in a hospital, because there is an overall pattern. Complexity science has shown

that it is often better to try multiple approaches and let direction arise by gradually shifting time,

resources, and attention towards things that seem to be working best. The study of complexity

can advise public health officials to use nonlinear models, accept unpredictability, and respond

flexibly to emerging patterns (Plsek & Greenhalgh, 2001).

Formal definitions for complex networks may vary but they consistently include the four

following properties. First, complex networks contain large numbers of heterogeneous elements.

Second, all of the heterogeneous elements interact with each other in some way. Third, the

element interactions create an emergent effect different from the effect that each individual

element would have on its own. Finally, the effect of the heterogeneous elements working

together persists over time and will make adaptations in response to changing circumstances

(Luke & Stamatakis, 2012).

Luke and Stamatakis (2012) suggest that the national vaccine system meets all of the

criteria of a complex system consisting of heterogeneous components that include individuals,

health clinics, public health agencies and pharmaceutical companies that interact with one

another and are organized at different levels. This same type of complex system can be seen in

hospitals among HCWs receiving an influenza vaccination. There are pharmaceutical companies

providing the vaccine to the hospital, administrators determining that the vaccination will be

provided and is mandatory, human resources distributing information out to all hospital

employees, managers and supervisors ensuring their employees are vaccinated and have all the

necessary information, employee health nurses administering the vaccination, and each HCW

receiving the vaccine.

It is important to note that *complex* problems are different from *complicated* problems.

Complex problems and systems result from multiple networks interacting (Poli, 2013).

Complicated problems result from causes that can be individually distinguished (Poli, 2013).

For example, brain surgery is described as complicated because it involves a detailed step by step

procedure. In addition, raising a child is described as being complex because it involves ever-

changing designs and actions. However, a system can be both complicated and complex (Polio,

2013).

The study of social networks uses many terms that may be unfamiliar to the public.

Table 2 lists some of the basic network terms and definitions. This information can be used to

assist the reader in understanding social network information.

Table 2

Basic Network Terms and Definitions

Terms	Network Meanings
Complexity	Can be used as a measurement in complete network analysis and is described as a system that involves several large networks with no central control, simple rules of operation, complex collective behavior, sophisticated information processing, and adaption (Mitchell, 2009).
Density	The proportion of all possible ties that are actually present. The density of a network may give insight to the speed at which information diffuses among the nodes (Hanneman & Riddle, 2005).
Ego	The smallest union of analysis in a social network setting is an individual in their social setting.
Tie (edge, relation)	A connection between two nodes within a network.
Strength of ties	A combination of the emotional intensity, amount of time, intimacy, and reciprocal services that are shared describe the tie, generally between two people (Granovetter, 1973).
Node (actor, point)	A point of interest in a network that could be a person, organization, or group.
Centrality	A larger aspect of betweenness. Network analysts are more likely to describe their approaches as descriptions of centrality than of power (Hanneman & Riddle, 2005).
Complete Network	Involves collecting information about all the nodes ties with other nodes with in the network. Focuses on the whole network not one particular node.
Egocentric Network	Centered around one node or focal point and studying what who that node is tied to (ego).
Structural holes	A missing tie between two nodes within a network.
Cohesion	Differences in how connected the actors in a population are may be a key indicator of cohesion. The extent of reciprocated ties may be linked to degree of cohesion (Hanneman & Riddle, 2005). Refers to the minimum number of members who, if removed from a group, would disconnect the group.
Broker	A node that ties two other nodes together that do not have a direct tie. Often fills in a structural hole.
Degree	The number of alternative trading partners, which affects which nodes are advantaged or disadvantaged.
Closeness	A measurement of how "close" one node is to others (Hanneman & Riddle, 2005).
Betweenness	Describes the location of individuals in terms of how close they are to the center of the action in a network (Hanneman & Riddle, 2005).

Methods

The following is an example of how social network analysis would be carried out in order to gather information about a complete network being studied. An illustration was conducted rather than an actual study due to logistical and time restrictions, as well as the potential of confounding factors contributing to complexity beyond what was needed to illustrate our thesis.

The first step of network analysis involves gathering information about the complete network. A questionnaire would be passed out to all members of the network. The questions asked would be geared to gather basic demographic data such as age and gender. Other questions would then focus on what is trying to be determined about the network. In the case of this example, questions would ascertain information about a member's level in the organization, the number of people within the organization that they talked to about mandatory influenza vaccination, and whether or not they received the influenza vaccination themselves or not. All of this information would then be compiled into the table below such as Table 3.

