Infection control and healthcare epidemiology in the real world

By

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Date
Abstract

This master’s paper entitled “Infection control and healthcare epidemiology in the real world” includes the following sections: 1) Infection control and healthcare epidemiology in the Department of Hospital Epidemiology, University of North Carolina (UNC) Health Care, including 1-1) Lessons learned through my practicum experience in UNC; 1-2) Descriptive analyses of healthcare-associated infections other than bloodstream, respiratory, urinary tract or surgical site; and 2) Infection control activities after the Great East Japan Earthquake, including 2-1) Infection control campaign at evacuation centers in Miyagi Prefecture; 2-2) Latent tuberculosis infection in nurses exposed to tuberculous patients cared for in rooms without negative pressure.

I visited the UNC Hospital Epidemiology Department to do a practicum in infection control and healthcare epidemiology. In UNC hospitals, the Epidemiology Department has conducted comprehensive surveillance for healthcare-associated infections (HAI). I participated and observed data collection and analysis, and infection control intervention programs to reduce HAI. I learned how UNC hospitals reduced HAI and gained an understanding of infection control issues in UNC and learned the basic skills of hospital epidemiology through this practicum. As a result of this practicum experience I applied this knowledge to my work in Japan. I have summarized this knowledge and work in my master’s paper and, as described above, this has led to several different studies and associated publications, coauthored by UNC faculty.

It is estimated that HAI accounts for approximately 1.7 million infections and 99,000 deaths in US hospitals. Standardized surveillance of HAI and intervention programs have focused on surgical site, respiratory tract, bloodstream, and urinary tract infections. In this study, I conducted descriptive analysis of HAI other than those infections through comprehensive hospital-wide surveillance. Other types of HAI were found in 9-17% of all HAI each year (2001-2011), demonstrating the substantial burden due to “other” HAI and the necessity of broad infection control efforts.

The Great East Japan Earthquake and subsequent tsunami on March 11, 2011 occurred while I was enrolled in the MPH Distance Education Leadership concentration of the Public Health Leadership Program. I was directly involved in infection control and other public health activities following the earthquake. After the earthquake, many survivors were obliged to reside in evacuation centers and suffered from unsanitary conditions due to poor environmental maintenance. There is a public health concern about the increased risk of infectious diseases after natural disasters. I conducted infection control activities at evacuation centers for control and prevention of infectious diseases. One goal of this paper is to introduce my activities as Tohoku regional infection control network to the world, and provide recommendations based on my experience obtained in such a difficult situation.
Healthcare personnel are at risk for tuberculosis exposure and infection when they care for patients in healthcare settings. There are no data assessing the importance of negative pressure rooms in the airborne transmission of tuberculosis following a natural disaster. I examined latent tuberculosis infection in nurses who were exposed to patients with active tuberculosis housed in rooms that could not be maintained under negative pressure room after the Great East Japan Earthquake. Through my practicum at UNC I was better able to understand the role of infection control and outbreak investigation in challenging situations such as the Great East Japan Earthquake. One outcome of this study was a better understanding of the importance of ventilation systems and airborne precautions in healthcare settings during natural disasters.

As a result of my experience with the Great East Japan Earthquake and my practicum at UNC the following scientific papers have been published or submitted for publication:


1. Infection control and healthcare epidemiology in the Department of Hospital Epidemiology, University of North Carolina Health Care

1-1. Lesson learned through practicum experience in UNC

I visited the UNC Hospital Epidemiology Department to do a practicum in infection control and healthcare epidemiology (Figure 1). In UNC hospitals, the Department has conducted comprehensive surveillance for healthcare-associated infections (HAIs) as well as targeted surveillance for home health/hospice infections. I participated and observed data collection and analysis, and infection control intervention programs to reduce HAIs. Surveillance data enables healthcare personnel (HCP) to rapidly respond to HAIs specific to each ward. For example, they can reduce HAIs by using day since last infection as an indicator. This indicator motivates them to do infection control activities and help monitor whether their practices are properly done to prevent HAIs. Therefore, I could learn how UNC hospitals actually reduced HAIs.

Infection control preventionists (ICPs) perform hospital rounds at wards and departments where they check infection control issues and provide HCP with adequate advices (Figure 2). ICPs also confirm precaution signs and documentation, and evaluate whether HCP adhere to guidelines and policies (Figure 3). In construction rounds, they checked whether construction in UNC hospitals is properly conducted in terms of infection
control: airflow, existing air ducts, construction zone, materials, and barriers. In burn center issues, I reviewed an outbreak investigation of multidrug-resistant *Pseudomonas aeruginosa* with ICPs (Figure 4). To prevent cross transmission, rapid response and recommendation, including strict contact precaution, hand hygiene observation, cohorting patients, and weekly surveillance, are needed. Thus, I could understand infection control issues in UNC and learn the basic skills of hospital epidemiology through this practicum. I would like to promote better infection control activities in my hospital.
UNC Hospital Epidemiology Department

