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**Simulation of Infectious Disease Transmission in a Hospital Emergency Department**

By

Yuke Wang

MSPH

Emory University

Rollins School of Public Health

Department of Biostatistics and Bioinformatics

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Thesis Advisor

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Reader

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B.S., South China University of Technology, 2012

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**Advisor:** Vicki S. Hertzberg, PhD.

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A thesis submitted to the Faculty of the

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Master of Science in Public Health

in Biostatistics

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Abstract:

People with infectious diseases in crowded emergency department may bring about a disease outbreak and endanger public health. This paper focused on finding out whether the probabilities of disease transmissions are diverse for various types of contacts between infectious sources and exposed individuals. By applying an empirical emergency department network data in the simulation, we can predict what kind of people in the emergency department will be most dangerous if they become infectious. By comparing a number generated from a cumulative exponential distribution using the contact's duration with a random number from uniform distribution, we determined whether the contact could infect others. We initialized people in these networks as infectious one by one, and ran 10,000 simulations for all its contacts to get percentage of spreading the disease. In accordance with the results, there were 3637 nodes and 31350 contacts between them delineating one meter contacts in networks across 35 shifts. Among them, there were 6 types of nodes (222 MD, 526 RN, 515 staff, 438 admitted, 1779 not admitted, and 157 unknown) and 36 types of two-way contacts. The simulation results were analyzed at both individual level and shift level.

The mean average degree of the networks was 16.8. In both levels, the percentage of getting infected and spreading diseases through ED network was low (<1%) for all three types of patients (admitted, not admitted, and unknown). By contrast, the percentage of spreading the disease between healthcare workers is relatively high. There are some extreme outlier contacts having about 25% of getting infected for RN-RN, RN-Staff, Staff-RN, and Staff-Staff in individual level. Moreover, when we compared day and night shifts, weekday and weekend shifts, H1N1 season and not H1N1 season shifts, we found the percentage of getting infected were almost identical for these shifts, except for the standard deviation. For night shifts and not H1N1 season shifts, there were more contacts with large probability of spreading the disease. These results are helpful for understanding the patterns of infectious disease transmission through social networks. Most importantly, the results can have an important impact on helping design interventions to control the spread of infectious disease inside hospitals.

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# Chapter I

## Introduction & Background

### Introduction

In the recent decade, numerous studies have applied the social network concept to various fields, including information science, biology, economics, sociology, and public health. Take the Internet for example: the success of Facebook indicates that people use social networks to help them acquire and share information (Barabási, A.-L., 2012). In war, the U.S. military's "poker card deck", which printed photos of terrorist targets, led to the capture of Saddam Hussein (Barabási, A.-L., 2012). Regarding public health, the social network paradigm provides a set of useful methods for understanding the patterns of infectious agents transmitted during close personal contact, as well as an opportunity to develop improved disease control programs (Klovdahl, 1994). An increasing number of studies have been done to evaluate how the knowledge of social networks can help us to prevent infectious disease from spreading and differentiate the risks for different populations. Studying the patterns of disease transmission through networks may help us lower the risk of disease transmission. For instance, if an infectious disease is most likely to be transmitted by physical contact, we may use social networks to determine who needs protection to control the disease.

In order for infectious diseases to spread, two conditions have to be fulfilled. There must be some source of infection. Also, to spread the disease, a path for the transmission is necessary. The most common paths are droplet contact, direct contact, indirect contact, airborne transmission and fecal-oral transmission (Killingley & Nguyen-Van-Tam, 2013; Hitchcock et al., 2003). Salathé et al. (2010) proposed that although there was evidence suggesting that most common infectious diseases like influenza may be transmitted by airborne and direct contact, we have considered droplet contact as the primary transmission path for infectious diseases for purposes of this thesis. The difference between airborne and droplet is that for airborne, bacteria or viruses are on dust particles or on ultra-small respiratory droplets and can travel for a long distance, while for droplet, droplets produced by the infected host are relative large and only travel a short distance.

An emergency department (ED) meets both important conditions mentioned above because a considerable proportion of patients come to the emergency department with infectious diseases (Williams et al., 2001) and healthcare workers and patients come in close contact with each other in many ways, creating opportunities for cross infection.

**Background**

Several studies have done research on hospital-based networks. Isella et al. (2011) did research on the network within a general pediatrics hospital ward for one week and analyzed the number, frequency and duration of contacts by category (e.g., Nurses-Patients). Lucet et al. (2012) studied daily recorded networks in two clinical wards of two hospitals for three months and analyzed characteristics of healthcare workers and patients as well as the contacts between them. Hornbeck et al. (2012) obtained contacts among healthcare workers and patients in a 20-bed intensive care unit. Later, they analyzed the networks and confirmed the presence of peripatetic healthcare workers. In addition, they ran an agent-based simulation to model the nosocomial (within hospital) spread of pathogens with various transmission probabilities.

The data used in the current study comes from a recent study measuring social contacts by Lowery-North et al (2013) in the ED of Emory University Hospital Midtown, a busy urban hospital. These data were collected over one year. Although contacts between patients and staff were quantified in that study, it did not look at the impact of different types of individuals on infectious disease transmission.

### Problem Statement

Few social network studies have been done to provide the data of infectious disease transmission in the hospital. The events, meaning the transmission actually occurred, are relatively rare and some of the events data may not have been collected. For instance, in some circumstances it is difficult to determine where someone became infected. In addition, a study that collected all the information for networks and disease transmission would be expensive. Using statistical software to simulate how infectious diseases might spread in an ED network is an alternative way to study the impact of healthcare works and patients in spreading diseases. Even without the transmission data of disease, an emprical contact distribution and randomization can still be used to simulate transmission patterns.

### Purpose Statement

The primary purpose of this paper is to describe transmission of infectious disease simulation results for an ED social network. Contacts between different types of healthcare workers and patients were evaluated to differentiate their risks in spreading disease. This study will seek to determine what kind of people entering the emergency department are the most dangerous to others if they are infectious, and if those at most risk differ depending on the type of infectious person. A secondary purpose of this study is to compare the risks of contacts by category between day and night shifts, weekday and weekend shifts, H1N1 season and not H1N1 season shifts.

### Significance Statement

This study will help us to understand how an infectious disease can be transmitted through an ED network and provide a comparison of the risks of spreading disease for different types of people. The information from this study can assist in deciding what kind of intervention may lower the risk of the infectious disease outbreaks in EDs.

# Chapter II

## Literature Review

### Introduction

The following literature (articles, books, and scientific papers) provided explanation and support for the background knowledge, supplemental concepts and several theories that were applied in this study. Their topics range from infectious diseases like SARS to social networks. Although the type of the disease and methods may differ from what this study utilized, these sources are helpful when we try to understand the reason why this study is valuable and why we use certain settings or methods.

### Literature

### Infectious Disease

Infectious disease, also known as communicable disease or transmissible disease, is caused by the presence and growth of pathogenic biological agents in an individual host organism. It can be transmitted to other individuals. Infections can result from pathogens including viruses, microorganisms, fungi, and nematodes. To infect a host body and cause the disease, pathogens must be able to enter the host's body and invade its tissues. Significant examples of infectious disease are HIV/AIDS, Pneumonia, Osteomyelitis, and Tuberculosis. Although all these diseases are infectious, the paths in which the disease gets transmitted are different.

### Transmission Paths

The transmission paths of infectious disease are diverse. In order to survive and infect other hosts, the pathogens must leave their current reservoir. The followings are the main transmission paths for infectious diseases:

- Droplet contact (also known as the respiratory route) is the primary route for respiratory illness like flu, tuberculosis, or pneumonia. The infection spreads through tiny airborne droplets when infected people cough, sneeze or even breathe. The pathogen in these droplets can enter another body through nose, mouth or eye surfaces. Sometimes droplets may not be able to transmit to others directly. Nevertheless, they are capable of living on the surface of skin or other objects for more than 2 hours. Thus, when a person touches the mouth, nose or eyes after touching a surface with attached pathogens, the pathogen can enter that person's body and cause infection (Killingley & Nguyen-Van-Tam, 2013; Hitchcock et al., 2003).
- Fecal-oral transmission occurs when people become infected by taking in contaminated food or water (Hitchcock et al., 2003). Many diseases such as Cryptosporidiosis, Hepatitis A, and Salmonella infection can be transmitted by this route. The pathogens are spread with feces from infected individuals. Food contamination is usually caused by preparing food without washing hands, while water contamination commonly results from releasing untreated sewage into water system.
- Sexual transmission, which means the infections are spread by sexual contact including genital to genital, oral to genital, or oral or genital to anal contact (Hitchcock et al., 2003). The examples of diseases transmitted by this route are HIV/AIDS, Syphilis, Chlamydia, and Gonorrhea.

- Direct contact and indirect contact can also be the paths of disease transmission. Direct contact transmission is defined as pathogens spread by direct skin or membrane contact, while indirect contact transmission is pathogens transmit when people's skin or membrane contact with contaminated objects or surfaces (Killingley & Nguyen-Van-Tam, 2013; Hitchcock et al., 2003).
- There are some other transmission paths for infectious disease. Vertical transmission is when children get infection from their mother (Fine, 1975) and iatrogenic transmission is caused by medical procedures like injection or transplantation.

In this study, the transmission we are interest in is droplet transmission. Based on the characteristics of droplet transmission, the social contact which is the potential transmission route for infectious diseases can be defined. Furthermore, droplet transmission is considered as a main path for respiratory infectious disease and in the following section some typical respiratory infectious diseases are introduced.

**Typical Respiratory Infectious Disease**

**SARS**

Severe acute respiratory syndrome (SARS) was a viral respiratory disease that originally occurred in Guangdong province of China in November 2002 (Meyers et al., 2005). It was caused by SARS coronavirus (SARS-CoV). The initial symptoms of SARS were just like those of influenza, specifically fever, cough, and sore throat. People with these symptoms including 38 °C (100 °F) or higher fever and who had been in previous contact with people identified as SARS patients were suspected of having SARS. The first case happened in Shunde, Foshan, Guangdong. A farmer who had flu-like symptoms died after being treated in the First People's

Hospital of Foshan. From November 2002 to July 2003, SARS led to 8273 cases and 775 deaths all around the world, and as many as 37 countries reported having infected individuals. The attention of the public was draw by this epidemic disease in February 2003. An American businessman who traveled from China developed pneumonia-like symptoms when he was taking a flight to Singapore. Then he was sent to the French Hospital of Hanoi in Hanoi, Vietnam and died soon after treatment in that hospital (Weston, 2008). However, this is not the end of the story. Several healthcare workers who took part in treating that patient got similar symptoms. An Italian doctor who evaluated the treatment and reported it to the local government and World Health Organization (WHO) died of the disease (Weston, 2008). This nosocomial outbreak of the disease alarmed the world and lots of governments and organizations including WHO, Centers for Disease Control and Prevention (CDC) proposed strategies and policies against this newly emerging disease.

The outbreak of SARS mainly occurred in public places like hospitals where people with symptoms were sent. The first cohort of SARS-infected patients in Hong Kong was in the hospital on March 2003 (Hui et al., 2004). The index SARS patient in Canada came back from Hong Kong and spread the disease after admitted in the Emergency Department (ED) in a local hospital in Toronto (Varia et al., 2003).

**Influenza**

Influenza is an infectious disease caused by RNA viruses of the family Orthomyxoviridae. The common symptoms of influenza include chills, fever, runny nose, sore throat, muscle pains, headache, coughing, weakness/fatigue and general discomfort. Influenza may also lead to nausea and vomiting, especially for children (Marguerite, 2009). The difference between influenza and common cold is that influenza is caused by different kinds of virus and it is more severe than the common cold. They are difficult to distinguish at early stages of the disease. However, the symptoms of influenza can be more complex. There are three paths for influenza transmission: the first one is direct contact, which occurs when the infected person coughs or sneezes into another person's mouth or nose; the second one is indirect contact, that is when people touch their mouths, noses or eyes after touching contaminated surfaces; the last one is when people inhale the aerosols generated by the coughing or sneezing of infected people (Brankston et al., 2007).

**Social Network**

A social network is a social structure consisting of a set of social actors (such as individuals or organizations) and a set of ties between these actors (Barabási, 2002). The social network perspective provides a set of methods for analyzing the structure of whole social entities as well as a variety of theories explaining the patterns observed in these structures (Wasserman & Faust, 1994). The social network can be used in studying the relationship among individuals, groups and organizations. Each of these social actors is represented as a node, and the social interactions between them are represented as lines linking two nodes (Barabási, 2002). Using this theoretical construct, we are able to build a network which can be applied in numerous fields such as biology, communication studies, economics, geography, information science, social psychology, sociology and public health.

Social contacts form networks by which many infectious disease spread through populations (Meyers et al., 2005). The spread of many directly transmissible infectious diseases such as HIV/AIDS, SARS, and influenza can be explained in term of contacts and social network

(Salathé & Jones, 2010). The reason why social network can explain the epidemiological patterns of transmission could be when two individuals have contact with each other, they must be within a close distance (one or two meters) and may have conversations or body contact. All these could make it possible for pathogens to transmit between them, with possible transmission paths being via droplets, direct contact, and indirect contact. From the perspective of public health, it is desirous to cut off the transmission of infectious diseases or at least lower the risk of people getting infection through social contacts, so it is important to understand the patterns of diseases spreading through networks.

Social network analysis has been widely used in epidemiology studies and infectious disease studies to research disease dynamics and to develop strategies for disease control. Although it is good to study common infectious disease using social contact networks, there still exist some limitations for this method. First, contacts can be difficult to measure that data may be incomplete or result in misleading conclusions. For example, it is hard to measure the true distance between two individuals, since they are not fixed nodes. Second, even for the most common infectious disease like influenza, it is still impossible to be sure about what kind of social contact is the route for transmission (Stehlé et al., 2011). So these limitations must be considered as conclusions are drawn from the analysis results.

**Emergency Department**

Hospitals play such a significant role in controlling the spread of infectious disease that understanding how the transmission process works there can help us to find out effective interventions for nosocomial outbreaks. Within a hospital, the ED may be a primary entrance for infectious disease entering hospitals and the place where diseases spread, since it is a hub for patients, of whom there is a large proportion with infectious diseases, and healthcare workers who take care of those patients (Williams et al., 2001).

In recent years, the EDs in most hospitals have been overcrowded. A study conducted by Wier et al. (2013) found that in 2009, there were an estimated 128,885,040 ED encounters in US hospitals. Horwitz et al. (2010) reported that an average ED waiting time was from 4 hours to 6 hours in United States. As more people enter the ED with increasing waiting time, it is crucial to understand the transmission patterns for infectious diseases through social contacts, when we are preventing cross infection and controlling serious nosocomial outbreaks of infectious diseases.

# Chapter III

## Methods

The ethics statement: The Emory University Institutional Review Board (IRB) granted waiver of all elements of informed consent and waiver of HIPAA authorization.

### Introduction

In this study, statistical software SAS v9.3 was used to simulate how an infectious disease spreads in a network formed from social contacts in an Emergency Department (ED). The empirical networks data used was from the ED of Emory University Hospital Midtown, for which visits numbered 56,641 in 2012, in Atlanta, GA. Social contacts were measured by advanced radio-frequency identification (RFID) technology (Lowery-North et al., 2013). This study utilized the probability for transmitting influenza in 10 minutes from a previous study (Potter et al., 2012) so as to simulate how the disease would spread if someone was infectious. Then in individual-level and shift-level, we summarized and compared simulation results for different types of infectious people and infected people. Also, results were compared respectively in these two levels by different types of shifts, including day and night shifts, weekday and weekend shifts, H1N1 season and not H1N1 season shifts.

### Data collection

The data were obtained through a prospective study conducted by Lowery-North et al (2013). The study was conducted at the ED of Emory University Hospital Midtown in Atlanta, GA from July 1$^{st}$ 2009 to June 30$^{th}$ 2010. The data was collected over one year by shifts of 12-hour periods. Two shifts per week consisting of one day shift (7 am-7 pm) and one night shift (7 pm-7 am) were randomly selected to ensure the number of day shifts equaled that of night shifts. Meanwhile, this selection could also account for seasonal network variability. However, in the current study, we only used 35 shifts from July 1st 2009 to Dec 27th 2009 because the data quality after the end of December 2009 was affected by failing batteries in the RFID tags.

Four types of participants took part in the study: providers (MD), registered nurses (RN), staff, and patients. Providers included medical doctors, nurse practitioners, and physician’s assistants. For patients, we divided them into three categories, according to hospital admission (admitted, not admitted, and unknown). “Unknown” consisted of patients who were either transferred or whose status was not recorded. Each participant wore an RFID tag which sent information to at least three receivers every ten seconds. The RFID system covered the whole ED area and recorded when the distance between two individuals was less than one meter in two-dimensional space, which was defined as a contact. This kind of contact is two directional, indicating that an infectious disease can transmit in either direction. In addition, we divided the ED area into 89 zones in order to leave out the incorrect contacts across the zones through obstacles like walls or closed doors.

Within a shift, individuals are referred to as nodes while contacts are referred to as edges in terms of social networks. Two individuals could have many contacts of various durations; multiple contacts between two people were considered as one edge, which could be identified by the nodes on each end of it. The sum of duration of these contacts between these two individuals was defined as the weight of the contact. Also, each shift was considered as an independent network, though the same healthcare workers could appear in several shifts.

**Infectious disease model**

We considered a simple stochastic model for the simulation of the infectious disease spread. Individuals have three states: susceptible, infectious, and infected. The assumption was made that the infectious individual could make a susceptible person in contact with him/her infected. However, after someone susceptible became infected, he/she would not be able to become infectious within this shift because of the short time period, which indicated these people could not make others infected.

It is possible that disease transmits from an infectious node to a susceptible node when they have social contacts (within one meter distance). We assumed the probability of somebody getting infected through social contacts with an infected individual followed an exponential distribution based on a study conducted by Potter et al. (2012) estimating the probability of influenza transmission within school networks. In Potter's study, the probability of influenza spreading per 10 minutes of contact was 0.004 that could be represented as $\int_0^{10} f_\lambda(t)\,dt = 0.004$, where $f_\lambda(t)$ denotes the density function of the exponential distribution. The maximum likelihood estimation (MLE) $\hat{\lambda}$ of parameter $\lambda$ for this exponential distribution could be calculated for simulation. The cumulative density function of $f_{\hat{\lambda}}(t)$ is $F(t, \hat{\lambda})$, where t is the total duration of contact, also known as the weight of the edge. Then we determined a number $V$ which equaled to $F(t, \hat{\lambda})$ for each edge. Meanwhile, a random number $R$ was generated from a uniform distribution from 0 to 1 for each edge. When $V \geq R$ for this edge, if one node is at the state of "infectious" and the other one is at the state of "susceptible", then the disease will be spread from the "infectious" node to the "susceptible" node. Otherwise, the disease will not be able to spread through this edge.

**Simulation**

At the very beginning of simulation, all people were assumed susceptible. First, we made one person in the network infectious; this person could be a provider, a nurse, a staff or a patient. This person was defined as the infectious source and people who had contacts with this person were defined as exposed participants. Based on all contacts for this infectious person, we compared for each edge the number *V* with a random number *R* to determine whether the state of the other nodes of these edges changed to “infected”. This procedure was repeated 10,000 times for each node in the ED networks from the 35 shifts. Figure 1 shows a schematic representation of this simulation method. In shift 1, there are 6 nodes inside the network. First, make the node 1 infectious, denoted with color red and node 1 contacts with node 2, 3 and 4. Then we determine number V based on the weight of edge and compare it with random number R for each edge to determine whether the node 2, 3, and 4 get infected. It turns out the node 3 becomes infected, denoted with color orange. Then we make the node 2 infectious and all other nodes susceptible and compare V and R for all 3 edges for the node 2. The result is that node 3 and 5 become infected. Do this for all the nodes and repeat 10,000 times. This is performed for all 35 shift networks separately. The statistical software used for simulation was SAS v9.3 for Windows 7 Enterprise (SAS Institute, Cary NC).

**Analysis of empirical networks and simulation results**

To describe the empirical ED network, we calculated the number of contacts, the mean and median duration of contacts for all edges in 35 shifts and the mean average degree for 35 shifts. Also we calculated the duration of different types of contacts like MD-MD, MD-RN, staff-RN. For analysis of empirical ED network, we divided patients into three categories based on admission status.

After running 10,000 infectious disease spread simulations, two different ways were used to analyze the results. We used a matrix to show the results from all 35 shifts, the rows represented different types of infectious nodes while the columns represented different types of infected nodes. A subset of the matrix is shown in table 1. Three shifts and only MDs are shown in the example. MD1-01 represents the MD in shift 1 with ID 01. The number in the cell means how many times the disease transmits from MD1-01 to others among 10,000 times of simulation. A missing value, denoted by dot, means these two intersecting nodes do not have any contacts. In the matrix, nodes from different shifts will not have contacts with each other.

At the individual level of this study, non-missing cell values from all 35 shifts were divided by 10,000, which equal the proportions getting infected. Each cell in the matrix represents one edge and each edge can be categorized by a kind of infection scenario (e.g. infectious MD and infected RN). In total, there are 36 different infection scenarios.

We examined both the variability of the individual and the variability of the shift networks. The individual level analysis focused on different infection scenarios across all shifts. By contrast, at the shift level, the per person infection values in each shift were summarized in the following way. We calculated the statistics of every single shift, summarized them as medians, and examined the distribution of medians for the 35 shifts. Furthermore, we compared the percentage of getting infected for different infection scenarios such as between day and night shifts, weekday and weekend shifts, H1N1 season and not H1N1 season shifts at both individual level and shift level.