Table 3

Example Informational Table Compiled from the Hypothetical Questionnaire

Name	Abbreviation	Age	Gender	Level in Organization	# of Discussants	Received Vaccination
1. Hospital CEO	C	67	M	Executive	2: #11 & #10	Yes
2. Administrative Assistant to CEO	AAC	25	F	Hourly	3: #3, #8, #9	Yes
3. Head Nurse	HN	54	F	Management	10: #2, #4, #5,#6,#7, #8 ,#9,#10,#11,#12	Yes
4. Nurse 1	N1	25	M	Salaried	3: #5, #6, #12	No
5. Nurse 2	N2	36	F	Salaried	3: #3, #4, #12	Yes
6. Nurse 3	N3	24	F	Salaried	2: #4, #12	Yes
7. Records Clerk	RC	20	M	Hourly	2: #8, #12	Yes
8. Front Desk	FD	21	F	Hourly	1: #7	No
9. Health Educator/ Outreach	HEO	28	F	Salaried	3: #2, #3, #12	Yes
10. Chief Physician	CMO	56	F	Executive	2: #1, #11	Yes
11. Director of Quality Improvement	DQI	46	M	Management	4: #1, #3, #10, #12	Yes
12. Immunization Supervisor (BSN)	IS	34	F	Management	5: #3, #4, #7, #9, #11	Yes
13. Social Worker	SW	26	M	Salaried	1: #14	No
14. Director of Social Services	DSS	51	M	Management	1: #13	Yes
15. Off-Site Clinic Coordinator	OSCC	27	F	Salaried	0: No one	Yes

After the information from the questionnaire is compiled, analysis and visualization tools

are used to study the data collected about that network. For the purpose of this example, a text

file was created in Excel and saved as a DOS TEXT file that is then input into UCInet (Borgatti,

Everett, & Freeman, 2002). The file input into UCInet is then saved as an Excel File type which

enables UCInet to take the matrix format and convert it to an arc list that can then be used for

analysis. These steps along with Network Overview Discovery and Exploration for Excel

(NodeXL) (Smith et al., 2010) were used to analyze and create a visual representation of the

fictional data. The following steps explain the process used.

Step 1- Create a text file in Excel

Step 2- Save file as a DOS TEXT file

Step 3- Paste DOS TEXT file into UCInet

Step 4- Save UCInet as an Excel file type

Step 5- Import UCInet file into NodeXL for visualization

Step 6- Using Visual Design

NodeXL allows for different parameters or attributes to be represented by shape and

color that can be determined by the user. In the case of this example the first attribute of Vertex

Color represents an employee's position. Red denotes individuals that are executives or hold a

management role and blue denotes employees that are salaried or hourly. Shapes are then used

to denote a second attribute which in this case focuses on influenza vaccination status.

Employees that were vaccinated are denoted by a square whereas employees not vaccinated are

denoted by a sphere. A third attribute is denoted by the size of the square or sphere. The larger

the square or sphere are the higher the betweenness centrality for that node is. This information

is also displayed in Key 1 below.

Key 1 for Figure 1 NodeXL of Complete Network

Vertex Color (Attribute)	
Executive/Management	Red
Salaried/Hourly	Blue
Vertex Shape (Vaccination Status)	
Solid Square	Vaccinated
Solid Sphere	Not Vaccinated
Ties	
Size of Nodes	Betweenness centrality

The result of our illustration using mock data is shown in Figure 1. Network Overview

Discovery and Exploration for Excel (NodeXL) is a template for visualizing social network data

(Smith, 2013). This graph is composed of nodes (actors or points) and connected by edges

(relations or ties) (Hanneman & Riddle, 2005). The nodes are represented by different colored

squares. Black line segments represent a reciprocated tie, while no black line segments between

squares represent that no tie is present between the nodes. The size of this network is composed

of 15 nodes, which are each numbered 1-15. Appendix A contains Table 4, which display the

matrix used to organize the information used to create Figure 1. In this example, the black lines

represent if the nodes had a discussion about mandatory vaccination. The circles represent nodes

that have not had the influenza vaccination, while the squares represent the nodes that have had

the influenza vaccination. The red nodes represent hourly and salaried staff, while the blue

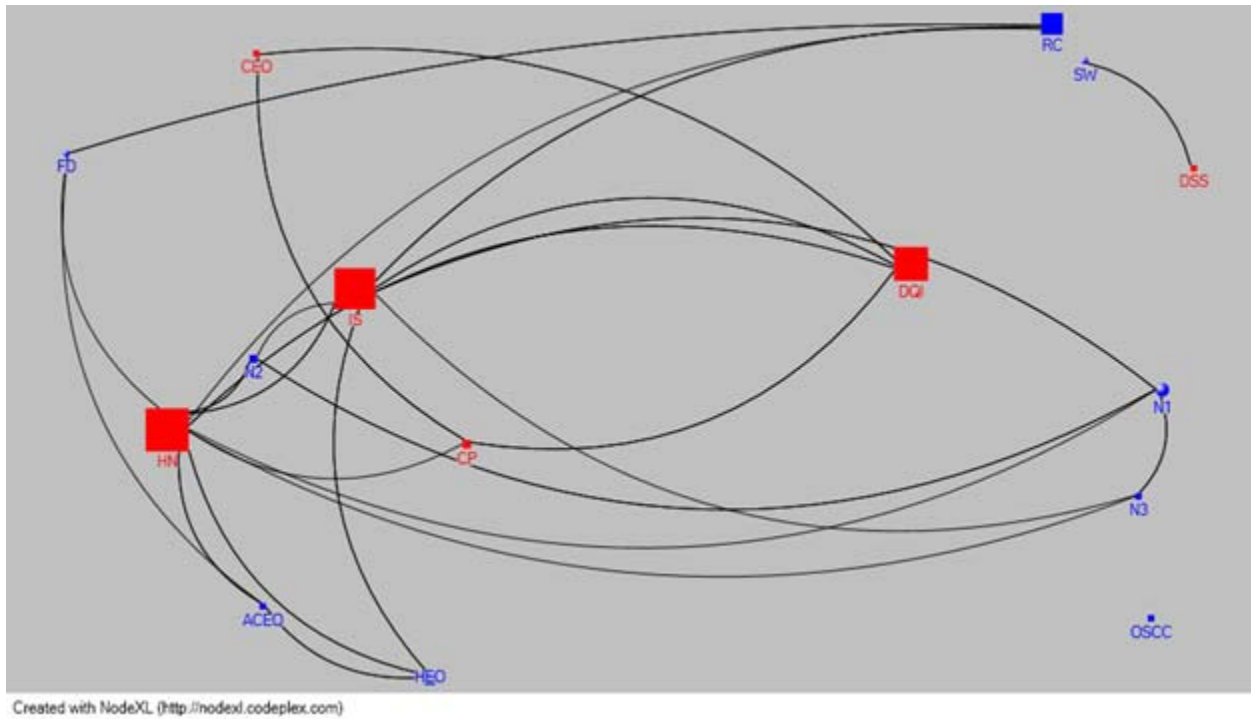nodes represent the management and executive staff.