Scope of Services

- Surveillance
- Committee Involvement
- Quality Control/Improvement
- Consultation
- Outbreaks/Exposures
- Regulatory Compliance and Accreditation
- Education

Infection Control Rounds

- check infection control issues, respond to consultations, and provide advices
- Appropriate precautions, hand hygiene and use of personal protective equipment to prevent healthcare-associated infections
Isolation Compliance Survey

- Monitor compliance of precautions and hand hygiene among healthcare personnel regularly

Outbreak Investigation

- Burn center issues: Multidrug-resistant *Pseudomonas aeruginosa*
- First positive MDRP in July
- Since then, 10 patients infected or colonized with MDRP (most susceptible to tobramycin)
- Site of infections: blood, cath tip, respiratory tract, and decubitus ulcer
- 3 PFGE types were identified
- Recommendation to prevent cross transmission: strict contact precaution, hand hygiene observation, cohorting patients, and weekly surveillance
1-2. Descriptive analysis of healthcare-associated infections other than bloodstream, respiratory, urinary tract or surgical site

It is estimated that healthcare-associated infections (HAI) account for approximately 1.7 million infections and 99,000 deaths in US hospitals. The Centers for Disease Control and Prevention (CDC) and the National Healthcare Safety Network (NHSN) have developed standardized surveillance definitions of HAI including surgical site infection (SSI), pneumonia, bloodstream infection (BSI) and urinary tract infection (UTI). All HAI except for those “Big Four” infection types are categorized as “other” types of HAI. Of the estimated total HAI (1,195,142) and deaths (98,987) associated with HAI in US hospitals among adults and children outside of intensive care units, other types of HAI accounted for 22% (263,810) and 11% (11,062), respectively, which suggests that other types of HAI provide a substantial burden in US healthcare facilities.

The NHSN reports have provided and focused on surveillance data on device-associated HAI such as central line–associated BSI, ventilator-associated pneumonia, and catheter–associated UTI. The University of North Carolina (UNC) Hospitals have conducted comprehensive hospital-wide surveillance for all HAI according to CDC criteria. The data from UNC Hospitals suggest that approximately 50% of HAI identified in a tertiary care hospital are not included in published NHSN reports. The data also revealed that respiratory tract infections (RTI) that were not associated with receipt of mechanical
ventilation, BSI that were not associated with a central line, UTI that were not associated
with a urinary catheter, SSI that were not included in NHSN surveillance accounted for
81.4%, 22.3%, 37.7%, and 25.5% of these body site infections, respectively, suggesting that
HAI for the major sites that are not device-associated nor are included in NHSN surveillance
reports have an important role in surveillance and healthcare epidemiology. Overall, 208
(16.5%) of a total of 1264 HAI were classified as “other” types of HAI in UNC Hospitals in
2010. For this reason we analyzed the UNC Hospitals data in order to: 1) investigate trends
and breakdown of HAI categorized as other types according to the CDC criteria; and 2)
analyze other HAI by selected variables (e.g. service, nurse station, and pathogen).

This study was conducted at UNC Hospitals, an 800-bed tertiary care facility, by
using Hospital Epidemiology data for 11 years (2001-2011). Comprehensive hospital-wide
surveillance for all HAI that included all CDC-defined sites was performed in accordance
with CDC criteria² by five infection preventionists and two full-time faculty members.
Sources for identification of HAI included laboratory reports of positive culture results,
results of serological testing or molecular-based diagnostic tests, morbidity and mortality
conferences, autopsies, and reports of infections from clinics and physicians. All surveillance
data were entered into an electronic database. This study was approved by the Institutional
Review Board of UNC Chapel Hill.

Of a total of 19,357 HAI in UNC Hospitals from 2001 to 2011, BSI, UTI, RTI, SSI,
and other types of HAI were identified in 4,989 (25.8%), 4,791 (24.8%), 3,389 (17.5%),
3,986 (20.6%), and 2,202 (11.4%) cases, respectively. In each year, other types of HAI have
been seen in 9-17% of all HAI. The frequency of BSI and UTI per all HAI each year has been
decreasing (from a maximum of 32.7% and 31.5% to 20.4% and 20.3% in 2011, respectively),
while that of RTI, SSI, and other types of HAI has not (from a minimum of 13.3%, 15.5%,
and 9.0% to 18.4%, 23.6%, and 17.2% in 2011, respectively) (Figure 5).