# Chapter IV

## Results

### Descriptive Statistics

Table 2 shows the summary statistics for nodes and edges. In the 35 shifts, there were 3637 nodes and 31350 contacts recorded. Among them, there were 6 types of nodes (222 MD, 526 RN, 515 staff, 438 admitted, 1779 not admitted, and 157 unknown) and 36 types of two-way contacts. However, admitted, not admitted and unknown patients were not shown in table 2. The mean average degree of all 35 networks was 16.8 (SD: 4.7). The duration of contacts had very large standard deviations across all types of contacts. Figure 2 presents the log scale boxplot of duration of contacts in minutes for different infectious sources and exposed participant types. The means are greater than medians in figure 2 due to the influence of many of outliers with long durations of contacts. Thus when we compared the duration of contacts among different types, we use the median which was more robust to outliers. We also found that the median duration of contacts of MD-MD, RN-Staff, RN-RN, and Staff-Staff were larger than the median duration of other types of contacts. This could be interpreted as MDs usually spend longer time with MDs, while RNs and Staffs usually work together generating long contacts. According to figure 2, it is apparent that patients generally have short contacts with all types of individuals.

### Simulation Results

After 10,000 times of simulation for each of the nodes set to be infectious in all 35 shifts, we plotted the percentage getting infected for different infectious sources and exposed participant types by both individual level(Figure 3.) and shift level(Figure 4.). The patients were divided into three parts (admitted, not admitted, unknown). Based on figure 3, we found that at the individual level, no matter what kind of exposed participant it was, the median percentage of all three types of patients spreading the disease into the ED network was very low (<1%) shown in table 3-5. The patients who were not admitted into hospital had more outlier contacts with staff having large percentage (>5%) of spreading diseases. However, the median percentages that a MD was infected by a MD (2.35%), and a staff was infected by a staff (4.28%) were relatively high. In addition, compared to patients, we observed that the healthcare workers had a greater percentage getting infected as well as greater percentage spreading the disease. The order of the percentage of getting infected for different types of contacts, from the highest to the lowest, was: healthcare workers-healthcare workers, healthcare workers-patients, patients-patients. This could be interpreted as healthcare workers having greater chance of spreading disease and getting infected through ED networks than patients.

In the shift level boxplot, the results were similar as in individual level. The mean of median percentage of spreading diseases for all three type of patients was low (<1%) (Table 6-8). The highest mean of median percentage of getting infected across 35 shifts was for Staff-Staff infection scenario (5.24%).

**Compare results for different types of shifts**

Moreover, we wanted to compare the networks and simulation results for different types of shifts. The individual level statistics of duration of contacts were summarized in table 9 without respect to the type of infection scenario. The number of contacts per shift was different. Generally speaking, the number of contacts per shift was larger for day shifts (1885.2) compared to night shifts (1666.4), was larger for weekday shifts (1880.2) compared to weekend shifts (1535.1) and was larger for H1N1 season shifts (1877.5) than not H1N1 season shifts (1676.7). The median percentage of getting infected for 10,000 times simulation through all contacts for day/night shifts (0.0022/0.0023) and H1N1/not H1N1 season (0.0022/0.0022) shifts were almost the same. However, the median of weekend (0.0019) was smaller than that of weekday (0.0023). The standard deviation of night shifts (0.043) was larger than that of day shifts (0.034), and of not H1N1 season (0.046) was larger than that of H1N1 season (0.032). All the distributions of the percentage of getting infected had long right tail, and there were more contacts with large percentage of spreading disease in night shifts and not H1N1 shifts.

Further comparisons of different types of shifts, by infection scenario, are shown in figure 5-7 and table 10-18. We found that when we compared the median for day and night shifts, they are almost the same. However, for night shifts, there were more outliers with large percentage of spreading disease, especially for RN and staff contacts. Thus, their mean percentage of getting infected are larger in night shifts compared to day shifts. This was also observed when we compared weekday and weekend shifts. Almost all types of contacts for weekday shifts had more contacts that had large percentages of getting infected. Additionally, MDs had higher percentage of getting infected from infectious MDs in weekday shifts (2.77%) than weekend shifts (1.48%). Among non H1N1 season shifts, there are more outliers with a large percentage of getting infected compared to H1N1 shifts.

On the other hand, the comparisons of percentage of getting infected for different types of shifts are shown in figure 8-10 and table 19-27. There are more outlier shifts in weekday shifts compared to weekend shifts. The mean median percentage of getting infected for MD-MD contacts was much higher in weekday shifts (4.18%) than weekend shifts (2.35%) and higher in H1N1 season shifts (4.16%) than not H1N1 season shifts (3.03%). Meanwhile, the median percentages of infected for unknown-unknown infection scenario in different shifts were quite variable. In general, mean median percentage of getting infected for other types of contacts in different shifts were basically the same.

# Chapter V

## Discussion

In both individual level and shift level, the simulation results showed that healthcare workers had higher percentage of transmission through social contacts compared to patients. The reason is be MD, RN, and staff spent longer time working with each other. However, the patients who are most likely coming to ED with various pathogens had very low percentage of making somebody else infected because patients made fewer and shorter contacts compared to healthcare workers. Gundlapalli et al. (2009) also reported similar results that healthcare workers make more and longer contacts than patients in the ED. In addition, Isella et al. (2011) reported the characteristics for 24-hours networks by category in 8 days, while we defined 36 infection scenarios and ran the simulation to determine the risk of each scenario across 35 shifts in our study. The results for the patients admitted into hospital were similar to those for not admitted, which indicated that admitted patients were as likely to spread the infectious diseases as those not admitted. Furthermore, the percentages of getting infected for different shifts were not that different except some shifts like night shifts and weekday shifts which had more outliers. This could be explained as there were more contacts with large risk spreading diseases in these shifts. Hornbeck et al. (2012) also found the similar right skewed distribution for the duration of contacts for different type of contacts as in our study. As to the cause of the extreme outliers, most of whom were RN-RN, RN-Staff, Staff-RN, and Staff-Staff, it could be they spent very long time working close with each other (e.g. they sit side by side) making the weight of these edges large. The sample size for unknown-unknown scenario is small, leading to the median percentages of infected being dependent on just a few individuals and quite variable across shifts.

## Limitations

This study made an assumption about the probability of transmission based on a previous study (Potter et al., 2012). In that study, within school network and influenza were used as the network and the infectious disease while those of our study were emergency department network and influenza. The probability used for school networks with influenza may not be perfectly applied in ED networks for influenza. Meanwhile, since healthcare workers theoretically have more sanitation procedures and protection for infectious diseases, the true risk of getting infected for them might be lower than for patients. In other words, the assumption that all types of contacts share the same transmission probability is likely to be inaccurate. Furthermore, the data didn't cover the whole year and we only used one half year, so it might fail to account adequately for seasonal variability. Although we wanted to collect data in 12-hour shifts, some lengths of shifts were less than 12 hours. In addition, patient contacts were not necessarily observed over their complete ED stay.

## Strength

This study utilized computer simulation to determine the patterns of diseases transmission through networks. The advantages for simulation are that it is easy to use, fast and inexpensive compared to designing an empirical study. Empirical networks data were obtained from 35 shifts which allowed us to evaluate and compare the patterns across shifts. Meanwhile, this study evaluated the risk of diseases transmission for different infection scenarios such as different edge types, so we could determine the impact of various individuals. For example, what kind of people are the riskiest in spreading diseases. This study also analyzed the results in individual level and shift level and compared them. It helped us not only to detect the influence of extreme outliers in individual level, but also to provide average median percentages of getting infected in shift level. Furthermore, this study took some important potential confounding factors into consideration by comparing simulation results for different types of shifts.

**Implications**

This study will be helpful to design interventions to prevent infectious disease nosocomial outbreaks, because we can determine which types of contacts are the riskiest for infectious disease transmission and which types of infectious people are the most dangerous for disease outbreaks. By improving the procedures in an ED, adding more protection for specific types of people, or modifying the floor map for an ED, we may lower the risk of infectious disease spreading in an ED. According to the results from this study, there is a notable risk of transmitting diseases among healthcare workers.  Though most of infectious diseases might be brought by patients who came to ED, we found that the risk of transmission through patient contacts was relatively low. Thus we can control the disease by applying interventions to lower the transmission probability for small number of healthcare workers rather numerous patients. For example, we can add some easy and quick daily test for them before they start to work or mandate vaccination for all the healthcare workers. For outlier edges with extremely high percentage of transmitting diseases, we may find out why healthcare workers made such long contacts with each other and apply some intervention. For instance, if two individuals worked at a very close distance for a long time, we could suggest hospitals to rearrange their location and keep a considerate distance between them.

**Recommendations for future study**

There are several recommendations for future study. Based on the knowledge we currently have, we could select different probability values of infection value for simulation. As the probability we used in this study came from a study for influenza, we may want to simulate other infectious diseases which could have higher or lower risk. Initially, for different types of social contacts, we can use different probabilities of the infectious disease transmission for simulations. For example, it may be harder for diseases to spread to doctors, nurses and staffs than patients with same contact time, so we may assume the probability of infected in 10 minutes for contacts between MDs is less than 0.004 for simulation. In addition, patients usually have higher probability to come into ED with infectious diseases. Therefore, we may differentiate the probability of being infectious for healthcare workers and patients. Furthermore, we may want to study the networks in different types of zones like waiting rooms, treating rooms, offices. For instance, in the waiting room, there may be lots of patients but few MD and RN and the contacts duration may be long while the number of contacts small in treating room.

**Conclusion**

This study provided some insights for the transmission of infectious diseases in the ED network. Generally, it is the healthcare workers like doctors, nurses, and staffs that we should focus on to prevent nosocomial outbreak of infectious diseases. Healthcare workers have contacts of longer durations and consequently higher probability of transmitting infection to other participants through social contacts than patients. Meanwhile, there is no obvious difference between the probabilities of getting infected for different types of shifts.

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# Appendix A

**Table 1.** Simulation Result Matrix.

| How many times the disease spread for 10,000 times among simulation | | | Infected | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Shift 1 | | | | Shift 2 | | | | Shift 3 | | |
| | | | MD1-01 | MD1-02 | MD1-03 | … | MD2-01 | MD2-02 | MD2-03 | … | MD3-01 | MD3-02 | … |
| Infectious | Shift 1 | MD1-01 | . | 155 | 190 | … | . | . | . | … | . | . | … |
| | | MD1-02 | 150 | . | 1000 | … | . | . | . | … | . | . | … |
| | | MD1-03 | 200 | 1100 | . | … | . | . | . | … | . | . | … |
| | | … | … | … | … | … | … | … | … | … | … | … | … |
| | Shift 2 | MD2-01 | . | . | . | … | . | 505 | . | … | . | . | … |
| | | MD2-02 | . | . | . | … | 500 | . | 1500 | … | . | . | … |
| | | MD2-03 | . | . | . | … | . | 1513 | . | … | . | . | … |
| | | … | … | … | … | … | … | … | … | … | … | … | … |
| | Shift 3 | MD3-01 | . | . | . | … | . | . | . | … | . | 512 | … |
| | | MD3-02 | . | . | . | … | . | . | . | … | 506 | . | … |
| | | … | … | … | … | … | … | … | … | … | … | … | … |

**Table 2.** Summary Statistics of ED network for all 35 shifts.

| | N (%) | Mean(SD) | Median |
|---|---|---|---|
| **Node, N** | 3637 | | |
| **Node Type** | | | |
| MD, N(%) | 222 (6.1%) | | |
| RN, N(%) | 526 (14.5%) | | |
| Staff, N(%) | 515 (14.2%) | | |
| Patient, N(%) | 2374 (65.3%) | | |
| **Edges, N**[1] | 31350 | | |
| **Duration of contacts per person**[2] | | 45.9 (103.5) | 5.6 |
| **Duration of contacts per person for different edge type**[3] | | | |
| STAFF-STAFF | 2590 (8.3%) | 171.1 (182.2) | 109.7 |
| MD-MD | 255 (0.8%) | 116.6 (130.6) | 61.3 |
| RN-STAFF | 4049 (12.9%) | 116.7 (153.9) | 40.6 |
| RN-RN | 1841 (5.9%) | 93.5 (135.4) | 22.4 |
| MD-RN | 1040 (3.3%) | 45.3 (85.3) | 9.8 |
| MD-STAFF | 658 (2.1%) | 32.6 (63.7) | 6.1 |
| STAFF-PAT | 4292 (13.7%) | 15.7 (30.8) | 4.7 |
| PAT-PAT | 9750 (31.1%) | 10.7 (21.1) | 3.1 |
| MD-PAT | 2424 (7.7%) | 15.5 (39.1) | 3.0 |
| RN-PAT | 4451 (14.2%) | 9.6 (25.3) | 2.1 |
| **Mean Average Degree (SD)** | | 16.8 (4.7) | |

[1]There are totally 31421 edges in the 35shifts, 71(0.23%) of edges only has one node, so we exclude them in the analysis. [2]Duration in minutes. [3]Duration in minutes ordered from the highest median to lowest median.

**Table 3.** Percentage of getting infected in different infection scenarios in individual level.

| Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|
| Admitted | Admitted | 812 | 0.50% | 0.08% | 0.02% | 0.40% |
| | Not Admitted | 2247 | 0.40% | 0.10% | 0.01% | 0.42% |
| | Unknown | 252 | 0.39% | 0.08% | 0.02% | 0.49% |
| | MD | 655 | 0.76% | 0.13% | 0.02% | 0.67% |
| | RN | 844 | 0.47% | 0.09% | 0.02% | 0.40% |
| | STAFF | 461 | 0.36% | 0.13% | 0.03% | 0.40% |
| Not Admitted | Admitted | 2247 | 0.40% | 0.10% | 0.01% | 0.42% |
| | Not Admitted | 11790 | 0.43% | 0.14% | 0.02% | 0.51% |
| | Unknown | 894 | 0.39% | 0.08% | 0.02% | 0.40% |
| | MD | 1564 | 0.54% | 0.11% | 0.02% | 0.46% |
| | RN | 3315 | 0.35% | 0.08% | 0.02% | 0.29% |
| | STAFF | 3713 | 0.67% | 0.20% | 0.03% | 0.67% |
| Unknown | Admitted | 252 | 0.39% | 0.08% | 0.01% | 0.50% |
| | Not Admitted | 894 | 0.39% | 0.08% | 0.01% | 0.39% |
| | Unknown | 112 | 0.67% | 0.18% | 0.02% | 0.65% |
| | MD | 205 | 0.62% | 0.12% | 0.02% | 0.50% |
| | RN | 292 | 0.42% | 0.10% | 0.02% | 0.39% |
| | STAFF | 118 | 0.29% | 0.12% | 0.03% | 0.25% |
| MD | Admitted | 655 | 0.75% | 0.12% | 0.02% | 0.62% |
| | Not Admitted | 1564 | 0.55% | 0.11% | 0.02% | 0.48% |
| | Unknown | 205 | 0.63% | 0.15% | 0.02% | 0.52% |
| | MD | 510 | 4.43% | 2.35% | 0.56% | 7.33% |
| | RN | 1040 | 1.74% | 0.39% | 0.09% | 1.79% |
| | STAFF | 658 | 1.27% | 0.24% | 0.05% | 1.23% |
| RN | Admitted | 844 | 0.47% | 0.09% | 0.02% | 0.38% |
| | Not Admitted | 3315 | 0.35% | 0.08% | 0.02% | 0.29% |
| | Unknown | 292 | 0.42% | 0.10% | 0.02% | 0.34% |
| | MD | 1040 | 1.75% | 0.40% | 0.09% | 1.81% |
| | RN | 3682 | 3.53% | 0.87% | 0.14% | 5.66% |
| | STAFF | 4049 | 4.39% | 1.59% | 0.15% | 7.31% |
| STAFF | Admitted | 461 | 0.37% | 0.13% | 0.03% | 0.41% |
| | Not Admitted | 3713 | 0.66% | 0.20% | 0.03% | 0.70% |
| | Unknown | 118 | 0.30% | 0.12% | 0.02% | 0.29% |
| | MD | 658 | 1.26% | 0.25% | 0.05% | 1.22% |
| | RN | 4049 | 4.39% | 1.64% | 0.15% | 7.30% |
| | STAFF | 5180 | 6.38% | 4.28% | 0.49% | 10.13% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 4.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients.

| Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|
| [3]Patients | Patients | 19500 | 0.42% | 0.12% | 0.02% | 0.47% |
| | MD | 2424 | 0.61% | 0.11% | 0.02% | 0.51% |
| | RN | 4451 | 0.38% | 0.08% | 0.02% | 0.31% |
| | STAFF | 4292 | 0.62% | 0.19% | 0.03% | 0.62% |
| MD | Patients | 2424 | 0.61% | 0.12% | 0.02% | 0.53% |
| | MD | 510 | 4.43% | 2.35% | 0.56% | 7.33% |
| | RN | 1040 | 1.74% | 0.39% | 0.09% | 1.79% |
| | STAFF | 658 | 1.27% | 0.24% | 0.05% | 1.23% |
| RN | Patients | 4451 | 0.38% | 0.08% | 0.02% | 0.31% |
| | MD | 1040 | 1.75% | 0.40% | 0.09% | 1.81% |
| | RN | 3682 | 3.53% | 0.87% | 0.14% | 5.66% |
| | STAFF | 4049 | 4.39% | 1.59% | 0.15% | 7.31% |
| STAFF | Patients | 4292 | 0.62% | 0.19% | 0.03% | 0.62% |
| | MD | 658 | 1.26% | 0.25% | 0.05% | 1.22% |
| | RN | 4049 | 4.39% | 1.64% | 0.15% | 7.30% |
| | STAFF | 5180 | 6.38% | 4.28% | 0.49% | 10.13% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 5.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients and combining three types of healthcare workers.

| Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|
| [3]Patients | Patients | 19500 | 0.42% | 0.12% | 0.02% | 0.47% |
| | HCW | 11167 | 0.52% | 0.12% | 0.02% | 0.45% |
| [4]HCW | Patients | 11167 | 0.52% | 0.12% | 0.02% | 0.45% |
| | HCW | 20866 | 4.28% | 1.39% | 0.16% | 7.06% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 6.** Median percentage of getting infected in different infection scenarios in shift level.

| Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|
| Admitted | Admitted | 34 | 0.12% | 0.09% | 0.04% | 0.16% |
| | Not Admitted | 35 | 0.10% | 0.09% | 0.05% | 0.15% |
| | Unknown | 32 | 0.20% | 0.09% | 0.03% | 0.25% |
| | MD | 35 | 0.21% | 0.12% | 0.05% | 0.24% |
| | RN | 35 | 0.14% | 0.09% | 0.05% | 0.16% |
| | STAFF | 30 | 0.17% | 0.11% | 0.03% | 0.23% |
| Not Admitted | Admitted | 35 | 0.10% | 0.09% | 0.05% | 0.13% |
| | Not Admitted | 35 | 0.14% | 0.12% | 0.08% | 0.18% |
| | Unknown | 32 | 0.09% | 0.06% | 0.04% | 0.13% |
| | MD | 35 | 0.18% | 0.09% | 0.04% | 0.17% |
| | RN | 35 | 0.08% | 0.07% | 0.06% | 0.10% |
| | STAFF | 35 | 0.24% | 0.15% | 0.07% | 0.30% |
| Unknown | Admitted | 32 | 0.19% | 0.08% | 0.02% | 0.22% |
| | Not Admitted | 32 | 0.08% | 0.06% | 0.04% | 0.12% |
| | Unknown | 23 | 0.68% | 0.18% | 0.04% | 0.44% |
| | MD | 30 | 0.29% | 0.12% | 0.06% | 0.25% |
| | RN | 32 | 0.17% | 0.10% | 0.06% | 0.21% |
| | STAFF | 20 | 0.19% | 0.10% | 0.04% | 0.16% |
| MD | Admitted | 35 | 0.21% | 0.11% | 0.06% | 0.23% |
| | Not Admitted | 35 | 0.20% | 0.10% | 0.05% | 0.15% |
| | Unknown | 30 | 0.32% | 0.14% | 0.05% | 0.29% |
| | MD | 34 | 3.69% | 2.62% | 1.37% | 5.47% |
| | RN | 34 | 0.49% | 0.37% | 0.18% | 0.65% |
| | STAFF | 34 | 0.74% | 0.19% | 0.07% | 0.75% |
| RN | Admitted | 35 | 0.13% | 0.09% | 0.05% | 0.16% |
| | Not Admitted | 35 | 0.08% | 0.08% | 0.05% | 0.10% |
| | Unknown | 32 | 0.16% | 0.10% | 0.04% | 0.20% |
| | MD | 34 | 0.50% | 0.37% | 0.23% | 0.73% |
| | RN | 35 | 1.28% | 0.90% | 0.40% | 1.60% |
| | STAFF | 35 | 1.78% | 1.77% | 0.95% | 2.40% |
| STAFF | Admitted | 30 | 0.17% | 0.12% | 0.05% | 0.20% |
| | Not Admitted | 35 | 0.24% | 0.15% | 0.07% | 0.28% |
| | Unknown | 20 | 0.20% | 0.10% | 0.03% | 0.17% |
| | MD | 34 | 0.73% | 0.21% | 0.07% | 0.82% |
| | RN | 35 | 1.77% | 1.80% | 0.95% | 2.41% |
| | STAFF | 35 | 5.24% | 4.83% | 2.81% | 7.16% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 7.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients.

| Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|
| [3]Patients | Patients | 35 | 0.12% | 0.11% | 0.07% | 0.16% |
| | MD | 35 | 0.19% | 0.09% | 0.05% | 0.19% |
| | RN | 35 | 0.08% | 0.07% | 0.06% | 0.10% |
| | STAFF | 35 | 0.22% | 0.16% | 0.06% | 0.27% |
| MD | Patients | 35 | 0.19% | 0.09% | 0.06% | 0.18% |
| | MD | 34 | 3.69% | 2.62% | 1.37% | 5.47% |
| | RN | 34 | 0.49% | 0.37% | 0.18% | 0.65% |
| | STAFF | 34 | 0.74% | 0.19% | 0.07% | 0.75% |
| RN | Patients | 35 | 0.08% | 0.08% | 0.05% | 0.10% |
| | MD | 34 | 0.50% | 0.37% | 0.23% | 0.73% |
| | RN | 35 | 1.28% | 0.90% | 0.40% | 1.60% |
| | STAFF | 35 | 1.78% | 1.77% | 0.95% | 2.40% |
| STAFF | Patients | 35 | 0.22% | 0.16% | 0.06% | 0.27% |
| | MD | 34 | 0.73% | 0.21% | 0.07% | 0.82% |
| | RN | 35 | 1.77% | 1.80% | 0.95% | 2.41% |
| | STAFF | 35 | 5.24% | 4.83% | 2.81% | 7.16% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 8.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients and combining three types of healthcare workers.

| Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|
| [3]Patients | Patients | 35 | 0.12% | 0.11% | 0.07% | 0.16% |
| | HCW | 35 | 0.12% | 0.09% | 0.07% | 0.17% |
| [4]HCW | Patients | 35 | 0.12% | 0.10% | 0.08% | 0.17% |
| | HCW | 35 | 1.60% | 1.51% | 1.06% | 1.97% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 9.** Compare the percentage of getting infected in 10,000 times of simulation based on shift characteristics.

| Shifts type | N | N/shift | Mean | Std Dev | Median | (Q1, Q3) |
|---|---|---|---|---|---|---|
| **Day shift** | 37704 | 1885.2 | 0.016 | 0.034 | 0.0022 | (0.0004, 0.0111) |
| **Night shift** | 24996 | 1666.4 | 0.020 | 0.043 | 0.0023 | (0.0003, 0.0123) |
| **Weekday shift** | 48884 | 1880.2 | 0.018 | 0.039 | 0.0023 | (0.0004, 0.0122) |
| **Weekend shift** | 13816 | 1535.1 | 0.016 | 0.037 | 0.0019 | (0.0003, 0.0095) |
| **H1N1 season shift** | 37550 | 1877.5 | 0.015 | 0.032 | 0.0022 | (0.0004, 0.0111) |
| **Not H1N1 season shift** | 25150 | 1676.7 | 0.021 | 0.046 | 0.0022 | (0.0003, 0.0123) |

**Table 10.** Percentage of getting infected in different infection scenarios in individual level for day and night shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Day | Admitted | Admitted | 418 | 0.40% | 0.11% | 0.02% | 0.38% |
| | | Not Admitted | 1261 | 0.39% | 0.10% | 0.01% | 0.42% |
| | | Unknown | 169 | 0.37% | 0.07% | 0.02% | 0.49% |
| | | MD | 417 | 0.67% | 0.11% | 0.02% | 0.63% |
| | | RN | 568 | 0.42% | 0.10% | 0.02% | 0.41% |
| | | STAFF | 267 | 0.44% | 0.13% | 0.02% | 0.46% |
| | Not Admitted | Admitted | 1261 | 0.39% | 0.09% | 0.01% | 0.43% |
| | | Not Admitted | 6548 | 0.45% | 0.14% | 0.02% | 0.52% |
| | | Unknown | 599 | 0.34% | 0.07% | 0.01% | 0.39% |
| | | MD | 960 | 0.59% | 0.10% | 0.02% | 0.46% |
| | | RN | 2168 | 0.34% | 0.08% | 0.02% | 0.29% |
| | | STAFF | 2249 | 0.63% | 0.21% | 0.04% | 0.64% |
| | Unknown | Admitted | 169 | 0.37% | 0.07% | 0.01% | 0.50% |
| | | Not Admitted | 599 | 0.35% | 0.07% | 0.01% | 0.39% |
| | | Unknown | 84 | 0.43% | 0.09% | 0.02% | 0.51% |
| | | MD | 147 | 0.40% | 0.11% | 0.02% | 0.48% |
| | | RN | 220 | 0.30% | 0.10% | 0.02% | 0.37% |
| | | STAFF | 85 | 0.23% | 0.10% | 0.03% | 0.18% |
| | MD | Admitted | 417 | 0.66% | 0.12% | 0.02% | 0.60% |
| | | Not Admitted | 960 | 0.59% | 0.10% | 0.02% | 0.47% |
| | | Unknown | 147 | 0.40% | 0.12% | 0.01% | 0.50% |
| | | MD | 326 | 4.48% | 2.36% | 0.42% | 7.52% |
| | | RN | 707 | 1.68% | 0.42% | 0.11% | 1.77% |
| | | STAFF | 470 | 1.39% | 0.26% | 0.05% | 1.37% |
| | RN | Admitted | 568 | 0.42% | 0.10% | 0.02% | 0.40% |
| | | Not Admitted | 2168 | 0.35% | 0.08% | 0.02% | 0.29% |
| | | Unknown | 220 | 0.30% | 0.09% | 0.02% | 0.32% |
| | | MD | 707 | 1.68% | 0.44% | 0.10% | 1.77% |
| | | RN | 2144 | 3.10% | 0.70% | 0.15% | 4.62% |
| | | STAFF | 2326 | 3.98% | 1.55% | 0.16% | 6.67% |
| | STAFF | Admitted | 267 | 0.44% | 0.12% | 0.02% | 0.43% |
| | | Not Admitted | 2249 | 0.64% | 0.21% | 0.04% | 0.64% |
| | | Unknown | 85 | 0.24% | 0.11% | 0.03% | 0.19% |
| | | MD | 470 | 1.39% | 0.25% | 0.05% | 1.47% |
| | | RN | 2326 | 3.98% | 1.57% | 0.16% | 6.59% |
| | | STAFF | 2958 | 6.01% | 4.43% | 0.62% | 9.51% |

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1 | Q3 |
|---|---|---|---|---|---|---|---|
| Night | Admitted | Admitted | 394 | 0.61% | 0.07% | 0.01% | 0.45% |
| | | Not Admitted | 986 | 0.41% | 0.10% | 0.01% | 0.43% |
| | | Unknown | 83 | 0.43% | 0.11% | 0.02% | 0.48% |
| | | MD | 238 | 0.93% | 0.15% | 0.02% | 0.68% |
| | | RN | 276 | 0.56% | 0.06% | 0.02% | 0.38% |
| | | STAFF | 194 | 0.26% | 0.15% | 0.03% | 0.35% |
| | Not Admitted | Admitted | 986 | 0.41% | 0.10% | 0.01% | 0.42% |
| | | Not Admitted | 5242 | 0.40% | 0.14% | 0.02% | 0.50% |
| | | Unknown | 295 | 0.48% | 0.11% | 0.02% | 0.42% |
| | | MD | 604 | 0.47% | 0.12% | 0.02% | 0.45% |
| | | RN | 1147 | 0.36% | 0.08% | 0.02% | 0.30% |
| | | STAFF | 1464 | 0.71% | 0.19% | 0.02% | 0.78% |
| | Unknown | Admitted | 83 | 0.42% | 0.11% | 0.01% | 0.52% |
| | | Not Admitted | 295 | 0.48% | 0.10% | 0.02% | 0.40% |
| | | Unknown | 28 | 1.38% | 0.40% | 0.14% | 2.28% |
| | | MD | 58 | 1.19% | 0.17% | 0.03% | 0.63% |
| | | RN | 72 | 0.79% | 0.14% | 0.03% | 0.41% |
| | | STAFF | 33 | 0.45% | 0.17% | 0.03% | 0.39% |
| | MD | Admitted | 238 | 0.93% | 0.14% | 0.02% | 0.64% |
| | | Not Admitted | 604 | 0.48% | 0.13% | 0.03% | 0.48% |
| | | Unknown | 58 | 1.23% | 0.20% | 0.03% | 0.75% |
| | | MD | 184 | 4.34% | 2.32% | 0.85% | 6.62% |
| | | RN | 333 | 1.87% | 0.33% | 0.05% | 1.89% |
| | | STAFF | 188 | 0.96% | 0.22% | 0.04% | 0.75% |
| | RN | Admitted | 276 | 0.57% | 0.08% | 0.02% | 0.37% |
| | | Not Admitted | 1147 | 0.36% | 0.08% | 0.02% | 0.29% |
| | | Unknown | 72 | 0.79% | 0.12% | 0.03% | 0.37% |
| | | MD | 333 | 1.88% | 0.35% | 0.06% | 1.84% |
| | | RN | 1538 | 4.14% | 1.28% | 0.10% | 6.75% |
| | | STAFF | 1723 | 4.95% | 1.65% | 0.14% | 8.49% |
| | STAFF | Admitted | 194 | 0.26% | 0.15% | 0.04% | 0.37% |
| | | Not Admitted | 1464 | 0.71% | 0.19% | 0.03% | 0.78% |
| | | Unknown | 33 | 0.47% | 0.19% | 0.02% | 0.41% |
| | | MD | 188 | 0.95% | 0.22% | 0.05% | 0.81% |
| | | RN | 1723 | 4.96% | 1.71% | 0.15% | 8.43% |
| | | STAFF | 2222 | 6.88% | 4.08% | 0.38% | 11.43% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 11.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients for day and night shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Day | [3]Patients | Patients | 11108 | 0.42% | 0.12% | 0.02% | 0.48% |
| | | MD | 1524 | 0.59% | 0.10% | 0.02% | 0.51% |
| | | RN | 2956 | 0.35% | 0.09% | 0.02% | 0.31% |
| | | STAFF | 2601 | 0.60% | 0.20% | 0.04% | 0.60% |
| | MD | Patients | 1524 | 0.59% | 0.11% | 0.02% | 0.52% |
| | | MD | 326 | 4.48% | 2.36% | 0.42% | 7.52% |
| | | RN | 707 | 1.68% | 0.42% | 0.11% | 1.77% |
| | | STAFF | 470 | 1.39% | 0.26% | 0.05% | 1.37% |
| | RN | Patients | 2956 | 0.36% | 0.08% | 0.02% | 0.31% |
| | | MD | 707 | 1.68% | 0.44% | 0.10% | 1.77% |
| | | RN | 2144 | 3.10% | 0.70% | 0.15% | 4.62% |
| | | STAFF | 2326 | 3.98% | 1.55% | 0.16% | 6.67% |
| | STAFF | Patients | 2601 | 0.60% | 0.19% | 0.04% | 0.61% |
| | | MD | 470 | 1.39% | 0.25% | 0.05% | 1.47% |
| | | RN | 2326 | 3.98% | 1.57% | 0.16% | 6.59% |
| | | STAFF | 2958 | 6.01% | 4.43% | 0.62% | 9.51% |
| Night | Patients | Patients | 8392 | 0.42% | 0.13% | 0.02% | 0.47% |
| | | MD | 900 | 0.64% | 0.13% | 0.02% | 0.49% |
| | | RN | 1495 | 0.42% | 0.08% | 0.02% | 0.31% |
| | | STAFF | 1691 | 0.66% | 0.18% | 0.03% | 0.65% |
| | MD | Patients | 900 | 0.65% | 0.14% | 0.02% | 0.54% |
| | | MD | 184 | 4.34% | 2.32% | 0.85% | 6.62% |
| | | RN | 333 | 1.87% | 0.33% | 0.05% | 1.89% |
| | | STAFF | 188 | 0.96% | 0.22% | 0.04% | 0.75% |
| | RN | Patients | 1495 | 0.42% | 0.08% | 0.02% | 0.31% |
| | | MD | 333 | 1.88% | 0.35% | 0.06% | 1.84% |
| | | RN | 1538 | 4.14% | 1.28% | 0.10% | 6.75% |
| | | STAFF | 1723 | 4.95% | 1.65% | 0.14% | 8.49% |
| | STAFF | Patients | 1691 | 0.65% | 0.18% | 0.03% | 0.66% |
| | | MD | 188 | 0.95% | 0.22% | 0.05% | 0.81% |
| | | RN | 1723 | 4.96% | 1.71% | 0.15% | 8.43% |
| | | STAFF | 2222 | 6.88% | 4.08% | 0.38% | 11.43% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 12.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients and combining three types of healthcare workers for day and night shifts.

| **Type of shift** | **Type of Infectious Node** | **Type of Infected Node** | **N** | **Mean** | **Median** | **Q1[1]** | **Q3[2]** |
|---|---|---|---|---|---|---|---|
| Day | [3]Patients | Patients | 11108 | 0.42% | 0.12% | 0.02% | 0.48% |
| | | HCW | 7081 | 0.50% | 0.12% | 0.02% | 0.44% |
| | [4]HCW | Patients | 7081 | 0.50% | 0.12% | 0.02% | 0.45% |
| | | HCW | 12434 | 3.87% | 1.28% | 0.17% | 6.37% |
| Night | Patients | Patients | 8392 | 0.42% | 0.13% | 0.02% | 0.47% |
| | | HCW | 4086 | 0.57% | 0.13% | 0.02% | 0.46% |
| | HCW | Patients | 4086 | 0.57% | 0.12% | 0.02% | 0.46% |
| | | HCW | 8432 | 4.88% | 1.53% | 0.14% | 8.24% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 13.** Percentage of getting infected in different infection scenarios in individual level for weekday and weekend shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Weekday | Admitted | Admitted | 576 | 0.52% | 0.09% | 0.02% | 0.40% |
| | | Not Admitted | 1708 | 0.40% | 0.10% | 0.01% | 0.41% |
| | | Unknown | 191 | 0.39% | 0.07% | 0.02% | 0.46% |
| | | MD | 486 | 0.82% | 0.12% | 0.02% | 0.67% |
| | | RN | 599 | 0.51% | 0.11% | 0.02% | 0.41% |
| | | STAFF | 361 | 0.37% | 0.15% | 0.03% | 0.40% |
| | Not Admitted | Admitted | 1708 | 0.40% | 0.09% | 0.01% | 0.41% |
| | | Not Admitted | 9206 | 0.46% | 0.15% | 0.02% | 0.55% |
| | | Unknown | 699 | 0.40% | 0.09% | 0.02% | 0.42% |
| | | MD | 1196 | 0.56% | 0.10% | 0.02% | 0.44% |
| | | RN | 2574 | 0.35% | 0.08% | 0.02% | 0.30% |
| | | STAFF | 3080 | 0.73% | 0.22% | 0.04% | 0.82% |
| | Unknown | Admitted | 191 | 0.39% | 0.07% | 0.01% | 0.50% |
| | | Not Admitted | 699 | 0.40% | 0.09% | 0.01% | 0.42% |
| | | Unknown | 100 | 0.66% | 0.18% | 0.02% | 0.63% |
| | | MD | 150 | 0.71% | 0.09% | 0.01% | 0.38% |
| | | RN | 226 | 0.44% | 0.10% | 0.03% | 0.33% |
| | | STAFF | 99 | 0.33% | 0.14% | 0.03% | 0.32% |
| | MD | Admitted | 486 | 0.82% | 0.11% | 0.02% | 0.62% |
| | | Not Admitted | 1196 | 0.56% | 0.10% | 0.02% | 0.46% |
| | | Unknown | 150 | 0.72% | 0.11% | 0.01% | 0.49% |
| | | MD | 390 | 4.78% | 2.77% | 0.59% | 7.68% |
| | | RN | 789 | 1.70% | 0.39% | 0.09% | 1.78% |
| | | STAFF | 513 | 1.23% | 0.26% | 0.05% | 1.36% |
| | RN | Admitted | 599 | 0.51% | 0.10% | 0.02% | 0.40% |
| | | Not Admitted | 2574 | 0.35% | 0.08% | 0.02% | 0.30% |
| | | Unknown | 226 | 0.44% | 0.10% | 0.02% | 0.29% |
| | | MD | 789 | 1.71% | 0.40% | 0.09% | 1.80% |
| | | RN | 2826 | 3.71% | 0.97% | 0.14% | 6.07% |
| | | STAFF | 3166 | 4.44% | 1.57% | 0.15% | 7.29% |
| | STAFF | Admitted | 361 | 0.37% | 0.14% | 0.03% | 0.40% |
| | | Not Admitted | 3080 | 0.73% | 0.22% | 0.04% | 0.82% |
| | | Unknown | 99 | 0.34% | 0.14% | 0.02% | 0.39% |
| | | MD | 513 | 1.24% | 0.28% | 0.05% | 1.38% |
| | | RN | 3166 | 4.44% | 1.63% | 0.14% | 7.30% |
| | | STAFF | 4112 | 6.35% | 4.28% | 0.44% | 10.29% |

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1 | Q3 |
|---|---|---|---|---|---|---|---|
| Weekend | Admitted | Admitted | 236 | 0.45% | 0.07% | 0.01% | 0.40% |
| | | Not Admitted | 539 | 0.41% | 0.12% | 0.01% | 0.50% |
| | | Unknown | 61 | 0.40% | 0.10% | 0.01% | 0.55% |
| | | MD | 169 | 0.59% | 0.14% | 0.02% | 0.64% |
| | | RN | 245 | 0.37% | 0.06% | 0.01% | 0.32% |
| | | STAFF | 100 | 0.35% | 0.10% | 0.02% | 0.44% |
| | Not Admitted | Admitted | 539 | 0.40% | 0.12% | 0.02% | 0.48% |
| | | Not Admitted | 2584 | 0.34% | 0.11% | 0.02% | 0.37% |
| | | Unknown | 195 | 0.34% | 0.07% | 0.01% | 0.35% |
| | | MD | 368 | 0.49% | 0.14% | 0.02% | 0.49% |
| | | RN | 741 | 0.35% | 0.08% | 0.02% | 0.25% |
| | | STAFF | 633 | 0.33% | 0.13% | 0.02% | 0.34% |
| | Unknown | Admitted | 61 | 0.39% | 0.10% | 0.02% | 0.50% |
| | | Not Admitted | 195 | 0.34% | 0.06% | 0.01% | 0.31% |
| | | Unknown | 12 | 0.75% | 0.25% | 0.03% | 1.84% |
| | | MD | 55 | 0.39% | 0.20% | 0.05% | 0.62% |
| | | RN | 66 | 0.36% | 0.11% | 0.02% | 0.46% |
| | | STAFF | 19 | 0.10% | 0.04% | 0.03% | 0.12% |
| | MD | Admitted | 169 | 0.57% | 0.14% | 0.02% | 0.61% |
| | | Not Admitted | 368 | 0.50% | 0.15% | 0.02% | 0.51% |
| | | Unknown | 55 | 0.41% | 0.25% | 0.05% | 0.68% |
| | | MD | 120 | 3.28% | 1.48% | 0.18% | 4.44% |
| | | RN | 251 | 1.88% | 0.40% | 0.09% | 1.80% |
| | | STAFF | 145 | 1.38% | 0.15% | 0.03% | 0.83% |
| | RN | Admitted | 245 | 0.37% | 0.07% | 0.01% | 0.34% |
| | | Not Admitted | 741 | 0.35% | 0.08% | 0.02% | 0.25% |
| | | Unknown | 66 | 0.34% | 0.07% | 0.02% | 0.46% |
| | | MD | 251 | 1.87% | 0.41% | 0.09% | 1.84% |
| | | RN | 856 | 2.95% | 0.61% | 0.11% | 3.87% |
| | | STAFF | 883 | 4.24% | 1.65% | 0.17% | 7.42% |
| | STAFF | Admitted | 100 | 0.35% | 0.10% | 0.02% | 0.44% |
| | | Not Admitted | 633 | 0.34% | 0.12% | 0.02% | 0.35% |
| | | Unknown | 19 | 0.09% | 0.05% | 0.02% | 0.14% |
| | | MD | 145 | 1.36% | 0.15% | 0.03% | 0.86% |
| | | RN | 883 | 4.24% | 1.68% | 0.19% | 7.46% |
| | | STAFF | 1068 | 6.51% | 4.31% | 0.72% | 9.40% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 14.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients for weekday and weekend shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Weekday | [3]Patients | Patients | 15078 | 0.44% | 0.13% | 0.02% | 0.50% |
| | | MD | 1832 | 0.64% | 0.10% | 0.02% | 0.49% |
| | | RN | 3399 | 0.38% | 0.09% | 0.02% | 0.32% |
| | | STAFF | 3540 | 0.68% | 0.21% | 0.04% | 0.72% |
| | MD | Patients | 1832 | 0.64% | 0.11% | 0.02% | 0.50% |
| | | MD | 390 | 4.78% | 2.77% | 0.59% | 7.68% |
| | | RN | 789 | 1.70% | 0.39% | 0.09% | 1.78% |
| | | STAFF | 513 | 1.23% | 0.26% | 0.05% | 1.36% |
| | RN | Patients | 3399 | 0.39% | 0.09% | 0.02% | 0.32% |
| | | MD | 789 | 1.71% | 0.40% | 0.09% | 1.80% |
| | | RN | 2826 | 3.71% | 0.97% | 0.14% | 6.07% |
| | | STAFF | 3166 | 4.44% | 1.57% | 0.15% | 7.29% |
| | STAFF | Patients | 3540 | 0.68% | 0.21% | 0.04% | 0.74% |
| | | MD | 513 | 1.24% | 0.28% | 0.05% | 1.38% |
| | | RN | 3166 | 4.44% | 1.63% | 0.14% | 7.30% |
| | | STAFF | 4112 | 6.35% | 4.28% | 0.44% | 10.29% |
| Weekend | Patients | Patients | 4422 | 0.36% | 0.11% | 0.02% | 0.40% |
| | | MD | 592 | 0.51% | 0.14% | 0.02% | 0.56% |
| | | RN | 1052 | 0.35% | 0.07% | 0.02% | 0.29% |
| | | STAFF | 752 | 0.33% | 0.12% | 0.02% | 0.34% |
| | MD | Patients | 592 | 0.51% | 0.15% | 0.02% | 0.56% |
| | | MD | 120 | 3.28% | 1.48% | 0.18% | 4.44% |
| | | RN | 251 | 1.88% | 0.40% | 0.09% | 1.80% |
| | | STAFF | 145 | 1.38% | 0.15% | 0.03% | 0.83% |
| | RN | Patients | 1052 | 0.35% | 0.07% | 0.02% | 0.29% |
| | | MD | 251 | 1.87% | 0.41% | 0.09% | 1.84% |
| | | RN | 856 | 2.95% | 0.61% | 0.11% | 3.87% |
| | | STAFF | 883 | 4.24% | 1.65% | 0.17% | 7.42% |
| | STAFF | Patients | 752 | 0.33% | 0.12% | 0.02% | 0.35% |
| | | MD | 145 | 1.36% | 0.15% | 0.03% | 0.86% |
| | | RN | 883 | 4.24% | 1.68% | 0.19% | 7.46% |
| | | STAFF | 1068 | 6.51% | 4.31% | 0.72% | 9.40% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 15.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients and combining three types of healthcare workers for weekday and weekend shifts.