Created with NodeXL (http://nodexl.codeplex.com)

Figure 1. NodeXL sociogram from simulation.

Note: The color red denotes that that an individual has been vaccinated. The color blue denotes

that that an individual has not been vaccinated. Squares denote a manager position. Circles

denote a salary paid position. Black lines denote a tie between two nodes.

Structural location can be advantageous or disadvantageous to actors. Generally, nodes

that are more central to the structure tend to have more connections and hence more power. For

example nodes 12 and 3 have more degree, closeness, and betweenness compared to the other

nodes. They have a higher degree because they have a higher number of alternative trading

partners, they are closer to more nodes than any other node, and they lie between pairs of other

nodes. Having more betweenness allows nodes 12 and 3 to be able to broker contacts among

other nodes. Therefore, degree, closeness and betweenness are measures of centrality because

they describe the location of nodes in terms of how close they are the center of the network

(Hanneman & Riddle, 2005). This is a complete network so complete network analysis is

appropriate.

Ethics

There are times where the concern for public health and safety conflicts with individual

rights and liberties. For example, public health has been involved in compulsory smallpox

vaccination, limits on public smoking, mandatory reporting of infected patients to public health

registries and the imposition of quarantine (Jones & Bayer, 2007). Before public health officials

mandate anything, values such as individual liberty and justice of the population must be

considered. Public health ethics include a loose set of general moral considerations, which are

clusters of moral concepts. These considerations are used because they are compatible with

different cultures and societies. Some general moral considerations include that a mandate must

produce benefits, avoid harm, distribute benefits fairly, respect autonomous choices, protect

privacy, keep commitments and build trust (Childress & Faden, 2002).

There are five justificatory conditions that help determine where promoting public health

warrants overriding individual liberty or justice: effectiveness, proportionality, necessity, least

infringement and public justification. Effectiveness involves infringing on one or more general

moral considerations in order to protect public health. Proportionality states that the probable

public health benefit should outweigh the infringed general moral considerations. Necessity

includes having good faith belief, for which they can give supportable reasons, that coercive

approach is necessary. Least infringement means that public health agents should seek to

minimize the infringement of general moral considerations. Public justification involves

explaining and justifying infringement to relevant parties, whenever possible, including those

affected by infringement (Childress & Faden, 2002).

Medical codes of ethics discuss how healthcare workers have duties that relate directly to

specialty training, their ability to provide healthcare as well as their access to resources.

However, none of these professional codes of ethics specifically mentions whether or not a HCW

should receive an influenza vaccination (Anikeeva, Braunack-Mayer, & Rogers, 2009).

Although there is no direct statement in professional codes of conduct that directly relates to

HCWs being vaccinated against influenza, medical codes of ethics discuss the ethical principles

of nonmaleficence and beneficence. In other words, "do no harm" (Anikeeva et al., 2009; p. 26).

This is where the justification can be made that all HCWs should be vaccinated annually against

influenza.

Documentation shows that there is nosocomial spread of influenza involving HCWs in a

number of healthcare settings that include (but are not limited to) long-term care facilities,

oncology units, transplant units, neonatal intensive care units, pediatric units, general care units

and emergency departments (Walker, Singleton, Lu, Wooten, & Strikas, 2006). Many of the

patients in these areas have underlying medical conditions or meet the age criteria for being at an

increased risk of complications or death due to influenza (Walker et al., 2006). In one

nosocomial outbreak reported by Walker (2006), 35% of the HCWs in a system contracted

influenza. The risk of nosocomial infections is substantial considering that a survey

demonstrated that more than 75% of HCWs with influenza like illnesses continued to work in an

acute care hospital setting (Walker et al., 2006). Even if HCWs did not work during

symptomatic periods of influenza, the virus can be spread for at least one day prior to the onset

of symptoms. Furthermore, only 50% of people affected by influenza develop symptoms, but

they can still spread the virus for 5 to 10 days. This evidence shows that HCWs can cause harm

unintentionally. It is important for HCWs to be vaccinated against influenza in order for HCWs

to avoid unknowingly harming patients.

There is some evidence of ethical justification to mandate HCWs to be vaccinated against

influenza, but a mandate does violate the right to autonomy, one of the basic principles of ethics.

This concept revolves around the idea that each individual has the right to make his or her own

decisions and have the ability to think for themselves (Gillion, 2003). It is a principle that the

healthcare setting deals with routinely. A classic example involves a Jehovah's Witness patient

that refuses blood products even when they may be the key to saving their life. Yet the

autonomy of a Jehovah's Witness is respected and no blood products are administered. The

same argument could be made for respecting autonomy of a HCW by allowing them the right to

refuse an influenza vaccination.

To respect the autonomy of HCWs suggestions have been made to use incentive-based

influenza vaccination initiatives rather than mandatory vaccination initiatives. Incentives for

HCWs that receive the influenza vaccination could include financial rewards, prizes or public

recognition. Rewards could be given to units, wards or departments whose total HCW

vaccination rate meets a set percentage. Using incentives protects the autonomy of all HCWs

and would likely be cost-effective for healthcare facilities (Anikeeva et al., 2009). An incentive

program at a hospital in the United States that offered movie tickets and health books to HCWs

that were vaccinated against influenza increased the vaccination rate from 42.6% to 56.4% in a

single year (Anikeeva et al., 2009). One potential drawback is negative peer pressure on

individuals with medical or religious reasons for not being vaccinated.

While mandatory influenza vaccination programs infringe upon the autonomy of HCWs, evidence shows that voluntary influenza vaccination programs alone do not meet the desired vaccination rates. This evidence also shows that the most successful way to increase the vaccination rates among HCWs is to use mandatory vaccination programs. Arguments can be made that mandatory influenza programs meet the five justificatory conditions that help determine where promoting public health warrants overriding individual liberty (autonomy) or justice. As part of their professional training and licensing, HCWs make a commitment to do no harm, to uphold patient autonomy and to treat each patient fairly. Vaccinating HCWs against influenza prevents harm to patients they care for by decreasing the nosocomial spread of influenza (Ottenberg et al., 2011; Anikeeva et al., 2009).

Theory

Social Network Theory

The Social Network Theory is defined as a group of quantitative methods used to measure and understand complex, interdependent relationships (Polgreen, Tassier, Pemmaraju, & Segre, 2010). This theory has been used to study influenza vaccination strategies. For example, the number of influenza cases attributable to an infected HCW is strongly linked to how many close contacts this person has had with patients and staff (Polgreen et al., 2010). Vaccination policies have traditionally been completed randomly. Complete social network analysis showed that people do not interact randomly because HCW in a hospital environment interact with some people more than others. Social network simulations show that highly connected people are usually reached early by newly introduced infections (Vidondo, Schwehm, Buhlmann, & Eichner, 2012). Being able to identify highly connected people in a social network can be used to improve outbreak detection because this may help public health officials control

entire groups of peoples' exposure to infection compared to control on an individual basis. This

strategy may hold true across a broad range of diseases and social networks (Polgreen et al.,

2010).

Health Belief Model

The Health Belief Model (HBM) is a psychological model that attempts to explain health

behaviors by focusing on the attitudes and beliefs of individuals. The HBM is based on the

understanding that a person will receive the influenza vaccination if that person: thinks that

influenza can be avoided, believes that receiving the influenza vaccination will be effective at

preventing influenza, and believes that he/she can receive the vaccination comfortably. The

HBM has four constructs representing the perceived threat and net benefits: perceived

susceptibility, severity, benefits, and barriers. Cues to action activate the readiness and stimulate

overt behavior. Self-efficacy is one's confidence in the ability to successfully perform an action.

Some challenges of using the HBM is that is does not consider the emotional component of a

behavior (Janz, Champion, & Skinner, 2008).

Diffusion of Innovation

Diffusion of innovation is a theory pertaining to how information spreads through a

network. Diffusion refers to the process through which an innovation is passed throughout a

network via certain channels. Diffusion contains four different elements which include

innovation, communication channels, time, and the social system (Rogers, 2002). The

innovation is an object, practice or idea that is perceived as new to a network. There are five

different elements that can affect the rate of adoption of innovations, which include relative

advantage, compatibility, complexity, trial ability and observability (Rogers, 2002).

The majority of individuals evaluate an intervention based on evaluations of near-peers who have adopted the innovation as opposed to relying on the basis of research done by experts (Rogers, 2002). This statement shows how social network analysis can be helpful with the diffusions of new innovations such as mandatory influenza vaccinations. Social network analysis can be used to determine a broker or an individual with high betweenness centrality within the social network that exhibits the desired behavior, in this case receiving the influenza vaccination. This individual can then spread information to his/her network of peers about the benefits of the influenza vaccination and information the decision to make it mandatory. Diffusion is essentially a social process through which people talking to people spread an innovation.