| **Type of shift** | **Type of Infectious Node** | **Type of Infected Node** | **N** | **Mean** | **Median** | **Q1[1]** | **Q3[2]** |
|---|---|---|---|---|---|---|---|
| Weekday | [3]Patients | Patients | 15078 | 0.44% | 0.13% | 0.02% | 0.50% |
| | | HCW | 8771 | 0.56% | 0.13% | 0.02% | 0.48% |
| | [4]HCW | Patients | 8771 | 0.56% | 0.13% | 0.02% | 0.48% |
| | | HCW | 16264 | 4.34% | 1.41% | 0.16% | 7.17% |
| Weekend | Patients | Patients | 4422 | 0.36% | 0.11% | 0.02% | 0.40% |
| | | HCW | 2396 | 0.38% | 0.10% | 0.02% | 0.36% |
| | HCW | Patients | 2396 | 0.39% | 0.10% | 0.02% | 0.37% |
| | | HCW | 4602 | 4.06% | 1.38% | 0.16% | 6.40% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 16.** Percentage of getting infected in different infection scenarios in individual level for H1N1 season and not H1N1 season shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| H1N1 Season | Admitted | Admitted | 456 | 0.44% | 0.10% | 0.02% | 0.38% |
| | | Not Admitted | 1367 | 0.39% | 0.10% | 0.01% | 0.43% |
| | | Unknown | 145 | 0.42% | 0.09% | 0.02% | 0.55% |
| | | MD | 399 | 0.76% | 0.13% | 0.02% | 0.66% |
| | | RN | 532 | 0.40% | 0.10% | 0.02% | 0.39% |
| | | STAFF | 327 | 0.40% | 0.18% | 0.04% | 0.44% |
| | Not Admitted | Admitted | 1367 | 0.39% | 0.10% | 0.01% | 0.44% |
| | | Not Admitted | 7224 | 0.46% | 0.16% | 0.03% | 0.56% |
| | | Unknown | 511 | 0.38% | 0.09% | 0.01% | 0.41% |
| | | MD | 871 | 0.58% | 0.09% | 0.02% | 0.46% |
| | | RN | 2125 | 0.35% | 0.08% | 0.02% | 0.30% |
| | | STAFF | 2687 | 0.79% | 0.25% | 0.06% | 0.89% |
| | Unknown | Admitted | 145 | 0.41% | 0.09% | 0.01% | 0.52% |
| | | Not Admitted | 511 | 0.38% | 0.09% | 0.01% | 0.44% |
| | | Unknown | 62 | 0.37% | 0.14% | 0.02% | 0.51% |
| | | MD | 121 | 0.41% | 0.08% | 0.02% | 0.50% |
| | | RN | 172 | 0.40% | 0.09% | 0.02% | 0.39% |
| | | STAFF | 69 | 0.24% | 0.11% | 0.03% | 0.18% |
| | MD | Admitted | 399 | 0.76% | 0.16% | 0.02% | 0.63% |
| | | Not Admitted | 871 | 0.58% | 0.10% | 0.02% | 0.47% |
| | | Unknown | 121 | 0.41% | 0.10% | 0.01% | 0.52% |
| | | MD | 300 | 4.41% | 2.39% | 0.38% | 7.27% |
| | | RN | 545 | 1.54% | 0.39% | 0.09% | 1.70% |
| | | STAFF | 393 | 1.25% | 0.20% | 0.04% | 1.06% |
| | RN | Admitted | 532 | 0.40% | 0.09% | 0.02% | 0.38% |
| | | Not Admitted | 2125 | 0.35% | 0.08% | 0.02% | 0.30% |
| | | Unknown | 172 | 0.40% | 0.09% | 0.02% | 0.38% |
| | | MD | 545 | 1.54% | 0.41% | 0.10% | 1.65% |
| | | RN | 1784 | 3.21% | 0.88% | 0.14% | 5.08% |
| | | STAFF | 2161 | 3.57% | 1.42% | 0.16% | 5.78% |
| | STAFF | Admitted | 327 | 0.40% | 0.16% | 0.04% | 0.46% |
| | | Not Admitted | 2687 | 0.79% | 0.25% | 0.06% | 0.91% |
| | | Unknown | 69 | 0.25% | 0.12% | 0.03% | 0.19% |
| | | MD | 393 | 1.24% | 0.21% | 0.04% | 1.07% |
| | | RN | 2161 | 3.57% | 1.39% | 0.16% | 5.82% |
| | | STAFF | 2874 | 5.85% | 4.40% | 0.74% | 9.11% |

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1 | Q3 |
|---|---|---|---|---|---|---|---|
| Not H1N1 Season | Admitted | Admitted | 356 | 0.58% | 0.05% | 0.01% | 0.45% |
| | | Not Admitted | 880 | 0.42% | 0.10% | 0.01% | 0.41% |
| | | Unknown | 107 | 0.35% | 0.06% | 0.02% | 0.43% |
| | | MD | 256 | 0.77% | 0.12% | 0.02% | 0.67% |
| | | RN | 312 | 0.58% | 0.07% | 0.02% | 0.41% |
| | | STAFF | 134 | 0.28% | 0.06% | 0.01% | 0.35% |
| | Not Admitted | Admitted | 880 | 0.42% | 0.09% | 0.01% | 0.41% |
| | | Not Admitted | 4566 | 0.38% | 0.12% | 0.02% | 0.43% |
| | | Unknown | 383 | 0.41% | 0.08% | 0.02% | 0.38% |
| | | MD | 693 | 0.49% | 0.12% | 0.02% | 0.44% |
| | | RN | 1190 | 0.34% | 0.07% | 0.01% | 0.29% |
| | | STAFF | 1026 | 0.35% | 0.09% | 0.01% | 0.31% |
| | Unknown | Admitted | 107 | 0.35% | 0.06% | 0.02% | 0.41% |
| | | Not Admitted | 383 | 0.40% | 0.07% | 0.02% | 0.35% |
| | | Unknown | 50 | 1.04% | 0.24% | 0.03% | 1.36% |
| | | MD | 84 | 0.93% | 0.21% | 0.03% | 0.55% |
| | | RN | 120 | 0.46% | 0.12% | 0.03% | 0.39% |
| | | STAFF | 49 | 0.36% | 0.14% | 0.02% | 0.38% |
| | MD | Admitted | 256 | 0.75% | 0.11% | 0.02% | 0.60% |
| | | Not Admitted | 693 | 0.50% | 0.13% | 0.03% | 0.48% |
| | | Unknown | 84 | 0.96% | 0.24% | 0.02% | 0.57% |
| | | MD | 210 | 4.45% | 2.32% | 0.85% | 7.52% |
| | | RN | 495 | 1.97% | 0.39% | 0.08% | 1.99% |
| | | STAFF | 265 | 1.29% | 0.35% | 0.06% | 1.33% |
| | RN | Admitted | 312 | 0.59% | 0.07% | 0.01% | 0.39% |
| | | Not Admitted | 1190 | 0.34% | 0.07% | 0.01% | 0.29% |
| | | Unknown | 120 | 0.44% | 0.11% | 0.03% | 0.33% |
| | | MD | 495 | 1.97% | 0.40% | 0.08% | 1.96% |
| | | RN | 1898 | 3.84% | 0.86% | 0.13% | 6.20% |
| | | STAFF | 1888 | 5.33% | 2.03% | 0.15% | 9.16% |
| | STAFF | Admitted | 134 | 0.29% | 0.07% | 0.01% | 0.37% |
| | | Not Admitted | 1026 | 0.35% | 0.09% | 0.01% | 0.31% |
| | | Unknown | 49 | 0.38% | 0.15% | 0.02% | 0.41% |
| | | MD | 265 | 1.30% | 0.35% | 0.06% | 1.35% |
| | | RN | 1888 | 5.34% | 1.99% | 0.15% | 9.15% |
| | | STAFF | 2306 | 7.05% | 3.86% | 0.32% | 12.70% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 17.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients for H1N1 season and not H1N1 season shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| H1N1 Season | [3]Patients | Patients | 11788 | 0.44% | 0.13% | 0.02% | 0.51% |
| | | MD | 1391 | 0.62% | 0.10% | 0.02% | 0.53% |
| | | RN | 2829 | 0.36% | 0.09% | 0.02% | 0.31% |
| | | STAFF | 3083 | 0.73% | 0.24% | 0.05% | 0.83% |
| | MD | Patients | 1391 | 0.62% | 0.11% | 0.02% | 0.55% |
| | | MD | 300 | 4.41% | 2.39% | 0.38% | 7.27% |
| | | RN | 545 | 1.54% | 0.39% | 0.09% | 1.70% |
| | | STAFF | 393 | 1.25% | 0.20% | 0.04% | 1.06% |
| | RN | Patients | 2829 | 0.37% | 0.09% | 0.02% | 0.31% |
| | | MD | 545 | 1.54% | 0.41% | 0.10% | 1.65% |
| | | RN | 1784 | 3.21% | 0.88% | 0.14% | 5.08% |
| | | STAFF | 2161 | 3.57% | 1.42% | 0.16% | 5.78% |
| | STAFF | Patients | 3083 | 0.73% | 0.23% | 0.05% | 0.82% |
| | | MD | 393 | 1.24% | 0.21% | 0.04% | 1.07% |
| | | RN | 2161 | 3.57% | 1.39% | 0.16% | 5.82% |
| | | STAFF | 2874 | 5.85% | 4.40% | 0.74% | 9.11% |
| Not H1N1 Season | Patients | Patients | 7712 | 0.40% | 0.11% | 0.02% | 0.42% |
| | | MD | 1033 | 0.60% | 0.13% | 0.02% | 0.48% |
| | | RN | 1622 | 0.40% | 0.08% | 0.01% | 0.30% |
| | | STAFF | 1209 | 0.34% | 0.09% | 0.01% | 0.31% |
| | MD | Patients | 1033 | 0.60% | 0.13% | 0.02% | 0.51% |
| | | MD | 210 | 4.45% | 2.32% | 0.85% | 7.52% |
| | | RN | 495 | 1.97% | 0.39% | 0.08% | 1.99% |
| | | STAFF | 265 | 1.29% | 0.35% | 0.06% | 1.33% |
| | RN | Patients | 1622 | 0.40% | 0.07% | 0.01% | 0.31% |
| | | MD | 495 | 1.97% | 0.40% | 0.08% | 1.96% |
| | | RN | 1898 | 3.84% | 0.86% | 0.13% | 6.20% |
| | | STAFF | 1888 | 5.33% | 2.03% | 0.15% | 9.16% |
| | STAFF | Patients | 1209 | 0.34% | 0.09% | 0.01% | 0.31% |
| | | MD | 265 | 1.30% | 0.35% | 0.06% | 1.35% |
| | | RN | 1888 | 5.34% | 1.99% | 0.15% | 9.15% |
| | | STAFF | 2306 | 7.05% | 3.86% | 0.32% | 12.70% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 18.** Percentage of getting infected in different infection scenarios in individual level after combining three types of patients and combining three types of healthcare workers for H1N1 season and not H1N1 season shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| H1N1 Season | [3]Patients | Patients | 11788 | 0.44% | 0.13% | 0.02% | 0.51% |
| | | HCW | 7303 | 0.57% | 0.14% | 0.03% | 0.53% |
| | [4]HCW | Patients | 7303 | 0.57% | 0.14% | 0.03% | 0.53% |
| | | HCW | 11156 | 3.76% | 1.40% | 0.18% | 6.19% |
| Not H1N1 Season | Patients | Patients | 7712 | 0.40% | 0.11% | 0.02% | 0.42% |
| | | HCW | 3864 | 0.43% | 0.09% | 0.02% | 0.35% |
| | HCW | Patients | 3864 | 0.43% | 0.09% | 0.02% | 0.35% |
| | | HCW | 9710 | 4.87% | 1.38% | 0.15% | 8.35% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 19.** Median percentage of getting infected in different infection scenarios in shift level for day and night shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Day | Admitted | Admitted | 19 | 0.12% | 0.12% | 0.06% | 0.17% |
| | | Not Admitted | 20 | 0.10% | 0.09% | 0.05% | 0.14% |
| | | Unknown | 19 | 0.13% | 0.09% | 0.03% | 0.10% |
| | | MD | 20 | 0.15% | 0.10% | 0.06% | 0.20% |
| | | RN | 20 | 0.11% | 0.11% | 0.05% | 0.17% |
| | | STAFF | 17 | 0.20% | 0.14% | 0.03% | 0.21% |
| | Not Admitted | Admitted | 20 | 0.09% | 0.08% | 0.05% | 0.14% |
| | | Not Admitted | 20 | 0.14% | 0.12% | 0.07% | 0.19% |
| | | Unknown | 19 | 0.09% | 0.07% | 0.04% | 0.11% |
| | | MD | 20 | 0.23% | 0.08% | 0.05% | 0.13% |
| | | RN | 20 | 0.08% | 0.07% | 0.06% | 0.10% |
| | | STAFF | 20 | 0.21% | 0.18% | 0.11% | 0.27% |
| | Unknown | Admitted | 19 | 0.13% | 0.07% | 0.03% | 0.12% |
| | | Not Admitted | 19 | 0.08% | 0.06% | 0.05% | 0.10% |
| | | Unknown | 14 | 0.26% | 0.11% | 0.04% | 0.40% |
| | | MD | 18 | 0.19% | 0.17% | 0.06% | 0.30% |
| | | RN | 19 | 0.15% | 0.10% | 0.06% | 0.14% |
| | | STAFF | 13 | 0.23% | 0.11% | 0.04% | 0.16% |
| | MD | Admitted | 20 | 0.15% | 0.11% | 0.06% | 0.19% |
| | | Not Admitted | 20 | 0.24% | 0.09% | 0.05% | 0.14% |
| | | Unknown | 18 | 0.21% | 0.18% | 0.03% | 0.29% |
| | | MD | 20 | 3.47% | 3.27% | 1.36% | 5.12% |
| | | RN | 20 | 0.45% | 0.35% | 0.22% | 0.53% |
| | | STAFF | 20 | 0.77% | 0.18% | 0.06% | 0.69% |
| | RN | Admitted | 20 | 0.11% | 0.11% | 0.05% | 0.16% |
| | | Not Admitted | 20 | 0.08% | 0.07% | 0.06% | 0.10% |
| | | Unknown | 19 | 0.15% | 0.10% | 0.04% | 0.16% |
| | | MD | 20 | 0.47% | 0.37% | 0.25% | 0.53% |
| | | RN | 20 | 1.23% | 0.69% | 0.40% | 1.25% |
| | | STAFF | 20 | 1.74% | 1.32% | 0.79% | 2.53% |
| | STAFF | Admitted | 17 | 0.20% | 0.14% | 0.06% | 0.20% |
| | | Not Admitted | 20 | 0.21% | 0.17% | 0.11% | 0.27% |
| | | Unknown | 13 | 0.25% | 0.12% | 0.05% | 0.16% |
| | | MD | 20 | 0.79% | 0.17% | 0.06% | 0.72% |
| | | RN | 20 | 1.72% | 1.43% | 0.70% | 2.50% |
| | | STAFF | 20 | 5.26% | 4.84% | 3.08% | 7.31% |