Best Practice

Healthy People 2020 Immunization and Infectious Disease objective IID-12.9 focuses specifically on increasing the percentage of HCWs that are vaccinated against seasonal influenza each year (Healthy People 2020, 2011). The baseline for the objective is 45.5% which is based on the National Health Interview Survey from 2008. The objective set by Healthy People 2020 seeks to increase the percentage of HCW receiving the influenza vaccination from 45.5% to 90.0% (Healthy People 2020, 2011).

Studies have shown that voluntary influenza vaccination programs for HCWs are not reaching desired vaccination rates. The typical influenza vaccination rate among HCWs is between 40 to 50%, with some healthcare facilities having coverage rates as low as 15% (Goldstein, Kincade, Gamble, & Bearman, 2004). Similar studies have shown that the vaccination rates among HCWs working at healthcare facilities that have a mandatory influenza vaccination policy coupled with exemption options have rates between 95% and 99% (Ottenberg

et al., 2011; Babcock et al., 2010). These rates surpass the Healthy People 2020 objective for

90% of HCWs to be vaccinated against influenza yearly. A study carried out by Goldstein,

Kincade, Gamble, and Bearman (2004) suggested that institutional policies and practices would

be needed to see a dramatic increase in the vaccination rate of HCWs. The suggested need for

institutional policies and the fact that the highest influenza vaccination rates come from

mandatory vaccination programs illustrate the merit and need for such mandatory programs in

the healthcare setting. These programs not only protect HCWs but also the patients they care for.

Studies show that the highest success in increasing influenza vaccination rates among HCWs it

to make annual influenza vaccinations mandatory (Anikeeva et al., 2009).

 Mandatory influenza vaccination programs are increasing the vaccination rates among

HCWs to the highest rates reported to date. Not only does vaccinating HCWs provide them with

protection but it provides the patients they care for with added protection as well. This is

particularly important for patients at an increased risk for complications from influenza. It has

been suggested that 60% of influenza infections can be prevented in facilities where all HCWs

are vaccinated against influenza (Ottenberg et al., 2011). HCWs are the main group of carriers

that transmit influenza to the patients they care for (Goldstein et al., 2004).

 HCWs not only have the risk to passing influenza to the patients they care for but they

are also at an increased risk of contracting the influenza virus from their patients, which can lead

to increased absenteeism and disruption of the healthcare system during outbreaks (Walker et al.,

2006). The vaccination of HCWs against influenza can be associated with reductions in

influenza cases, respiratory illness and lost works days as well as a reduction in total patient

mortality and influenza-like illness among patients (Walker et al., 2006). By vaccinating HCWs

and reducing the amount of time HCWs are absent from work, healthcare systems can save an

estimated $2.85 for every dollar invested in an influenza vaccination program (Anikeeva et al,
2009).

When implementing a mandatory influenza vaccination campaign it is important to make
it easy for employees to receive the vaccination. Institutions have seen an increase in the
influenza vaccination rate when mobile vaccination carts are used. Larger facilities have seen
great success using the mobile carts to take free influenza vaccine to all work areas in the
hospitals during all shifts (Walker et al., 2006).

It is important for all vaccination programs, including mandatory vaccination programs,
to be accompanied by education campaigns. Studies show there are a number of reasons why
HCWs do not get vaccinated under voluntary policies: these include HCWs miscalculating the
risk of influenza to their patients and themselves, not understanding that they can shed the virus
before they become symptomatic, and misjudging (overestimating) the health risks associated
with the vaccination (Douville et al., 2010; Goldstein et al., 2004). Educational campaigns
targeting these reasons increase vaccination rates in voluntary vaccination programs (Douville et
al., 2010). These same reasons should be focused highlighted in mandatory vaccination
education campaigns in order to help promote the campaigns acceptance among HCWs. The
educational campaigns should also include information on focusing on the protection of patients
and not just the personal health concerns of HCW (Walker et al., 2006).

As healthcare organizations implement mandatory influenza vaccination campaigns,
studies suggest that it is necessary to create an intervention at the institutional level (Goldstein et
al., 2004). Social network analysis can help determine the most effective way to present these
interventions within the unique complex network at each institution or hospital. Although it
there is little published literature modeling hospitals as complex networks, we note that they

have the four components that form the consensus definition of a complex system. First, complex networks contain large numbers of heterogeneous elements (Luke & Stamatakis, 2012). Within a hospital there are a number of different job types (elements) in a hospital that include physicians, nurses, laboratory staff, radiology staff, pharmacy staff, maintenance staff, custodial staff and culinary staff just to name a few. Second, all of the heterogeneous elements interact with each other in some way (Luke & Stamatakis, 2012). All of the elements previously mentioned interact in the hospital with the common goal of caring for patients and family that walk through the hospital doors. Third, the element interactions create an emergent effect different from the effect that each individual element would have on its own (Luke & Stamatakis, 2012). All of the elements in the hospital must work together to provide the best care for patients. Physicians must make the best possible decision for the patients care with information provided to them by laboratory and radiology staff. The nurses are at the front of taking care of patients' immediate needs, while the pharmacy staff works to provide lifesaving medications. The maintenance staff ensures that everything in the hospital is in working order while the custodial staff works continuously to keep the hospital free of infectious materials and pathogens. None of these elements alone could take care of all the needs of patients being cared for in a hospital setting. Finally, the effect of the heterogeneous elements working together persists over time and will make adaptations in response to changing circumstances (Luke & Stamatakis, 2012). All the elements within in the hospital must adapt to changes in standard of care, new treatment methods, new equipment that is made available, the way the hospital is reimbursed for services rendered, and most importantly each element must be able to adapt to the different needs of each individual patient. These rationales show how hospitals meet all four criteria of a complex network and therefore can be considered complex networks.