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1 | Q3 |
|---|---|---|---|---|---|---|---|
| Night | Admitted | Admitted | 15 | 0.11% | 0.07% | 0.03% | 0.13% |
| | | Not Admitted | 15 | 0.11% | 0.10% | 0.06% | 0.16% |
| | | Unknown | 13 | 0.31% | 0.20% | 0.02% | 0.30% |
| | | MD | 15 | 0.29% | 0.15% | 0.04% | 0.34% |
| | | RN | 15 | 0.17% | 0.05% | 0.04% | 0.11% |
| | | STAFF | 13 | 0.12% | 0.06% | 0.04% | 0.23% |
| | Not Admitted | Admitted | 15 | 0.11% | 0.10% | 0.05% | 0.13% |
| | | Not Admitted | 15 | 0.13% | 0.12% | 0.08% | 0.18% |
| | | Unknown | 13 | 0.09% | 0.05% | 0.03% | 0.14% |
| | | MD | 15 | 0.12% | 0.09% | 0.04% | 0.19% |
| | | RN | 15 | 0.09% | 0.09% | 0.06% | 0.10% |
| | | STAFF | 15 | 0.28% | 0.11% | 0.04% | 0.47% |
| | Unknown | Admitted | 13 | 0.28% | 0.17% | 0.02% | 0.29% |
| | | Not Admitted | 13 | 0.09% | 0.05% | 0.03% | 0.17% |
| | | Unknown | 9 | 1.34% | 0.19% | 0.16% | 2.03% |
| | | MD | 12 | 0.43% | 0.09% | 0.07% | 0.20% |
| | | RN | 13 | 0.19% | 0.10% | 0.05% | 0.25% |
| | | STAFF | 7 | 0.12% | 0.07% | 0.03% | 0.17% |
| | MD | Admitted | 15 | 0.29% | 0.12% | 0.05% | 0.41% |
| | | Not Admitted | 15 | 0.14% | 0.11% | 0.06% | 0.21% |
| | | Unknown | 12 | 0.47% | 0.12% | 0.10% | 0.25% |
| | | MD | 14 | 4.02% | 1.75% | 1.37% | 5.83% |
| | | RN | 14 | 0.55% | 0.51% | 0.06% | 0.86% |
| | | STAFF | 14 | 0.68% | 0.22% | 0.07% | 0.75% |
| | RN | Admitted | 15 | 0.16% | 0.07% | 0.04% | 0.13% |
| | | Not Admitted | 15 | 0.09% | 0.10% | 0.05% | 0.10% |
| | | Unknown | 13 | 0.17% | 0.11% | 0.04% | 0.27% |
| | | MD | 14 | 0.56% | 0.49% | 0.09% | 0.95% |
| | | RN | 15 | 1.34% | 1.38% | 0.40% | 1.83% |
| | | STAFF | 15 | 1.83% | 1.91% | 1.03% | 2.31% |
| | STAFF | Admitted | 13 | 0.12% | 0.07% | 0.05% | 0.19% |
| | | Not Admitted | 15 | 0.28% | 0.11% | 0.03% | 0.42% |
| | | Unknown | 7 | 0.13% | 0.09% | 0.03% | 0.18% |
| | | MD | 14 | 0.66% | 0.22% | 0.08% | 0.82% |
| | | RN | 15 | 1.83% | 1.88% | 1.17% | 2.31% |
| | | STAFF | 15 | 5.21% | 4.83% | 2.40% | 7.16% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 20.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients for day and night shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Day | [3]Patients | Patients | 20 | 0.12% | 0.10% | 0.07% | 0.15% |
| | | MD | 20 | 0.24% | 0.09% | 0.05% | 0.15% |
| | | RN | 20 | 0.08% | 0.08% | 0.06% | 0.11% |
| | | STAFF | 20 | 0.20% | 0.17% | 0.07% | 0.27% |
| | MD | Patients | 20 | 0.23% | 0.09% | 0.06% | 0.15% |
| | | MD | 20 | 3.47% | 3.27% | 1.36% | 5.12% |
| | | RN | 20 | 0.45% | 0.35% | 0.22% | 0.53% |
| | | STAFF | 20 | 0.77% | 0.18% | 0.06% | 0.69% |
| | RN | Patients | 20 | 0.08% | 0.08% | 0.05% | 0.10% |
| | | MD | 20 | 0.47% | 0.37% | 0.25% | 0.53% |
| | | RN | 20 | 1.23% | 0.69% | 0.40% | 1.25% |
| | | STAFF | 20 | 1.74% | 1.32% | 0.79% | 2.53% |
| | STAFF | Patients | 20 | 0.19% | 0.17% | 0.07% | 0.24% |
| | | MD | 20 | 0.79% | 0.17% | 0.06% | 0.72% |
| | | RN | 20 | 1.72% | 1.43% | 0.70% | 2.50% |
| | | STAFF | 20 | 5.26% | 4.84% | 3.08% | 7.31% |
| Night | Patients | Patients | 15 | 0.12% | 0.11% | 0.08% | 0.16% |
| | | MD | 15 | 0.12% | 0.09% | 0.04% | 0.19% |
| | | RN | 15 | 0.08% | 0.07% | 0.06% | 0.09% |
| | | STAFF | 15 | 0.26% | 0.11% | 0.04% | 0.29% |
| | MD | Patients | 15 | 0.12% | 0.09% | 0.05% | 0.21% |
| | | MD | 14 | 4.02% | 1.75% | 1.37% | 5.83% |
| | | RN | 14 | 0.55% | 0.51% | 0.06% | 0.86% |
| | | STAFF | 14 | 0.68% | 0.22% | 0.07% | 0.75% |
| | RN | Patients | 15 | 0.09% | 0.08% | 0.06% | 0.10% |
| | | MD | 14 | 0.56% | 0.49% | 0.09% | 0.95% |
| | | RN | 15 | 1.34% | 1.38% | 0.40% | 1.83% |
| | | STAFF | 15 | 1.83% | 1.91% | 1.03% | 2.31% |
| | STAFF | Patients | 15 | 0.26% | 0.11% | 0.04% | 0.28% |
| | | MD | 14 | 0.66% | 0.22% | 0.08% | 0.82% |
| | | RN | 15 | 1.83% | 1.88% | 1.17% | 2.31% |
| | | STAFF | 15 | 5.21% | 4.83% | 2.40% | 7.16% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 21.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients and combining three types of healthcare workers for day and night shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Day | [3]Patients | Patients | 20 | 0.12% | 0.10% | 0.07% | 0.15% |
| | | HCW | 20 | 0.11% | 0.10% | 0.07% | 0.17% |
| | [4]HCW | Patients | 20 | 0.11% | 0.10% | 0.07% | 0.16% |
| | | HCW | 20 | 1.49% | 1.25% | 0.98% | 1.85% |
| Night | Patients | Patients | 15 | 0.12% | 0.11% | 0.08% | 0.16% |
| | | HCW | 15 | 0.12% | 0.09% | 0.07% | 0.18% |
| | HCW | Patients | 15 | 0.12% | 0.10% | 0.08% | 0.17% |
| | | HCW | 15 | 1.75% | 1.69% | 1.32% | 2.31% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 22.** Median percentage of getting infected in different infection scenarios in shift level for weekday and weekend shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Weekday | Admitted | Admitted | 25 | 0.14% | 0.12% | 0.07% | 0.17% |
| | | Not Admitted | 26 | 0.10% | 0.10% | 0.06% | 0.13% |
| | | Unknown | 23 | 0.14% | 0.09% | 0.03% | 0.20% |
| | | MD | 26 | 0.23% | 0.11% | 0.05% | 0.24% |
| | | RN | 26 | 0.16% | 0.10% | 0.05% | 0.19% |
| | | STAFF | 22 | 0.16% | 0.09% | 0.03% | 0.21% |
| | Not Admitted | Admitted | 26 | 0.09% | 0.10% | 0.05% | 0.13% |
| | | Not Admitted | 26 | 0.14% | 0.14% | 0.08% | 0.21% |
| | | Unknown | 24 | 0.09% | 0.06% | 0.03% | 0.15% |
| | | MD | 26 | 0.20% | 0.08% | 0.04% | 0.12% |
| | | RN | 26 | 0.09% | 0.08% | 0.05% | 0.11% |
| | | STAFF | 26 | 0.27% | 0.19% | 0.07% | 0.31% |
| | Unknown | Admitted | 23 | 0.13% | 0.07% | 0.02% | 0.17% |
| | | Not Admitted | 24 | 0.09% | 0.06% | 0.04% | 0.15% |
| | | Unknown | 21 | 0.69% | 0.16% | 0.04% | 0.40% |
| | | MD | 21 | 0.32% | 0.13% | 0.02% | 0.20% |
| | | RN | 24 | 0.16% | 0.09% | 0.05% | 0.20% |
| | | STAFF | 17 | 0.21% | 0.11% | 0.05% | 0.16% |
| | MD | Admitted | 26 | 0.24% | 0.11% | 0.06% | 0.23% |
| | | Not Admitted | 26 | 0.21% | 0.09% | 0.05% | 0.14% |
| | | Unknown | 21 | 0.35% | 0.11% | 0.02% | 0.25% |
| | | MD | 25 | 4.18% | 3.67% | 1.37% | 5.83% |
| | | RN | 25 | 0.47% | 0.32% | 0.18% | 0.65% |
| | | STAFF | 25 | 0.47% | 0.23% | 0.07% | 0.75% |
| | RN | Admitted | 26 | 0.16% | 0.10% | 0.07% | 0.20% |
| | | Not Admitted | 26 | 0.08% | 0.08% | 0.05% | 0.11% |
| | | Unknown | 24 | 0.17% | 0.11% | 0.04% | 0.17% |
| | | MD | 25 | 0.49% | 0.36% | 0.23% | 0.61% |
| | | RN | 26 | 1.41% | 0.94% | 0.40% | 1.63% |
| | | STAFF | 26 | 1.77% | 1.74% | 0.95% | 2.40% |
| | STAFF | Admitted | 22 | 0.16% | 0.08% | 0.05% | 0.20% |
| | | Not Admitted | 26 | 0.27% | 0.19% | 0.07% | 0.30% |
| | | Unknown | 17 | 0.22% | 0.11% | 0.04% | 0.16% |
| | | MD | 25 | 0.46% | 0.24% | 0.08% | 0.82% |
| | | RN | 26 | 1.75% | 1.63% | 0.95% | 2.41% |
| | | STAFF | 26 | 5.14% | 4.74% | 2.81% | 7.16% |

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1 | Q3 |
|---|---|---|---|---|---|---|---|
| Weekend | Admitted | Admitted | 9 | 0.07% | 0.04% | 0.03% | 0.07% |
| | | Not Admitted | 9 | 0.12% | 0.09% | 0.05% | 0.19% |
| | | Unknown | 9 | 0.37% | 0.10% | 0.02% | 0.46% |
| | | MD | 9 | 0.16% | 0.12% | 0.10% | 0.18% |
| | | RN | 9 | 0.07% | 0.04% | 0.03% | 0.10% |
| | | STAFF | 8 | 0.17% | 0.13% | 0.04% | 0.30% |
| | Not Admitted | Admitted | 9 | 0.11% | 0.07% | 0.05% | 0.19% |
| | | Not Admitted | 9 | 0.11% | 0.11% | 0.09% | 0.13% |
| | | Unknown | 8 | 0.07% | 0.08% | 0.04% | 0.09% |
| | | MD | 9 | 0.15% | 0.09% | 0.08% | 0.21% |
| | | RN | 9 | 0.08% | 0.07% | 0.06% | 0.09% |
| | | STAFF | 9 | 0.15% | 0.13% | 0.10% | 0.15% |
| | Unknown | Admitted | 9 | 0.35% | 0.11% | 0.05% | 0.44% |
| | | Not Admitted | 8 | 0.06% | 0.06% | 0.04% | 0.08% |
| | | Unknown | 2 | 0.57% | 0.57% | 0.18% | 0.97% |
| | | MD | 9 | 0.22% | 0.11% | 0.08% | 0.32% |
| | | RN | 8 | 0.18% | 0.10% | 0.06% | 0.35% |
| | | STAFF | 3 | 0.09% | 0.04% | 0.02% | 0.22% |
| | MD | Admitted | 9 | 0.15% | 0.12% | 0.09% | 0.20% |
| | | Not Admitted | 9 | 0.15% | 0.11% | 0.07% | 0.17% |
| | | Unknown | 9 | 0.25% | 0.15% | 0.12% | 0.29% |
| | | MD | 9 | 2.35% | 1.57% | 1.45% | 2.88% |
| | | RN | 9 | 0.55% | 0.51% | 0.37% | 0.79% |
| | | STAFF | 9 | 1.49% | 0.14% | 0.07% | 0.23% |
| | RN | Admitted | 9 | 0.06% | 0.05% | 0.02% | 0.10% |
| | | Not Admitted | 9 | 0.08% | 0.07% | 0.06% | 0.10% |
| | | Unknown | 8 | 0.15% | 0.08% | 0.04% | 0.27% |
| | | MD | 9 | 0.55% | 0.46% | 0.34% | 0.94% |
| | | RN | 9 | 0.89% | 0.48% | 0.42% | 1.40% |
| | | STAFF | 9 | 1.80% | 1.85% | 1.03% | 2.17% |
| | STAFF | Admitted | 8 | 0.18% | 0.15% | 0.04% | 0.30% |
| | | Not Admitted | 9 | 0.14% | 0.14% | 0.09% | 0.15% |
| | | Unknown | 3 | 0.11% | 0.05% | 0.03% | 0.25% |
| | | MD | 9 | 1.50% | 0.18% | 0.06% | 0.21% |
| | | RN | 9 | 1.83% | 1.89% | 1.01% | 2.23% |
| | | STAFF | 9 | 5.51% | 5.03% | 2.92% | 7.03% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 23.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients for weekday and weekend shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Weekday | [3]Patients | Patients | 26 | 0.12% | 0.11% | 0.07% | 0.16% |
| | | MD | 26 | 0.21% | 0.09% | 0.05% | 0.18% |
| | | RN | 26 | 0.09% | 0.09% | 0.07% | 0.10% |
| | | STAFF | 26 | 0.26% | 0.18% | 0.06% | 0.29% |
| | MD | Patients | 26 | 0.21% | 0.09% | 0.06% | 0.17% |
| | | MD | 25 | 4.18% | 3.67% | 1.37% | 5.83% |
| | | RN | 25 | 0.47% | 0.32% | 0.18% | 0.65% |
| | | STAFF | 25 | 0.47% | 0.23% | 0.07% | 0.75% |
| | RN | Patients | 26 | 0.09% | 0.08% | 0.06% | 0.10% |
| | | MD | 25 | 0.49% | 0.36% | 0.23% | 0.61% |
| | | RN | 26 | 1.41% | 0.94% | 0.40% | 1.63% |
| | | STAFF | 26 | 1.77% | 1.74% | 0.95% | 2.40% |
| | STAFF | Patients | 26 | 0.25% | 0.18% | 0.07% | 0.28% |
| | | MD | 25 | 0.46% | 0.24% | 0.08% | 0.82% |
| | | RN | 26 | 1.75% | 1.63% | 0.95% | 2.41% |
| | | STAFF | 26 | 5.14% | 4.74% | 2.81% | 7.16% |
| Weekend | Patients | Patients | 9 | 0.10% | 0.09% | 0.07% | 0.14% |
| | | MD | 9 | 0.12% | 0.08% | 0.07% | 0.23% |
| | | RN | 9 | 0.07% | 0.06% | 0.05% | 0.09% |
| | | STAFF | 9 | 0.11% | 0.13% | 0.07% | 0.16% |
| | MD | Patients | 9 | 0.13% | 0.09% | 0.08% | 0.21% |
| | | MD | 9 | 2.35% | 1.57% | 1.45% | 2.88% |
| | | RN | 9 | 0.55% | 0.51% | 0.37% | 0.79% |
| | | STAFF | 9 | 1.49% | 0.14% | 0.07% | 0.23% |
| | RN | Patients | 9 | 0.07% | 0.07% | 0.05% | 0.10% |
| | | MD | 9 | 0.55% | 0.46% | 0.34% | 0.94% |
| | | RN | 9 | 0.89% | 0.48% | 0.42% | 1.40% |
| | | STAFF | 9 | 1.80% | 1.85% | 1.03% | 2.17% |
| | STAFF | Patients | 9 | 0.12% | 0.14% | 0.05% | 0.17% |
| | | MD | 9 | 1.50% | 0.18% | 0.06% | 0.21% |
| | | RN | 9 | 1.83% | 1.89% | 1.01% | 2.23% |
| | | STAFF | 9 | 5.51% | 5.03% | 2.92% | 7.03% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 24.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients and combining three types of healthcare workers for weekday and weekend shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| Weekday | [3]Patients | Patients | 26 | 0.12% | 0.11% | 0.07% | 0.16% |
| | | HCW | 26 | 0.12% | 0.12% | 0.07% | 0.19% |
| | [4]HCW | Patients | 26 | 0.12% | 0.11% | 0.08% | 0.19% |
| | | HCW | 26 | 1.65% | 1.54% | 1.10% | 2.15% |
| Weekend | Patients | Patients | 9 | 0.10% | 0.09% | 0.07% | 0.14% |
| | | HCW | 9 | 0.09% | 0.09% | 0.08% | 0.11% |
| | HCW | Patients | 9 | 0.09% | 0.09% | 0.07% | 0.12% |
| | | HCW | 9 | 1.47% | 1.31% | 1.04% | 1.93% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

**Table 25.** Median percentage of getting infected in different infection scenarios in shift level for H1N1 season and not H1N1 season shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| H1N1 Season | Admitted | Admitted | 19 | 0.12% | 0.13% | 0.06% | 0.16% |
| | | Not Admitted | 20 | 0.10% | 0.10% | 0.06% | 0.14% |
| | | Unknown | 18 | 0.28% | 0.10% | 0.03% | 0.36% |
| | | MD | 20 | 0.16% | 0.12% | 0.05% | 0.23% |
| | | RN | 20 | 0.10% | 0.10% | 0.05% | 0.13% |
| | | STAFF | 19 | 0.19% | 0.14% | 0.04% | 0.24% |
| | Not Admitted | Admitted | 20 | 0.10% | 0.09% | 0.06% | 0.14% |
| | | Not Admitted | 20 | 0.15% | 0.14% | 0.09% | 0.22% |
| | | Unknown | 18 | 0.09% | 0.07% | 0.03% | 0.13% |
| | | MD | 20 | 0.24% | 0.08% | 0.05% | 0.16% |
| | | RN | 20 | 0.09% | 0.07% | 0.06% | 0.10% |
| | | STAFF | 20 | 0.28% | 0.23% | 0.15% | 0.40% |
| | Unknown | Admitted | 18 | 0.26% | 0.10% | 0.02% | 0.32% |
| | | Not Admitted | 18 | 0.08% | 0.06% | 0.04% | 0.13% |
| | | Unknown | 12 | 0.29% | 0.18% | 0.04% | 0.35% |
| | | MD | 18 | 0.16% | 0.08% | 0.06% | 0.20% |
| | | RN | 18 | 0.15% | 0.09% | 0.05% | 0.21% |
| | | STAFF | 10 | 0.27% | 0.13% | 0.05% | 0.17% |
| | MD | Admitted | 20 | 0.16% | 0.11% | 0.05% | 0.22% |
| | | Not Admitted | 20 | 0.25% | 0.08% | 0.05% | 0.14% |
| | | Unknown | 18 | 0.19% | 0.11% | 0.03% | 0.25% |
| | | MD | 20 | 4.16% | 3.71% | 1.41% | 5.58% |
| | | RN | 20 | 0.53% | 0.45% | 0.18% | 0.81% |
| | | STAFF | 19 | 0.58% | 0.18% | 0.05% | 0.47% |
| | RN | Admitted | 20 | 0.10% | 0.09% | 0.06% | 0.12% |
| | | Not Admitted | 20 | 0.09% | 0.09% | 0.06% | 0.10% |
| | | Unknown | 18 | 0.15% | 0.10% | 0.03% | 0.15% |
| | | MD | 20 | 0.54% | 0.43% | 0.23% | 0.94% |
| | | RN | 20 | 1.34% | 0.86% | 0.38% | 1.53% |
| | | STAFF | 20 | 1.56% | 1.09% | 0.79% | 1.92% |
| | STAFF | Admitted | 19 | 0.20% | 0.16% | 0.06% | 0.22% |
| | | Not Admitted | 20 | 0.28% | 0.23% | 0.15% | 0.38% |
| | | Unknown | 10 | 0.29% | 0.13% | 0.05% | 0.18% |
| | | MD | 19 | 0.56% | 0.14% | 0.06% | 0.40% |
| | | RN | 20 | 1.53% | 1.09% | 0.79% | 1.96% |
| | | STAFF | 20 | 5.21% | 5.08% | 3.35% | 7.05% |

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1 | Q3 |
|---|---|---|---|---|---|---|---|
| Not H1N1 Season | Admitted | Admitted | 15 | 0.12% | 0.07% | 0.03% | 0.18% |
| | | Not Admitted | 15 | 0.11% | 0.09% | 0.05% | 0.16% |
| | | Unknown | 14 | 0.10% | 0.06% | 0.02% | 0.10% |
| | | MD | 15 | 0.28% | 0.12% | 0.05% | 0.37% |
| | | RN | 15 | 0.19% | 0.06% | 0.03% | 0.20% |
| | | STAFF | 11 | 0.12% | 0.05% | 0.02% | 0.21% |
| | Not Admitted | Admitted | 15 | 0.10% | 0.10% | 0.05% | 0.13% |
| | | Not Admitted | 15 | 0.11% | 0.10% | 0.07% | 0.14% |
| | | Unknown | 14 | 0.09% | 0.06% | 0.04% | 0.18% |
| | | MD | 15 | 0.11% | 0.09% | 0.04% | 0.19% |
| | | RN | 15 | 0.08% | 0.08% | 0.05% | 0.11% |
| | | STAFF | 15 | 0.19% | 0.10% | 0.04% | 0.13% |
| | Unknown | Admitted | 14 | 0.10% | 0.06% | 0.02% | 0.12% |
| | | Not Admitted | 14 | 0.08% | 0.06% | 0.04% | 0.10% |
| | | Unknown | 11 | 1.11% | 0.18% | 0.06% | 2.03% |
| | | MD | 12 | 0.48% | 0.17% | 0.08% | 0.28% |
| | | RN | 14 | 0.19% | 0.12% | 0.06% | 0.25% |
| | | STAFF | 10 | 0.11% | 0.09% | 0.02% | 0.11% |
| | MD | Admitted | 15 | 0.28% | 0.10% | 0.07% | 0.36% |
| | | Not Admitted | 15 | 0.12% | 0.11% | 0.06% | 0.16% |
| | | Unknown | 12 | 0.51% | 0.20% | 0.11% | 0.32% |
| | | MD | 14 | 3.03% | 1.94% | 1.37% | 4.78% |
| | | RN | 14 | 0.43% | 0.35% | 0.24% | 0.53% |
| | | STAFF | 15 | 0.93% | 0.24% | 0.07% | 0.91% |
| | RN | Admitted | 15 | 0.18% | 0.07% | 0.03% | 0.25% |
| | | Not Admitted | 15 | 0.08% | 0.07% | 0.05% | 0.11% |
| | | Unknown | 14 | 0.18% | 0.12% | 0.06% | 0.28% |
| | | MD | 14 | 0.45% | 0.36% | 0.29% | 0.57% |
| | | RN | 15 | 1.20% | 0.90% | 0.40% | 1.83% |
| | | STAFF | 15 | 2.06% | 2.02% | 1.46% | 2.69% |
| | STAFF | Admitted | 11 | 0.12% | 0.05% | 0.02% | 0.16% |
| | | Not Admitted | 15 | 0.18% | 0.09% | 0.04% | 0.14% |
| | | Unknown | 10 | 0.12% | 0.09% | 0.03% | 0.16% |
| | | MD | 15 | 0.95% | 0.24% | 0.07% | 0.96% |
| | | RN | 15 | 2.08% | 1.88% | 1.67% | 2.65% |
| | | STAFF | 15 | 5.28% | 3.61% | 2.40% | 8.03% |

[1]Lower quartiles. [2]Upper quartiles.

**Table 26.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients for H1N1 season and not H1N1 season shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| H1N1 Season | [3]Patients | Patients | 20 | 0.13% | 0.11% | 0.08% | 0.16% |
| | | MD | 20 | 0.23% | 0.07% | 0.05% | 0.15% |
| | | RN | 20 | 0.08% | 0.09% | 0.07% | 0.10% |
| | | STAFF | 20 | 0.26% | 0.20% | 0.15% | 0.30% |
| | MD | Patients | 20 | 0.23% | 0.08% | 0.05% | 0.15% |
| | | MD | 20 | 4.16% | 3.71% | 1.41% | 5.58% |
| | | RN | 20 | 0.53% | 0.45% | 0.18% | 0.81% |
| | | STAFF | 19 | 0.58% | 0.18% | 0.05% | 0.47% |
| | RN | Patients | 20 | 0.08% | 0.09% | 0.07% | 0.10% |
| | | MD | 20 | 0.54% | 0.43% | 0.23% | 0.94% |
| | | RN | 20 | 1.34% | 0.86% | 0.38% | 1.53% |
| | | STAFF | 20 | 1.56% | 1.09% | 0.79% | 1.92% |
| | STAFF | Patients | 20 | 0.25% | 0.21% | 0.15% | 0.29% |
| | | MD | 19 | 0.56% | 0.14% | 0.06% | 0.40% |
| | | RN | 20 | 1.53% | 1.09% | 0.79% | 1.96% |
| | | STAFF | 20 | 5.21% | 5.08% | 3.35% | 7.05% |
| Not H1N1 Season | Patients | Patients | 15 | 0.10% | 0.09% | 0.06% | 0.16% |
| | | MD | 15 | 0.13% | 0.10% | 0.06% | 0.19% |
| | | RN | 15 | 0.08% | 0.07% | 0.05% | 0.09% |
| | | STAFF | 15 | 0.18% | 0.06% | 0.04% | 0.13% |
| | MD | Patients | 15 | 0.13% | 0.11% | 0.07% | 0.21% |
| | | MD | 14 | 3.03% | 1.94% | 1.37% | 4.78% |
| | | RN | 14 | 0.43% | 0.35% | 0.24% | 0.53% |
| | | STAFF | 15 | 0.93% | 0.24% | 0.07% | 0.91% |
| | RN | Patients | 15 | 0.08% | 0.07% | 0.05% | 0.10% |
| | | MD | 14 | 0.45% | 0.36% | 0.29% | 0.57% |
| | | RN | 15 | 1.20% | 0.90% | 0.40% | 1.83% |
| | | STAFF | 15 | 2.06% | 2.02% | 1.46% | 2.69% |
| | STAFF | Patients | 15 | 0.18% | 0.07% | 0.04% | 0.16% |
| | | MD | 15 | 0.95% | 0.24% | 0.07% | 0.96% |
| | | RN | 15 | 2.08% | 1.88% | 1.67% | 2.65% |
| | | STAFF | 15 | 5.28% | 3.61% | 2.40% | 8.03% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown.