Social network analysis is key in understanding a network and how information spreads

through it. This is where social network analysis can play a pivotal role within mandatory

vaccination programs. Social network analysis can provide information about the cohesion of

the network, or ,in other words, how closely together the network is distributed. Are there

individuals within the network that communicate with each other consistently? Do all the nodes

of the network communicate with each other or is there a node in the network that does not

communicate with anyone else within the network about the issue at hand? This isolated node

would be considered an "outlier". In the case of the illustration we presented in this study

(Figure 1), node 15 or OSCC would be considered an outlier. He or she does not have a tie or

connection with anyone else in the network. Therefore it would be important that information

about the mandatory vaccination campaign be directly conveyed to that node as there is no other

way for the information to be conveyed. Multiple modes of transmission such as email,

educational information through interoffice mail or mail to nodes home, or a message to office

phones would be good idea as well. It is also a good idea for policy administrators to follow up

with an outlier to ensure they understand the reasoning for the policy and that their questions are

answered since they do not have any ties with other nodes with whom to discuss the policy.

Social network analysis can also help understand the density of a network. Density refers

to the proportion of the number of possible ties within the network that actually exist. The

density can help determine how fast the information will disseminate throughout the network

(Hanneman & Riddle, 2005). If each node in the network has a tie with every other node within

the network, then the information will spread quickly and to everyone. However, if there are few

ties between the nodes within the network, information may travel more slowly and there is a

possibility that outliers will not receive the information at all. Density can show nodes that

might not receive the information they need or the support to talk with others to make sense of

the decision and possible fears.

Betweenness centrality could be considered one of the most important measures when

looking at the interaction of a network. Betweenness centrality examines nodes at the figurative

"center of attention" within the network being studied. Nodes with high betweenness centrality

have ties with the majority of the network. They are individuals that other nodes within the

network trust, and tend to be a "go to" individual for questions, concerns or complaints. The

nodes with the highest betweenness centrality are not necessarily supervisors or managers. They

could be nodes that have worked on the same unit for years and have come to be respected by

everyone working in that unit. It could be a node that everyone enjoys speaking with casually

when they have concerns or when difficult decisions need to be made. It could be a node that

people trust for other reasons. The nodes with high betweenness centrality are nodes that

hospitals will want to support a mandatory influenza vaccination campaign because they are the

nodes that everyone is going to contact. These nodes can be distributors of education materials,

b the first line of defense against resistance to the policy, and be nodes that can get others to

listen to them. Lacking the backing of a node with high betweenness centrality can also be

problematic if that node decides to voice a negative opinion, concerns or disagreement about

mandatory influenza vaccination campaigns. Knowing the opinion of a node with high

betweenness centrality can prevent a problem before it presents itself.

List of Best Practices

The following is a summary list of best practices concerning mandatory influenza

vaccination of HCWs.

- Mandatory influenza vaccination campaigns are needed to reach the vaccination rates set by Healthy People 2020.

- Offering free vaccinations with mobile vaccination carts and varied vaccination times is important.

- Couple exemptions for medical and religious reasons to help gain support for the program.

- Educational material needs to be part of the campaign. Make sure education material involves information on:

  o Basic information about the influenza virus

  o Benefits to employees

  o Benefits to patients

  o Risks of the vaccination

  o How the virus can be shed before symptoms present themselves

  o Present the educational material in multiple media forms

    ▪ E-mail

    ▪ Newsletters

    ▪ Mail for to offices and/or homes

    ▪ Direct contact from managers and supervisors

- Social network analysis should be used to determine how information will flow through the network.

  o Discover outliers that need follow up to address possible concerns.

  o Determine individuals with high betweenness centrality that can provide support to the mandatory vaccination campaign.

o   Use Cohesion and density to help determine how information will spread through

the network and some of the best ways to distribute information.

o   Determine if individuals with high betweenness centrality are against the program

and gain their understanding to prevent possible problems.

Discussion and Recommendations

The current status of research in the area of mandatory HCW vaccination is increasing as

many efforts are in effect to further accelerate patient safety measures. Network studies are not

always methodologically feasible or analytically appropriate. A complete network approach

requires a defined boundary of a population and information about direct ties. The current

computer hardware and software limits analysis because it is only possible to study a few types

of relationships in populations no larger than several hundred. In addition, it is not feasible to

contain complete list of the ties of population members in naturally occurring settings. These

limitations cause many structural analysts to concentrate on smaller egocentric networks

(Wellman, 1988). The surveys and interviews often used to study the complete network

approach can be difficult and burdensome for both the researchers and the participants. In

addition, when studied alone network analysis can offer only vague answers to many questions.

Social networks can guide scientist where to look for answers but may not tell them an exact

solution (Marin & Wellman, 2009).

There may be a gap in knowledge about the structure of hospitals in peer-reviewed

research. Information about the hierarchy of hospital management would be beneficial when

studying the strength of ties between employees. Information regarding the organization of

management may help researchers identify who the central actors are in a hospital system.

The number of healthcare organizations that are implementing mandatory immunization policies to be required in a manner similar to other obligatory hygiene measures is also increasing (Music, 2012). The status of social networking studies in this field is limited to only a few preliminary social networking studies that have been performed in a hospital environment. A complete network approach is used to research this topic because it permits simultaneous views of the social system as complete and as parts that make up the system (Wellman, 1988). Additionally, there are only a few complementing studies based on compartmentalized epidemiological models (Polgreen et al., 2010).

Although mandatory influenza vaccination campaigns are the best method to achieve vaccination rates among HCWs that meet Healthy People 2020s objective of 90%, there are those that believe that the autonomy of HCWs is being infringed upon, which makes such programs unethical. Influenza vaccination campaigns focusing on incentives have shown some merit. One incentive-based program conducted in the United States offered employees that received the influenza vaccination health books and movie tickets. These incentives caused an increased rate of influenza vaccination among HCWs from 52.6% to 56.4% in a single year (Anikeeva et al., 2009). Incentive-based programs such this could offer other prizes including honorable mentions for units or staffs that reach a set percentage vaccination level, or even financial incentives. Couple this with a strong educational campaign and there is a good chance that the vaccination rate of HCWs will be higher than a strictly voluntary program. Incentive-based programs do not infringe on ethics, but it is unlikely that they will reach the same level of vaccination rates obtained by mandatory vaccination programs.

Identifying the components of a specific social network is the first step in analyzing low influenza vaccination rates. A system involves elements that are interconnected and organized in

such a way that it can achieve something (Meadows, 2008). The main components of any

system are elements, interconnections, and a purpose. Some of the elements in a hospital

network are the patients, employees, hospital building, and the influenza vaccination. Changing

elements usually have the least effect on the network. For example, if the all of the patients in a

hospital unit change, it is still recognizably a hospital. Interconnections are the relationships that

hold the elements together. For example, some hospital systems interconnections are the staff

communications, mandatory vaccination rules, budget, and management's strategy. These

interconnections allow one part of the hospital to respond to what is happening in another part of

the hospital. Modifications in interconnections can greatly alter a system. For example, if the

communication of knowledge between employees changes, how the network is put together may

change. One of the many purposes of the hospital is to help patients maintain their health. A

networks purpose can be deduced from observing how the system behaves. Changes in the

purpose of a network usually have the most effect on the network. Elements, interconnections,

and purposes are all essential. Analysis of these characteristics shows that the structure of a

network affects its behavior (Meadows, 2008).

Strength of ties can also be used as a type of measurement and is defined as an amount of

time, emotional intensity, intimacy, and reciprocal services between ties (Granovetter, 1973).

The strength of ties in a hospital network is an important measurement that can be used during

the process of making the influenza vaccination mandatory. The strength of ties is commonly

described as being either strong, weak, or absent (Granovetter, 1973). Empirical evidence

suggests that the stronger the network ties' connection, the more similar the nodes are in various

ways. It is also indicated that weak ties are less likely to interact and are less compatible. When

information is diffused to a large number of people and must travel along distance, it is better to

use weak ties rather than strong ties. This is because strong ties form a dense network across less

social space while weak ties form a less dense network across greater social space. For example,

in a weak network, ideas, influences, and information may reach farther compared to a strong

network. This may be because weak ties are linked to more nodes and play a role in social

cohesion. Work-related ties are almost invariably reported as being weak ties. Therefore, weak

ties are more likely to link members of different small groups than strong ties (Granovetter,

1973). This is applicable to the many departments in a hospital being linked by weak ties, which

will transmit information about the mandatory influenza vaccination policy better than strong

ties. In comparison, strong ties in a hospital may reach fewer nodes. Therefore, the compliance

of the influenza vaccination in a hospital is more likely to increase when using weak ties to

transmit information.

Social network analysis can also be used to generate a priority vaccination ordering of

HCW based on how many human interactions the worker has. Social contact can be inferred

from electronic medical record logs or an analysis of the team structure and its meeting schedule.

A worker that is likely to spread infection to more people may be considered a vaccination

priority. This can allow public health officials to target a small proportion of the population that

is fuelling the spread of infection (Vidondo et al., 2012). Understanding the cases attributable

from an infected HCW is particularly important when vaccine shortages occur (Polgreen et al.,

2010). This strategy depends on a high compliance of people selected for vaccination and high

vaccine efficacy. This strategy will not be very effective if the influenza vaccination does not

work or if highly connected people are not vaccinated. Vaccination priority ordering may result

in fewer infections, but will not increase the total number of people vaccinated (Polgreen et al.,

2010).

The use of whole network analysis has developed a coherent set of characteristics and principles backed up by a sizeable body of empirical work. Achievements of whole network analysis include collecting new types of evidence, posing new intellectual questions, and providing new ways to describe and analyze social structures. Structural analysts have been able to map ties from corporations, states, and world systems. By introducing a different way of looking at the successes and failures of interventions more effective interventions may be developed. New concepts, methods, and techniques have been produced by structural analysts that provide reliable answers to complex questions.