**Table 27.** Median percentage of getting infected in different infection scenarios in shift level after combining three types of patients and combining three types of healthcare workers for H1N1 season and not H1N1 season shifts.

| Type of shift | Type of Infectious Node | Type of Infected Node | N | Mean | Median | Q1[1] | Q3[2] |
|---|---|---|---|---|---|---|---|
| H1N1 Season | [3]Patients | Patients | 20 | 0.13% | 0.11% | 0.08% | 0.16% |
| | | HCW | 20 | 0.13% | 0.12% | 0.09% | 0.20% |
| | [4]HCW | Patients | 20 | 0.13% | 0.12% | 0.09% | 0.19% |
| | | HCW | 20 | 1.71% | 1.57% | 1.07% | 2.19% |
| Not H1N1 Season | Patients | Patients | 15 | 0.10% | 0.09% | 0.06% | 0.16% |
| | | HCW | 15 | 0.09% | 0.08% | 0.06% | 0.12% |
| | HCW | Patients | 15 | 0.09% | 0.08% | 0.06% | 0.11% |
| | | HCW | 15 | 1.46% | 1.33% | 1.06% | 1.80% |

[1]Lower quartiles. [2]Upper quartiles. [3]Patients including admitted, not admitted and unknown. [4]Healthcare workers (HCW) including MD, RN and staff.

# Appendix B

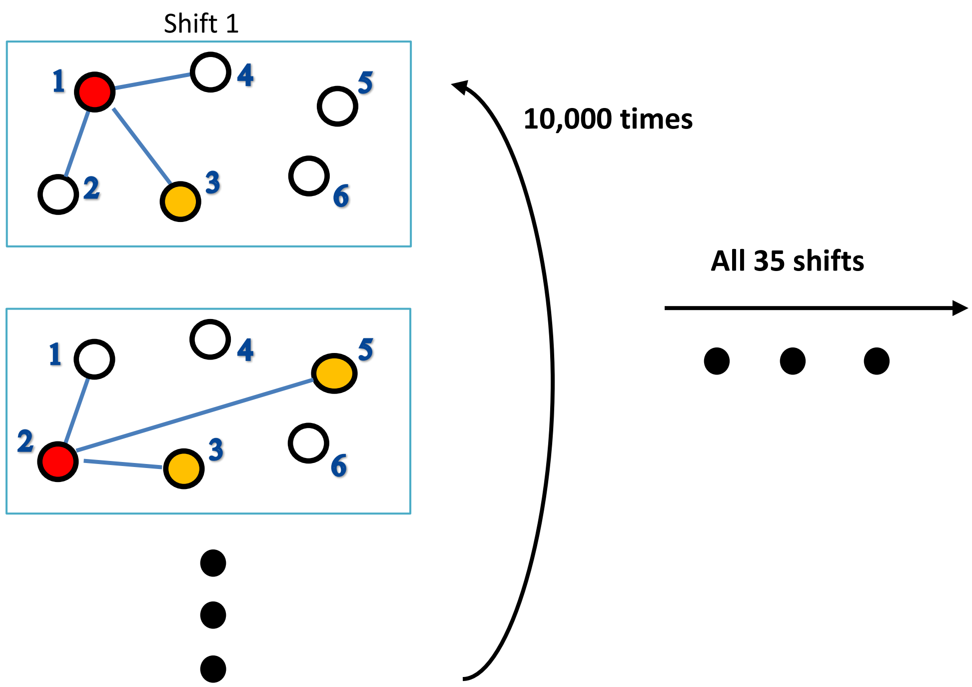



Figure 1. A schematic representation of the simulation method.

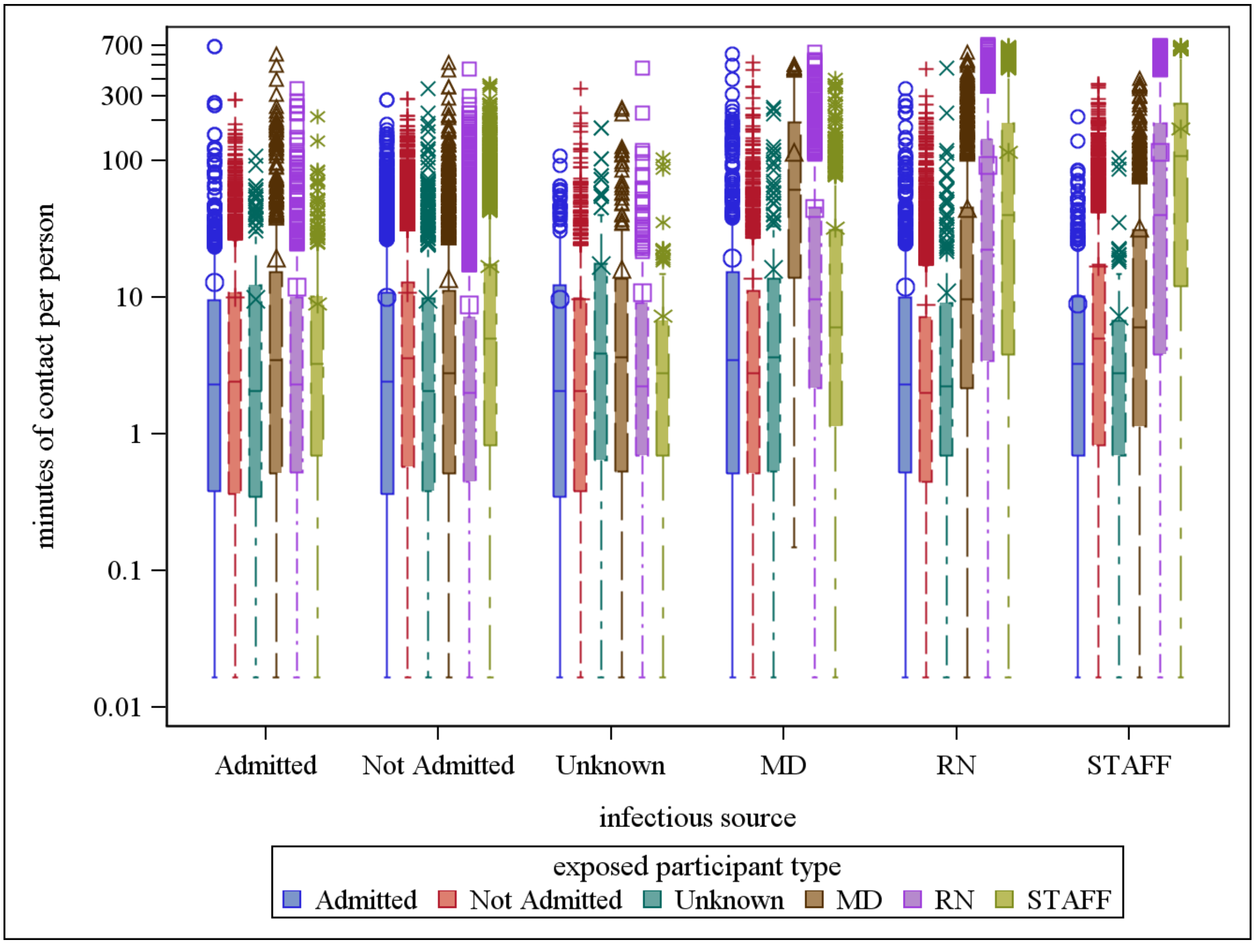



Figure 2. Logarithm scale boxplots of duration of contacts in minutes for different infectious sources and exposed participant types.

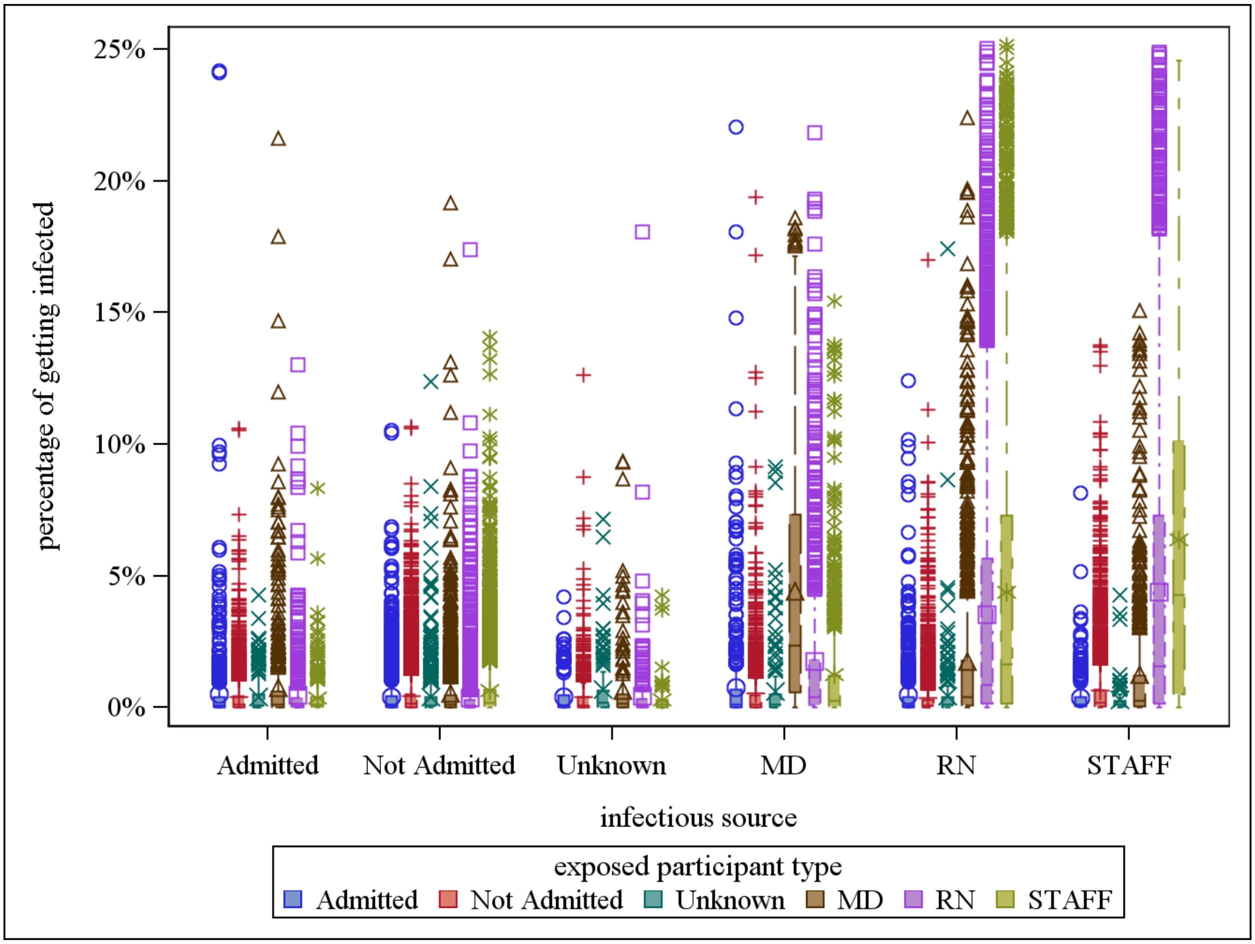



Figure 3. Individual level boxplots of percentage of getting infected for 10,000 times simulation for different infectious sources and exposed participant types in 35 shifts.

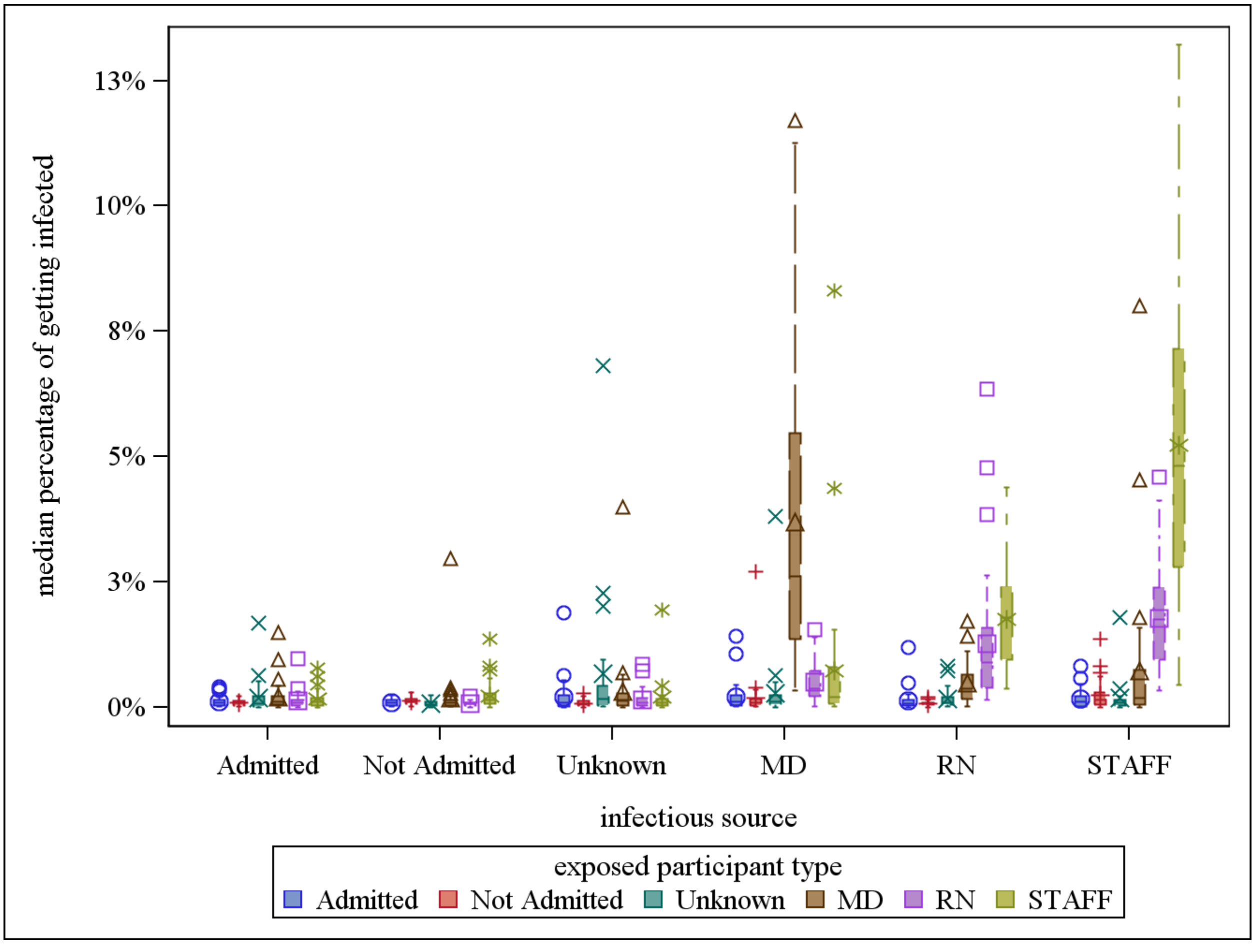



Figure 4. Shift level boxplots of 35 shifts' median percentage of getting infected for 10,000 times simulation for different infectious sources and exposed participant types.

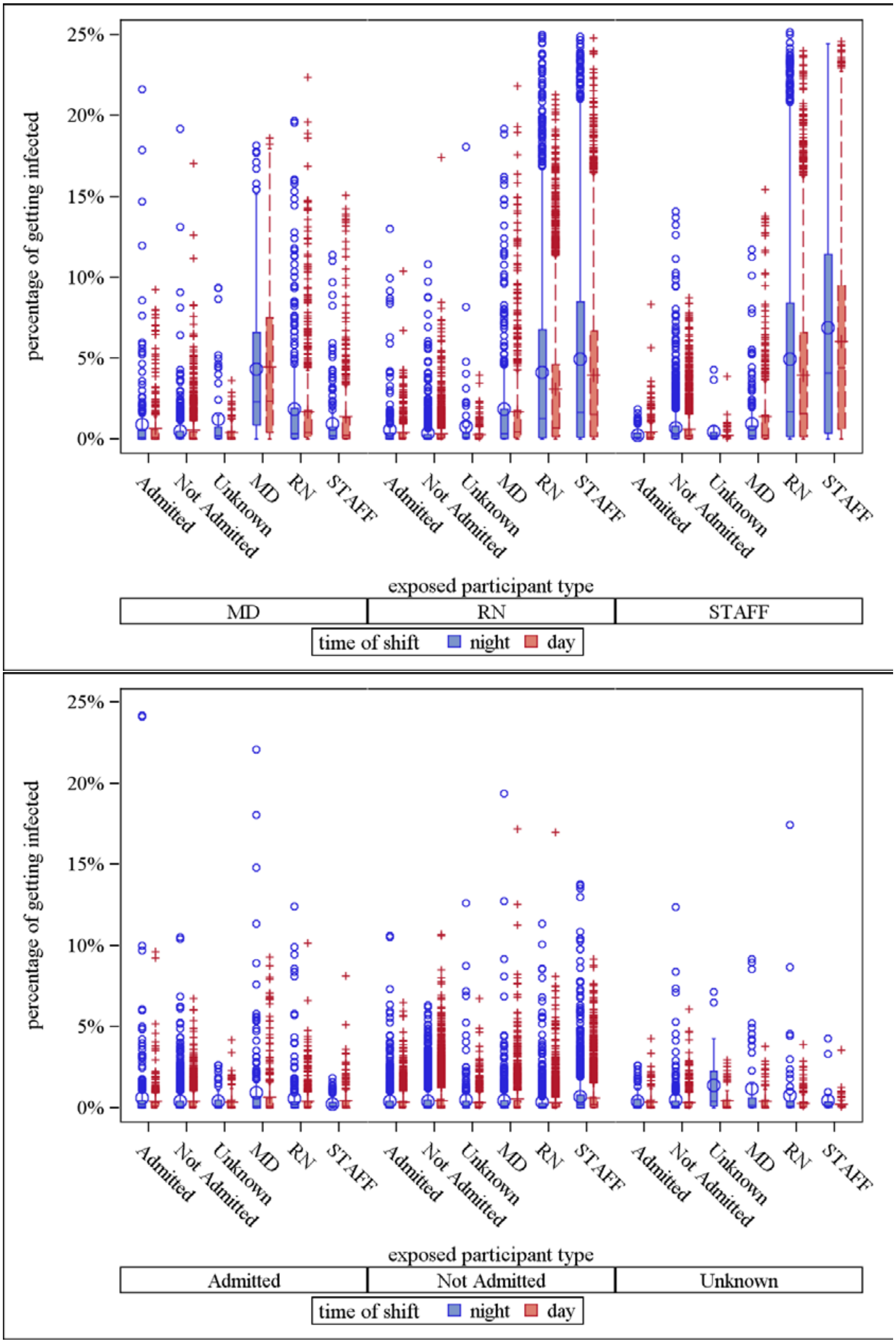
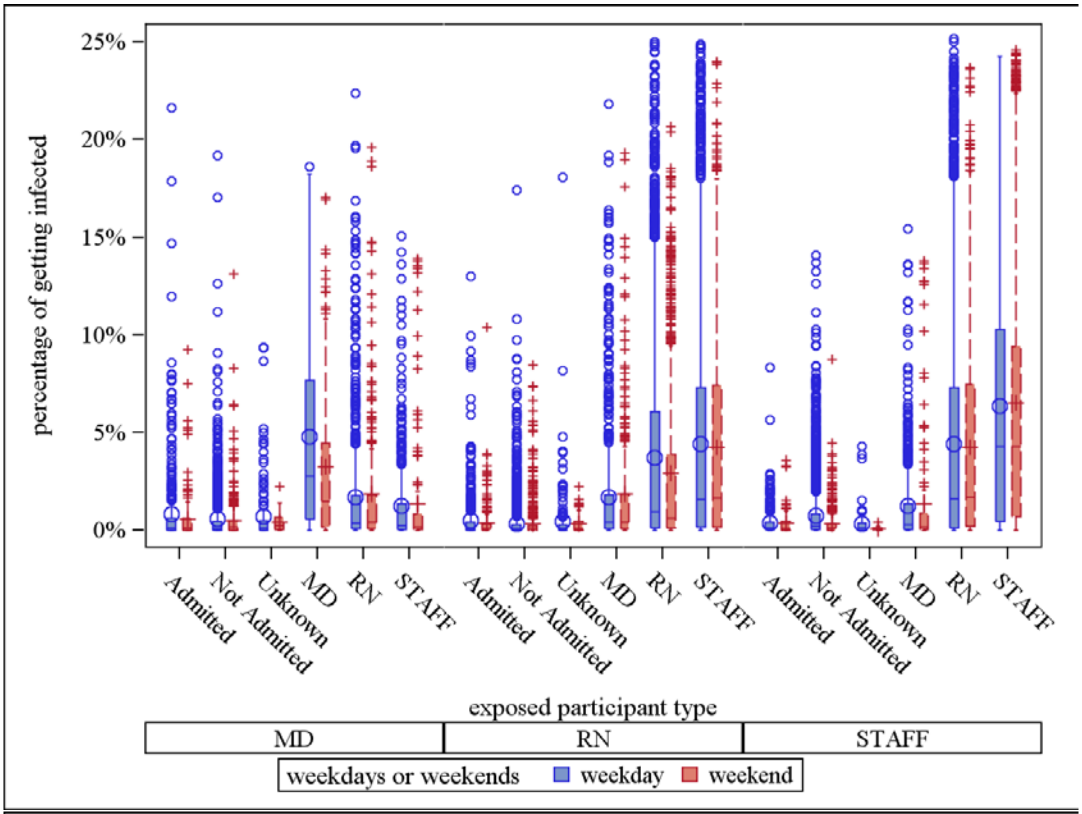



Figure 5. Compare day and night shifts' percentage of getting infected for 10,000 times simulation in individual level.