Despite evidence that vaccination of HCW against seasonal and pandemic influenza protects patients, vaccination for HCW in the United States remains at unacceptable levels (Quan et al., 2012). Using social network analysis, complexity, density, cohesion, centrality and strength of ties may help locate ways to increase the vaccination rate. These strategies are capable of finding out information on limitations that cannot be achieved by other research strategies. Research regarding strength of ties in a hospital will provide supporting evidence for changes that need to be made for information to reach more HCW (Granovetter, 1973). Public health officials can gain insight on complexity by using nonlinear models (Mitchell, 2009). Therefore a social network approach is a very appropriate strategy to respond to the low influenza vaccination rates of HCW in hospital settings.

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Appendix A

Table 4

Who Talked to Who About Mandatory Vaccination Pajet Matrix

ID	1-CEO	2-ACEO	3-HN	4-N1	5-N2	6-N3	7-RC	8-FD	9-HEO	10-CP	11-DQI	12-IS	13-SW	14-DSS	15-OSCC
CEO	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
AAC	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0
HN	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0
N1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
N2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
N3	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
RC	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
FD	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
HEO	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
CP	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
DQI	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0
IS	0	0	1	1	0	0	1	0	1	0	1	0	0	0	0
SW	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
DSS	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0SCC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Key 2 for Table 4 Pajet Matrix

0	No conversation about Vaccination
1	Conversation about Vaccination
X-Axis	Node ID
Y-Axis	Node ID

Appendix B – List of Competencies Met in CE

Tier 1 Core Public Health Competencies – Attenweiler & Thomure

Domain #1: Analytic/Assessment
Identify the health status of populations and their related determinants of health and illness (e.g., factors contributing to health promotion and disease prevention, the quality, availability and use of health services)
Describe the characteristics of a population-based health problem (e.g., equity, social determinants, environment)
Use methods and instruments for collecting valid and reliable quantitative and qualitative data
Identify sources of public health data and information
Identify gaps in data sources
Describe the public health applications of quantitative and qualitative data
Use information technology to collect, store, and retrieve data
Describe how data are used to address scientific, political, ethical, and social public health issues
Domain #2: Policy Development and Program Planning
Gather information relevant to specific public health policy issues
Describe how policy options can influence public health programs
Explain the expected outcomes of policy options (e.g., health, fiscal, administrative, legal, ethical, social, political)
Gather information that will inform policy decisions (e.g., health, fiscal, administrative, legal, ethical, social, political)
Describe the public health laws and regulations governing public health programs
Domain #3: Communication
Communicate in writing and orally, in person, and through electronic means, with linguistic and cultural proficiency
Convey public health information using a variety of approaches (e.g., social networks, media, blogs)
Participate in the development of demographic, statistical, programmatic and scientific presentations
Domain #4: Cultural Competency
N/A
Domain #5: Community Dimensions of Practice
Recognize community linkages and relationships among multiple factors (or determinants) affecting health (e.g., The Socio-Ecological Model)
Describe the role of governmental and non-governmental organizations in the delivery of community health services
Domain #6:Public Health Sciences
Describe the scientific foundation of the field of public health
Identify the basic public health sciences (including, but not limited to biostatistics, epidemiology, environmental health sciences, health services administration, and social and behavioral health sciences)
Describe the scientific evidence related to a public health issue, concern, or, intervention
Retrieve scientific evidence from a variety of text and electronic sources
Discuss the limitations of research findings (e.g., limitations of data sources, importance of observations and interrelationships)
Domain #7: Financial Planning and Management
Describe the organizational structures, functions, and authorities of local, state, and federal public health agencies
Domain #8: Leadership and Systems Thinking
Describe how public health operates within a larger system
Identify internal and external problems that may affect the delivery of Essential Public Health Services
Describe the impact of changes in the public health system, and larger social, political, economic environment on organizational practices

Concentration Competencies - Attenweiler

Health Promotion and Education:
Area 2: Plan health education programs
2.1 Use assessment results to inform the planning process
2.3 Develop goal statements
Area 3: Implement health education
3.3 Create training using best practices
Area 6: Serve as a health education resource person
6.3 Assess needs training
6.5 Use learning theory to develop or adapt training programs
Area 7: Communicate and advocate for health and health education
7.3 Use evaluation and research findings in policy analysis

Concentration Competencies - Thomure

Public Health Management:
Have a knowledge of strategy and management principles related to public health and health care settings
Know effective communication strategies used by health service organizations
Have a knowledge of leadership principles
Have a knowledge of systems thinking principles
Know strategies for promoting teamwork for enhanced efficiency
Be able to use negotiation techniques
Be able to determine how public health challenges can be addressed by applying strategic principles and management-based solutions
A knowledge of the finance and accounting skills needed for operational management, performance assessment, and forecasting
A knowledge of ethical principles relative to data collection, usage, and reporting results
An awareness of ethical standards related to management
A knowledge of ethical standards for program development
Detailed knowledge of public health laws and regulations