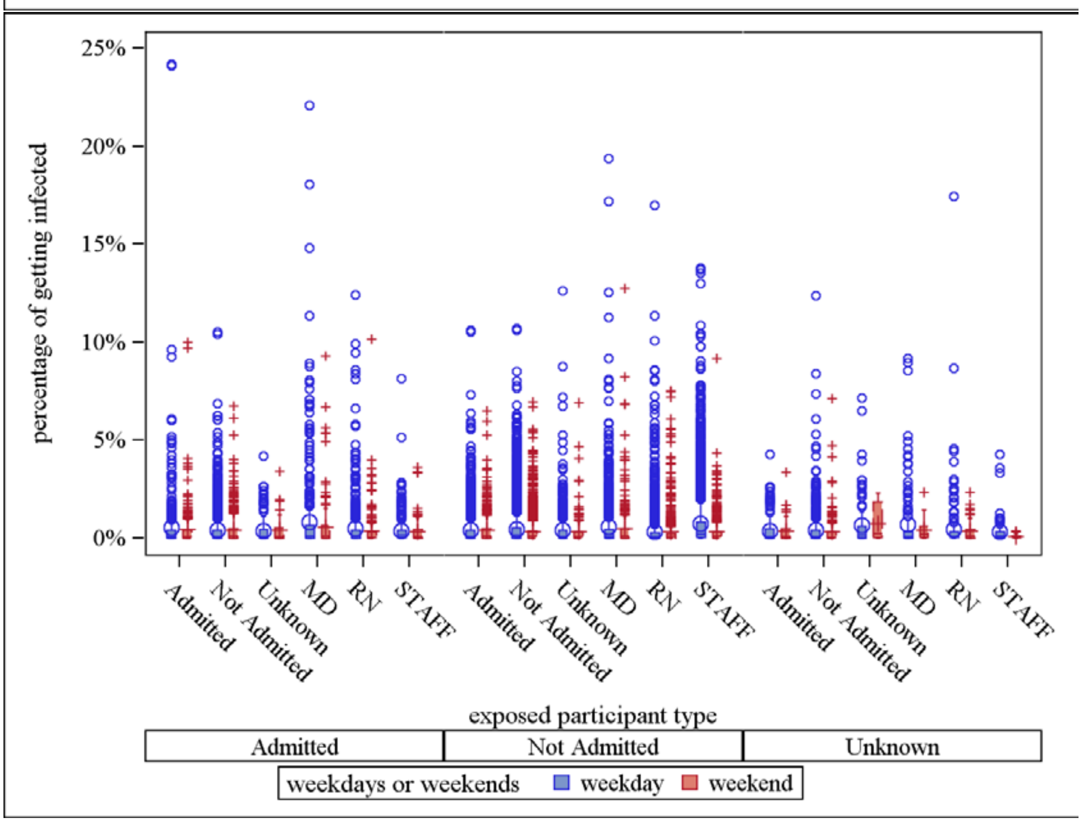




Figure 6. Compare weekday and weekend shifts' percentage of getting infected for 10,000 times simulation in individual level.

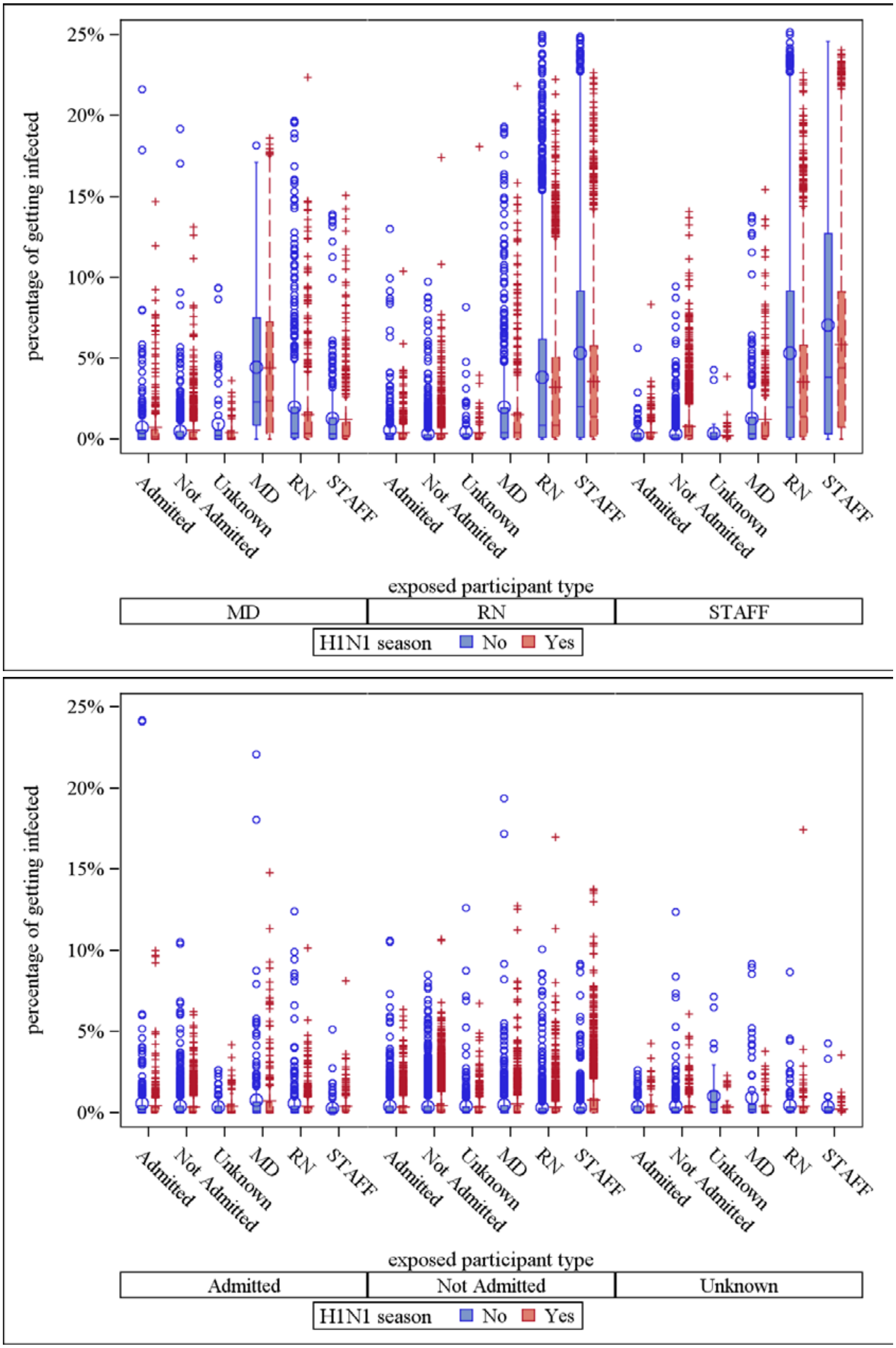



Figure 7. Compare H1N1 season and not H1N1 season shifts' percentage of getting infected for 10,000 times simulation in individual level.

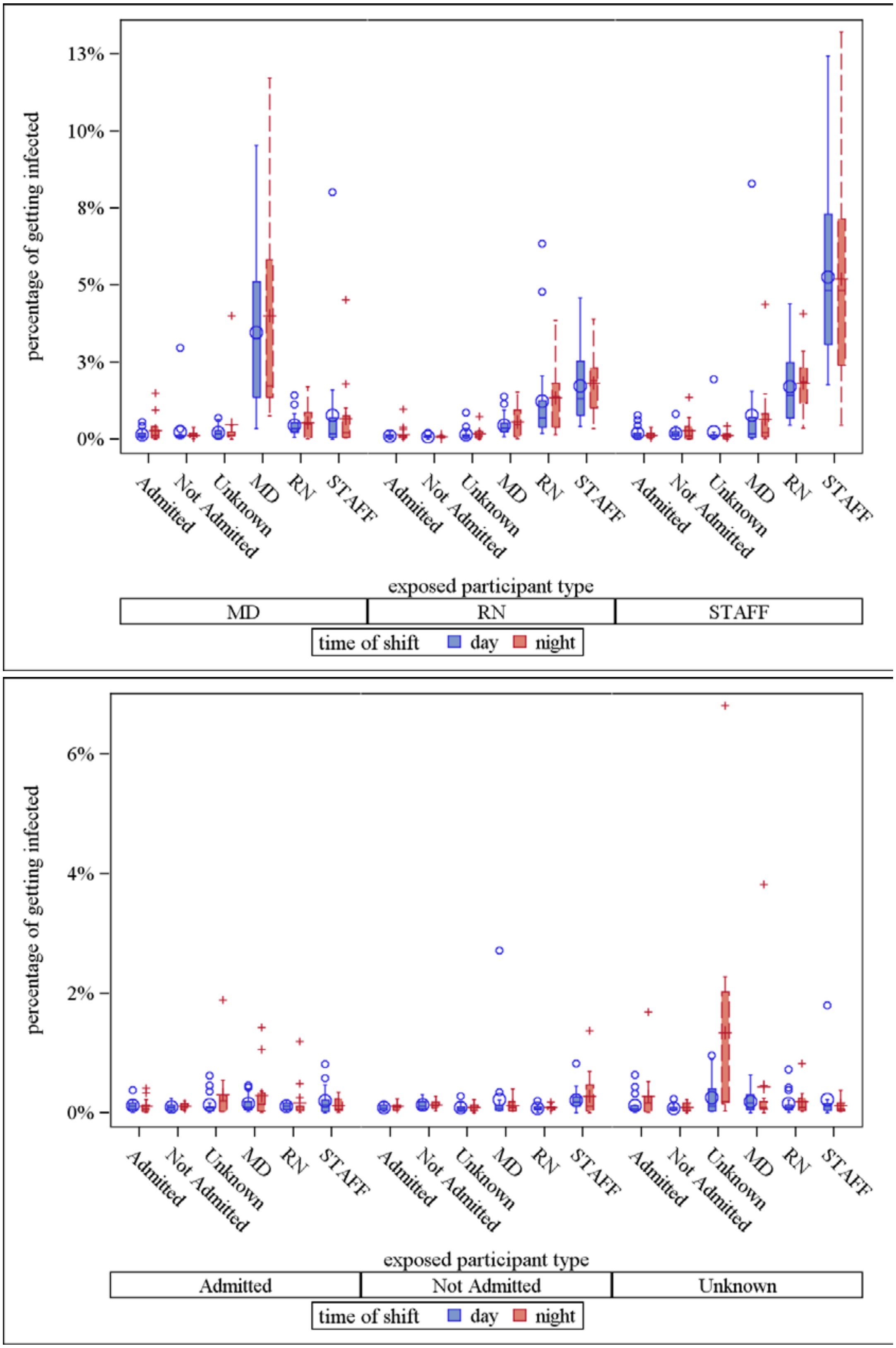



Figure 8. Compare day and night shifts' percentage of getting infected for 10,000 times simulation in shift level.

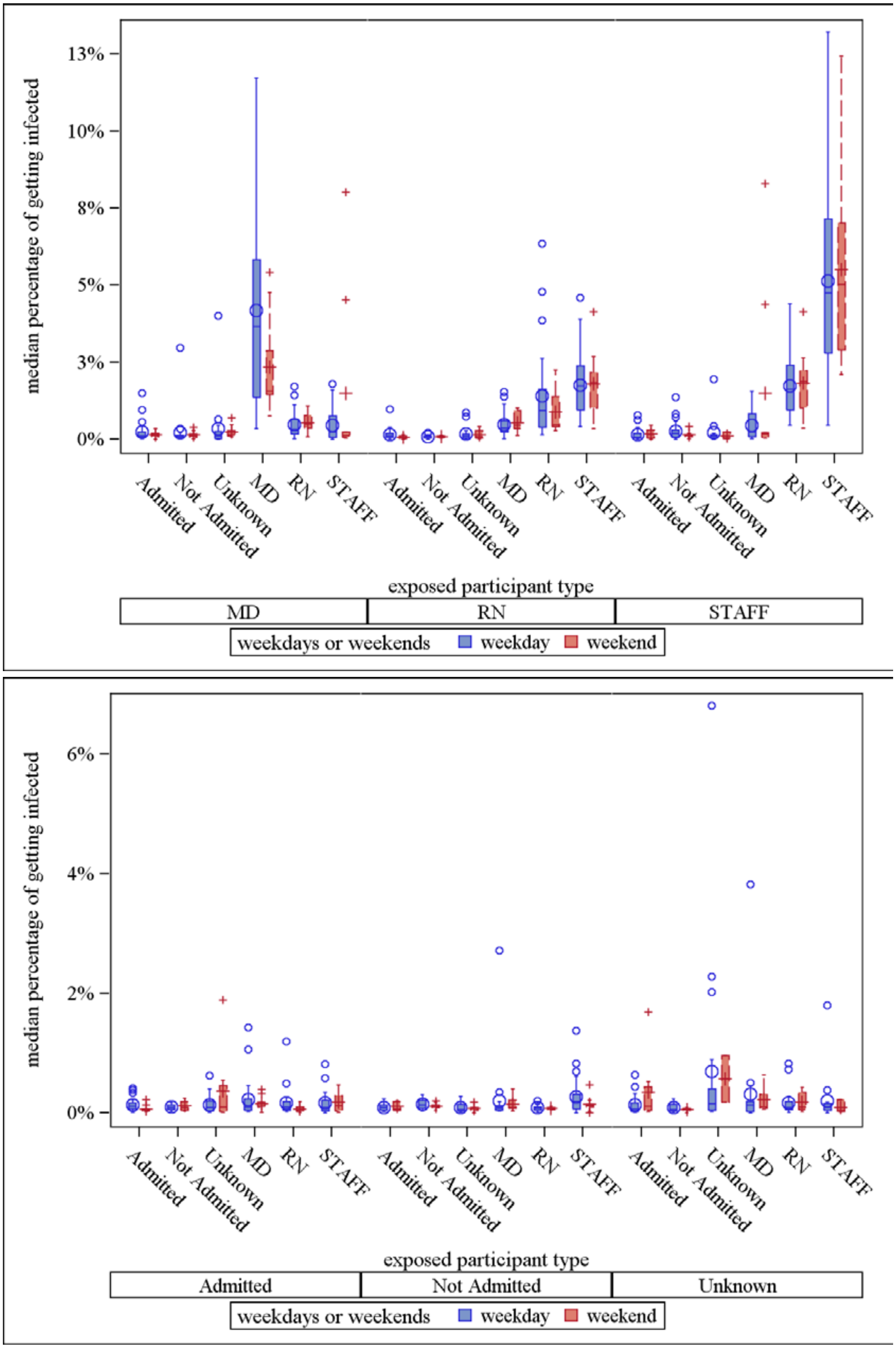



Figure 9. Compare weekday and weekend shifts' percentage of getting infected for 10,000 times simulation in shift level.

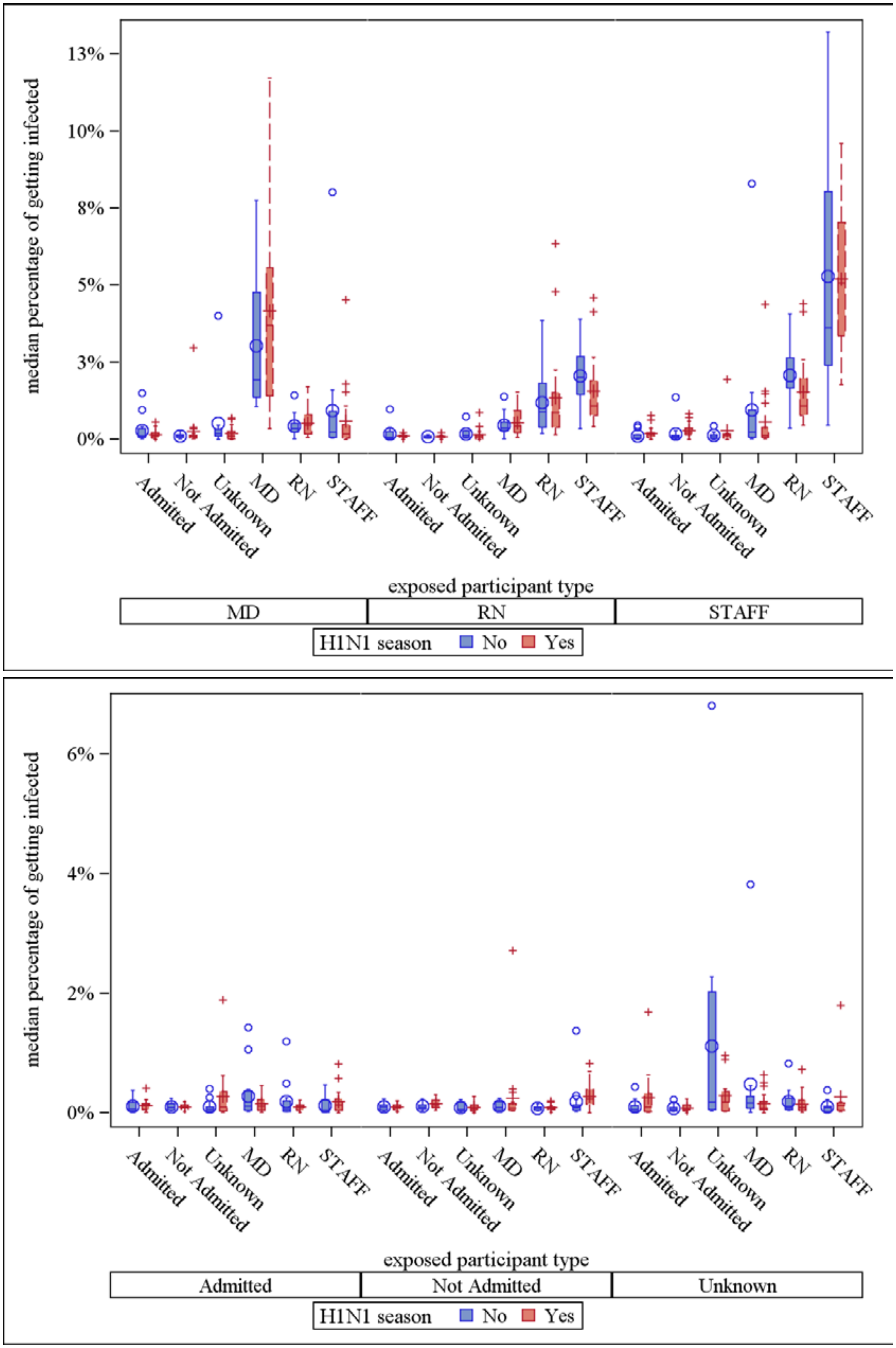



Figure 10. Compare H1N1 season and not H1N1 season shifts' percentage of getting infected for 10,000 times simulation in shift level.

# Appendix C

## SAS Code

```
* weighted edge for all shift Yuke Wang;
/****************************************************************************
**
*    Program: ED study---weighted edge for all shift
*
*    created by: Yuke Wang (Andrew)
*
*    Date: Mar 15th, 2013
*
*    Location:  'H:\ED\code\simulation_for_all_shift.sas'
*
*    Email: Yuke.Wang@emory.edu
*
****************************************************************************
*/
*create ed library;
libname ed "H:\ed\dataset";

***separate patients into three parts***;
data node;
   set ed.nodelevel_all_19_halfyr;
   where staff=0;
   keep id ED_Disposition;
run;

data new_edge0;
   set ed.edges2;
   where D8<=18261;
   new_idi=input(idi,best12.);
   new_idj=input(idj,best12.);
run;

data node_i;
   set node;
   length new_type_i $20.;
   if ED_Disposition="Admit" then new_type_i=" Admitted";
   else if ED_Disposition="AMA" or ED_Disposition="Discharge" or
ED_Disposition="Left W/out Being Seen" then new_type_i=" Not Admitted";
   else if ED_Disposition="Not Recorded" or ED_Disposition="Transfer" then
new_type_i=" Unknown";
   new_idi=id;
   drop id ED_Disposition;
run;

data node_j;
   set node;
   length new_type_j $20.;
   if ED_Disposition="Admit" then new_type_j=" Admitted";
   else if ED_Disposition="AMA" or ED_Disposition="Discharge" or
ED_Disposition="Left W/out Being Seen" then new_type_j=" Not Admitted";
   else if ED_Disposition="Not Recorded" or ED_Disposition="Transfer" then
new_type_j=" Unknown";
```

```
   new_idj=id;
   drop id ED_Disposition;
run;

proc sort data=node_i;
   by new_idi;
run;

proc sort data=node_j;
   by new_idj;
run;

proc sort data=new_edge0;
   by new_idi;
run;

data new_edge1;
   merge node_i new_edge0;
   by new_idi;
run;

proc sort data=new_edge1;
   by new_idj;
run;

data new_edge2;
   merge node_j new_edge1;
   by new_idj;
run;

data edge;
   length i_participant_type $20 j_participant_type $20;
   set new_edge2;
   if i_participant_type="_PAT" then i_participant_type=new_type_i;
   if j_participant_type="_PAT" then j_participant_type=new_type_j;
   where numshift>0;
   drop new_type_i new_type_j new_idi new_idj;
run;

***save the edge***;
data ed.edge;
    set edge;
run;

ods rtf file="H:\ED\documents\results1.rtf";

*create a new dataset allshift in work library from ed.edges;
proc sql;
   create table allshift as
   select *, edgeweight*60 as min_edgeweight label="mins of contact"
   from ed.edge
quit;

***simulate 10000 times to generate how many times and the probability each
person get infected;
data allshift_1;
   set allshift;
```

```
   lambda=-log(0.996)/10;
   inv_lambda=1/lambda;
   v=cdf("exponential",min_edgeweight,inv_lambda);
   p_infected=0;
   num_infected=0;
   do z=1 to 10000;
   r=ranuni(0);
   if v>=r then inf=1;
   else inf=0;
   num_infected=num_infected+inf;
   end;
   p_infected=num_infected/10000;
   if p_infected>0 then infected=1;
   else infected=0;
   drop inf z lambda inv_lambda;
run;
*******************************************************;
***since the contacts are two ways, so we double the rows for dataset and
switch node i information and node j information;
proc sql;
   create table allshift_2 as
   select numshift, shiftampm, D8, d9, H1N1, quarter, sidj as sidi label="",
sidi as sidj label="", j as i label="", i as j label="", idj as idi label="",
idi as idj label="",
   j_participant_type as i_participant_type label="", i_participant_type as
j_participant_type label="", staffj as staffi label="", staffi as staffj
label="", anycontact, combo, comboc, combo4,
   md_contacts, rn_contacts, staff_contacts, pat_contacts, md_withwhom,
rn_withwhom, staff_withwhom, pat_withwhom, edgeweight, min_edgeweight
   from allshift;
quit;

proc sql;
   create table allshift_3 as
   select * from allshift
   outer union corr
   select * from allshift_2;
quit;

***simulate 10000 times to generate how many times and the probability each
person get infected;
data allshift_4;
   set allshift_3;
   lambda=-log(0.996)/10;
   inv_lambda=1/lambda;
   v=cdf("exponential",min_edgeweight,inv_lambda);
   num_infected=0;
   do z=1 to 10000;
   r=ranuni(0);
   if v>=r then inf=1;
   else inf=0;
   num_infected=num_infected+inf;
   end;
   p_infected=num_infected/10000;
   if p_infected>0 then infected=1;
   else infected=0;
   drop inf z lambda inv_lambda;
```

```
run;

***save the dataset;
data ed.allshift;
   set allshift_4;
run;

***table***;
data allshift_5;
   set allshift_4;
   where i>0 and j>0;*delete no contacts rows;
   keep idi idj i_participant_type j_participant_type num_infected;
run;

proc tabulate data=allshift_5;
   class i_participant_type j_participant_type;
   var num_infected;
   table i_participant_type,j_participant_type*mean*num_infected;
run;

***summary statistics***;
******************************************************************;
data stats;
   set allshift_1;
   where i>0 and j>0;
run;

proc means data=stats n mean median q1 q3 min max;
   var min_edgeweight;
run;

proc means data=stats n mean median q1 q3 min max;
   var min_edgeweight;
   class combo4;
run;

***node number***
data findnode;
   set allshift_4;
run;

proc sort data=findnode;
   by idi;
run;

data findnode1;
   set findnode;
   id=idi*1;
run;

proc sort data=findnode1;
   by id;
run;

data findnode2;
   set findnode1;
   by id;
```

```
   first=first.id;
run;

data findnode3;
   set findnode2;
   where first=1;
run;

***node number for different types of people;
proc freq data=findnode3;
   table i_participant_type;
run;

*group box plot;
data boxplot0;
   set allshift_3;
   where i>0 and j>0;*delete no contacts rows;
   if i_participant_type="_PAT" then i_participant_type="PATIENT";
   if j_participant_type="_PAT" then j_participant_type="PATIENT";
run;

proc sort data=boxplot0;
   by i_participant_type j_participant_type;
run;

ods graphics / antialiasmax=10000;

***log scale;
proc sgplot data=boxplot0;
   vbox min_edgeweight / category=j_participant_type group=i_participant_type;
   xaxis label="infectious source";
   yaxis type=log logbase=10 logstyle=linear label="minutes of contact per
person";
   keylegend / title="exposed participant type";
run;

*****************************************************************************
****
***box plot of percent of getting infected;
data boxplot1;
   set allshift_4;
   where i>0 and j>0;*delete no contacts rows;
   if i_participant_type="_PAT" then i_participant_type="PATIENT";
   if j_participant_type="_PAT" then j_participant_type="PATIENT";
   format p_infected percent5.;
run;

proc sort data=boxplot1;
   by i_participant_type j_participant_type;
run;

proc sgplot data=boxplot1;
   vbox p_infected / category=j_participant_type group=i_participant_type;
   xaxis label="infectious source";
   yaxis label="percentage of getting infected";
   keylegend / title="exposed participant type";
run;
```

```
*****************************************************************************
********;
***statistics***;
proc means data=boxplot1 n mean median q1 q3 min max;
   var p_infected;
   class shiftampm;
run;

data weekday0;
   set boxplot0;
   weekday=1;
   if mod(d9,7)=1 then weekday=0;
   if mod(d9,7)=2 then weekday=0;
run;

data weekday1;
   set boxplot1;
   weekday=1;
   if mod(d9,7)=1 then weekday=0;
   if mod(d9,7)=2 then weekday=0;
run;

proc means data=weekday1 n mean median q1 q3 min max;
   var p_infected;
   class weekday;
run;

proc means data=boxplot1 n mean median q1 q3 min max;
   var p_infected;
   class H1N1;
run;

****************************************************************
***plot in individual level***;
data boxplot1;
   set boxplot1;
   if H1N1=0 then flu1="No ";
   if H1N1=1 then flu1="Yes";
   if H1N1=0 then flu0="Not H1N1 season";
   if H1N1=1 then flu0="H1N1 season";
   week_day="weekday";
   if mod(d9,7)=1 then week_day="weekend";
   if mod(d9,7)=2 then week_day="weekend";
   if shiftampm=2 then dn="night";
   if shiftampm=1 then dn="day";
run;

proc sort data=boxplot1;
   by i_participant_type j_participant_type;
run;

data box1;
   set boxplot1;
   where i_participant_type="MD" or i_participant_type="RN" or
i_participant_type="STAFF";
run;
```

```
data box2;
   set boxplot1;
   where i_participant_type=" Admitted" or i_participant_type=" Not Admitted"
or i_participant_type=" Unknown";
run;

title;
*****************************************************************************
*********************;
***day and night***;
proc sgpanel data=box1;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox p_infected / category=j_participant_type group=dn;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="time of shift";
run;

proc sgpanel data=box2;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox p_infected / category=j_participant_type group=dn;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="time of shift";
run;

***weekday and weekend***;
proc sgpanel data=box1;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox p_infected / category=j_participant_type group=week_day;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="weekdays or weekends";
run;

proc sgpanel data=box2;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox p_infected / category=j_participant_type group=week_day;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="weekdays or weekends";
run;

***H1N1 season***;
proc sgpanel data=box1;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox p_infected / category=j_participant_type group=flu1;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="H1N1 season";
run;
```

```
proc sgpanel data=box2;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox p_infected / category=j_participant_type group=flu1;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="H1N1 season";
run;

ods rtf close;
ods html;

*************************************************************************;
data stats;
   set allshift_1;
   where i>0 and j>0;
   if i_participant_type="_PAT" then i_participant_type="PATIENT";
   if j_participant_type="_PAT" then j_participant_type="PATIENT";
run;

proc means data=stats n mean std median q1 q3 min max;
   var min_edgeweight;
   class numshift;
run;

proc means data=stats n mean std median q1 q3 min max;
   var min_edgeweight;
   class combo4 numshift;
   output out=min0 n=N mean=mean std=std median=median q1=q1 q3=q3 min=min
max=max;
run;

proc means data=boxplot1 n mean std median q1 q3 min max noprint;
   var min_edgeweight;
   class numshift;
   output out=min1 n=N mean=mean std=std median=median q1=q1 q3=q3 min=min
max=max;
run;

proc means data=boxplot1 n mean std median q1 q3 min max noprint;
   var min_edgeweight;
   class i_participant_type j_participant_type numshift;
   output out=min2 n=N mean=mean std=std median=median q1=q1 q3=q3 min=min
max=max;
run;

proc means data=boxplot1 n mean std median q1 q3 min max;
   var p_infected;
   class numshift;
   output out=percent0 n=N mean=mean std=std median=median q1=q1 q3=q3
min=min max=max;
run;

proc means data=boxplot1 n mean std median q1 q3 min max;
   var p_infected;
   class i_participant_type j_participant_type numshift;
```

```
   output out=percent1 n=N mean=mean std=std median=median q1=q1 q3=q3
min=min max=max;
run;

data min0;
   set min0;
   where _type_=3;
run;

data min1;
   set min1;
   where _type_=1;
run;

data min2;
   set min2;
   where _type_=7;
run;

data percent0;
   set percent0;
   where _type_=1;
run;

data percent1;
   set percent1;
   where _type_=7;
run;

proc means data=percent0 n mean std median q1 q3 min max;
   var median;
run;

proc means data=percent1 n mean std median q1 q3 min max;
   var median;
   class i_participant_type j_participant_type;
run;

proc sort data=min0;
   by combo4;
run;

proc sort data=min2;
   by i_participant_type j_participant_type;
run;

proc sort data=percent1;
   by i_participant_type j_participant_type;
run;

***shifts level plot***;

ods rtf file="H:\ED\documents\graphs_35shifts.rtf";
***duration***;
***normal scale***;
proc sgplot data=min0;
   vbox median / category=combo4;
```

```
   xaxis label="types of contacts";
   yaxis label="median duration of contact in minutes";
run;

***log scale***;
proc sgplot data=min0;
   vbox median / category=combo4;
   xaxis label="types of contacts";
   yaxis type=log logbase=10 logstyle=linear label="median duration of
contact in minutes";
run;

***normal scale***;
proc sgplot data=min2;
   vbox median / category=j_participant_type group=i_participant_type;
   xaxis label="infectious source";
   yaxis label="median duration of contact in minutes";
   keylegend / title="exposed participant type";
run;
title;

***log scale***;
proc sgplot data=min2;
   vbox median / category=j_participant_type group=i_participant_type;
   xaxis label="infectious source";
   yaxis type=log logbase=10 logstyle=linear label="median duration of
contact in minutes";
   keylegend / title="exposed participant type";
run;

*****************************************************************************
**********;
***percent of getting infected plot***;
proc sgplot data=percent1;
   vbox median / category=j_participant_type group=i_participant_type;
   xaxis label="infectious source";
   yaxis label="median percentage of getting infected";
   keylegend / title="exposed participant type";
run;

***day and night***;
proc means data=boxplot1 n mean std median q1 q3 min max noprint;
   var p_infected;
   class dn i_participant_type j_participant_type numshift;
   output out=percent2 n=N mean=mean std=std median=median q1=q1 q3=q3
min=min max=max;
run;

data percent2;
   set percent2;
   where _type_=15;
run;

proc sort data=percent2;
   by i_participant_type j_participant_type;
run;
```

```
***weekday and weekend***;
proc means data=boxplot1 n mean std median q1 q3 min max noprint;
   var p_infected;
   class week_day i_participant_type j_participant_type numshift;
   output out=percent3 n=N mean=mean std=std median=median q1=q1 q3=q3
min=min max=max;
run;

data percent3;
   set percent3;
   where _type_=15;
run;

proc sort data=percent3;
   by i_participant_type j_participant_type;
run;

***H1N1 and not H1N1***;
proc means data=boxplot1 n mean std median q1 q3 min max noprint;
   var p_infected;
   class flu0 i_participant_type j_participant_type numshift;
   output out=percent4 n=N mean=mean std=std median=median q1=q1 q3=q3
min=min max=max;
run;

data percent4;
   set percent4;
   where _type_=15;
run;

proc sort data=percent4;
   by i_participant_type j_participant_type;
run;

*******************************************************************************
*****************************;
***plot of day and night shifts;
data percent2_1;
   set percent2;
   where i_participant_type="MD" or i_participant_type="RN" or
i_participant_type="STAFF";
run;

data percent2_2;
   set percent2;
   where i_participant_type=" Admitted" or i_participant_type=" Not Admitted"
or i_participant_type=" Unknown";
run;

proc sgpanel data=percent2_1;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox median / category=j_participant_type group=dn;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="time of shift";
run;
```

```
proc sgpanel data=percent2_2;
   panelby  i_participant_type/ layout=columnlattice onepanel
         colheaderpos=bottom rows=1 novarname noborder;
   vbox median / category=j_participant_type group=dn;
   colaxis label="exposed participant type";
   rowaxis label="percentage of getting infected";
   keylegend / title="time of shift";
run;

***plot of weekday and weekend shifts***;
data percent3_1;
   set percent3;
   where i_participant_type="MD" or i_participant_type="RN" or
i_participant_type="STAFF";
run;

data percent3_2;
   set percent3;
   where i_participant_type=" Admitted" or i_participant_type=" Not Admitted"
or i_participant_type=" Unknown";
run;

proc sgpanel data=percent3_1;
   panelby  i_participant_type/ layout=columnlattice onepanel
         colheaderpos=bottom rows=1 novarname noborder;
   vbox median / category=j_participant_type group=week_day;
   colaxis label="exposed participant type";
   rowaxis label="median percentage of getting infected";
   keylegend / title="weekdays or weekends";
run;

proc sgpanel data=percent3_2;
   panelby  i_participant_type/ layout=columnlattice onepanel
         colheaderpos=bottom rows=1 novarname noborder;
   vbox median / category=j_participant_type group=week_day;
   colaxis label="exposed participant type";
   rowaxis label="median percentage of getting infected";
   keylegend / title="weekdays or weekends";
run;

***plot of H1N1 season and not H1N1 season***;
proc means data=boxplot1 n mean std median q1 q3 min max noprint;
   var p_infected;
   class flu1 i_participant_type j_participant_type numshift;
   output out=percent5 n=N mean=mean std=std median=median q1=q1 q3=q3
min=min max=max;
run;

data percent5;
   set percent5;
   where _type_=15;
run;

proc sort data=percent5;
   by i_participant_type j_participant_type;
run;
```

```
data percent5_1;
   set percent5;
   where i_participant_type="MD" or i_participant_type="RN" or
i_participant_type="STAFF";
run;

data percent5_2;
   set percent5;
   where i_participant_type=" Admitted" or i_participant_type=" Not Admitted"
or i_participant_type=" Unknown";
run;

proc sgpanel data=percent5_1;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox median / category=j_participant_type group=flu1;
   colaxis label="exposed participant type";
   rowaxis label="median percentage of getting infected";
   keylegend / title="H1N1 season";
run;

proc sgpanel data=percent5_2;
   panelby  i_participant_type/ layout=columnlattice onepanel
          colheaderpos=bottom rows=1 novarname noborder;
   vbox median / category=j_participant_type group=flu1;
   colaxis label="exposed participant type";
   rowaxis label="median percentage of getting infected";
   keylegend / title="H1N1 season";
run;

ods rtf close;

ods html;

proc means data=boxplot1 n mean median q1 q3 min max;
   var p_infected;
   class i_participant_type j_participant_type;
run;

data table;
   set boxplot1;
   if i_participant_type=" Admitted" or i_participant_type=" Not Admitted" or
i_participant_type=" Unknown" then i_type_1=" Patients";
   else i_type_1=i_participant_type;
   if j_participant_type=" Admitted" or j_participant_type=" Not Admitted" or
j_participant_type=" Unknown" then j_type_1=" Patients";
   else j_type_1=j_participant_type;
   if i_participant_type=" Admitted" or i_participant_type=" Not Admitted" or
i_participant_type=" Unknown" then i_type_2=" Patients";
   else i_type_2="HCW";
   if j_participant_type=" Admitted" or j_participant_type=" Not Admitted" or
j_participant_type=" Unknown" then j_type_2=" Patients";
   else j_type_2="HCW";
run;
```

```
***overall individual level***;
proc means data=table n mean median q1 q3;
   var p_infected;
   class i_participant_type j_participant_type;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class i_type_1 j_type_1;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class i_type_2 j_type_2;
run;

***day and night***;
proc means data=table n mean median q1 q3;
   var p_infected;
   class dn i_participant_type j_participant_type;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class dn i_type_1 j_type_1;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class dn i_type_2 j_type_2;
run;

***weekday and weekend***;
***day and night***;
proc means data=table n mean median q1 q3;
   var p_infected;
   class week_day i_participant_type j_participant_type;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class week_day i_type_1 j_type_1;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class week_day i_type_2 j_type_2;
run;

***H1N1***;
***day and night***;
proc means data=table n mean median q1 q3;
   var p_infected;
   class flu0 i_participant_type j_participant_type;
run;

proc means data=table n mean median q1 q3;
```

```
   var p_infected;
   class flu0 i_type_1 j_type_1;
run;

proc means data=table n mean median q1 q3;
   var p_infected;
   class flu0 i_type_2 j_type_2;
run;

***********************************************************;
***shift level***;
data table1;
   set boxplot1;
   if i_participant_type=" Admitted" or i_participant_type=" Not Admitted" or
i_participant_type=" Unknown" then i_type_1=" Patients";
   else i_type_1=i_participant_type;
   if j_participant_type=" Admitted" or j_participant_type=" Not Admitted" or
j_participant_type=" Unknown" then j_type_1=" Patients";
   else j_type_1=j_participant_type;
   if i_participant_type=" Admitted" or i_participant_type=" Not Admitted" or
i_participant_type=" Unknown" then i_type_2=" Patients";
   else i_type_2="HCW";
   if j_participant_type=" Admitted" or j_participant_type=" Not Admitted" or
j_participant_type=" Unknown" then j_type_2=" Patients";
   else j_type_2="HCW";
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class i_participant_type j_participant_type numshift;
   output out=shift1 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift1;
   set shift1;
   where _type_=7;
run;

proc means data=shift1 n mean median q1 q3;
   var median;
   class i_participant_type j_participant_type;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class i_type_1 j_type_1 numshift;
   output out=shift2 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift2;
   set shift2;
   where _type_=7;
run;

proc means data=shift2 n mean median q1 q3;
   var median;
   class i_type_1 j_type_1;
```

```
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class i_type_2 j_type_2 numshift;
   output out=shift3 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift3;
   set shift3;
   where _type_=7;
run;

proc means data=shift3 n mean median q1 q3;
   var median;
   class i_type_2 j_type_2;
run;

***day and night***;
proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class dn i_participant_type j_participant_type numshift;
   output out=shift1 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift1;
   set shift1;
   where _type_=15;
run;

proc means data=shift1 n mean median q1 q3;
   var median;
   class dn i_participant_type j_participant_type;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class dn i_type_1 j_type_1 numshift;
   output out=shift2 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift2;
   set shift2;
   where _type_=15;
run;

proc means data=shift2 n mean median q1 q3;
   var median;
   class dn i_type_1 j_type_1;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class dn i_type_2 j_type_2 numshift;
   output out=shift3 n=N mean=mean median=median q1=q1 q3=q3;
run;
```

```
data shift3;
   set shift3;
   where _type_=15;
run;

proc means data=shift3 n mean median q1 q3;
   var median;
   class dn i_type_2 j_type_2;
run;

***weekday***;
proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class week_day i_participant_type j_participant_type numshift;
   output out=shift1 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift1;
   set shift1;
   where _type_=15;
run;

proc means data=shift1 n mean median q1 q3;
   var median;
   class week_day i_participant_type j_participant_type;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class week_day i_type_1 j_type_1 numshift;
   output out=shift2 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift2;
   set shift2;
   where _type_=15;
run;

proc means data=shift2 n mean median q1 q3;
   var median;
   class week_day i_type_1 j_type_1;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class week_day i_type_2 j_type_2 numshift;
   output out=shift3 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift3;
   set shift3;
   where _type_=15;
run;

proc means data=shift3 n mean median q1 q3;
   var median;
   class week_day i_type_2 j_type_2;
```

```
run;

***H1N1***;
proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class flu0 i_participant_type j_participant_type numshift;
   output out=shift1 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift1;
   set shift1;
   where _type_=15;
run;

proc means data=shift1 n mean median q1 q3;
   var median;
   class flu0 i_participant_type j_participant_type;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class flu0 i_type_1 j_type_1 numshift;
   output out=shift2 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift2;
   set shift2;
   where _type_=15;
run;

proc means data=shift2 n mean median q1 q3;
   var median;
   class flu0 i_type_1 j_type_1;
run;

proc means data=table1 n mean median q1 q3 noprint;
   var p_infected;
   class flu0 i_type_2 j_type_2 numshift;
   output out=shift3 n=N mean=mean median=median q1=q1 q3=q3;
run;

data shift3;
   set shift3;
   where _type_=15;
run;

proc means data=shift3 n mean median q1 q3;
   var median;
   class flu0 i_type_2 j_type_2;
run;
```