Table 1 shows breakdown of the 2,202 other types of HAIs by specific infection site,
service, and nursing station. The five major other types of HAI were as follows:

- gastrointestinal system infectionl 48.2% (N=1061);
- skin and soft tissue infection 27.7% (N=610);
- cardiovascular system infection 13.4% (N=295);
- ear, nose, throat, and oral infection 5.4% (N=118);
- intracranial infection 3.2% (N=70) (Table). Other types included reproductive tract 0.8% (N=18),
- bone/joint infections 0.7% (N=15), systemic infections 0.6% (N=14), and miscellaneous <0.1% (N=1). Approximately 40% and 50% of other HAI were identified in surgery service and ICU, respectively. Overall, other infections occurred on surgery 39.8% (N=877), medicine 27.7% (N=609), pediatric-surgery 14.1% (N=310), pediatric-medicine 10.2% (N=224), rehabilitation 3.0% (N=67), gynecology-obstetrics 2.5% (N=54) and miscellaneous 2.8% (N=61). Infection occurred in an ICU 48.0% (N=1057), non-ICU 47.3% (N=1041) and outpatient 4.7% (N=104).

Specific infections in five major other types of HAI and those pathogens are shown
in the Table 2. Of 1061 gastrointestinal system infections, gastroenteritis and peritonitis accounted for 843 (79.5%) and 135 (12.7%), respectively, and Clostridium difficile was detected in 785 (74.0%) cases. Of 610 skin and soft tissue infections, 273 (44.8%) were seen in burn wound cellulitis, followed by 147 (24.1%) in other skin and soft tissue infection and 66 (10.8%) in burn-related surgical wound infection, and Staphylococcus aureus was detected in 128 (21.0%) cases. Venous infection and endocarditis were responsible for 264 (89.5%) and 15 (5.1%) of 295 cardiovascular system infections, respectively, and the pathogens included coagulase-negative staphylococci (CNS), S. aureus, Enterococcus sp., Pseudomonas sp., and Gram-negative rods. Conjunctivitis (69.5%) was the most common in ear, nose, throat, and oral infection, while meningitis/ventriculitis (98.6%) was the most common infection in intracranial infection.

In the present study, we identified five major other types of HAI. Healthcare-associated gastroenteritis due to C. difficile was the most common in gastrointestinal system infections, which may reflect the increasing incidence rates of C. difficile infection over time and across US healthcare institutions as reported previously.6 Our previous study in UNC Hospitals over the 29-year period revealed increases in the relative proportion of pathogens, including S. aureus, CNS, Enterococcus sp., and C. difficile and other anaerobes.7 The data from the present study suggest that those pathogens have an important role in other types of HAI (Table 2).
BSI and UTI were the most common of all healthcare-associated infections, but the frequency of those infections has been decreasing in our study. UNC Hospitals has introduced multiple interventions to reduce the rate of central line-associated BSIs since 1999 and then have accomplished a sustained and prolonged reduction in ICUs by 73% in 2008.\textsuperscript{8} They also have reduced catheter-associated UTI by more than 30% over the last five years.\textsuperscript{9} The successful reduction of those HAI could be attributed, in part, by the multiple interventions and bundled approaches for device-associated infections. In this study, however, the frequency of other types of HAI has not decreased and has been found in greater than 10% of all HAI each year. Although there are no published data regarding other HAI, our data highlight the burden due to other types of HAI and should lead to efforts to prevention such infections.

In conclusion, we conducted descriptive analysis of HAI other than bloodstream, respiratory, urinary tract or surgical site through comprehensive hospital-wide surveillance at an academic hospital. Further investigation is needed to clarify epidemiology and establish infection control strategies in “other” HAI. Part of this section was submitted to a peer-reviewed journal, Infection Control and Hospital Epidemiology, on March 17, 2012 (Kanamori H, Weber DJ, Sickbert-Bennett EE, Brown V, Kaku M, Rutala WA. Descriptive analysis of healthcare-associated infections other than bloodstream, respiratory, urinary tract or surgical site, 2001-2011).
Figure 5. Trend in healthcare-associated infections (HAIs) at University of North Carolina (UNC) Hospitals from 2001 to 2011
Table 1. Frequency of each specific infection site, service, and nurse station in 2,202 other types of healthcare-associated infections (HAIs), University of North Carolina (UNC) Hospitals, 2001-2011

<table>
<thead>
<tr>
<th>Other types of HAIs</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Infection Site</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal System Infection</td>
<td>1061</td>
<td>48.2</td>
</tr>
<tr>
<td>Skin and Soft Tissue Infection</td>
<td>610</td>
<td>27.7</td>
</tr>
<tr>
<td>Cardiovascular System Infection</td>
<td>295</td>
<td>13.4</td>
</tr>
<tr>
<td>Ear, Nose, Throat, and Mouth Infection (code as other)</td>
<td>118</td>
<td>5.4</td>
</tr>
<tr>
<td>Intracranial Infection</td>
<td>70</td>
<td>3.2</td>
</tr>
<tr>
<td>Reproductive Tract Infection</td>
<td>18</td>
<td>0.8</td>
</tr>
<tr>
<td>Bone and Joint Infection</td>
<td>15</td>
<td>0.7</td>
</tr>
<tr>
<td>Systemic Infection</td>
<td>14</td>
<td>0.6</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td>877</td>
<td>39.8</td>
</tr>
<tr>
<td>Medicine</td>
<td>609</td>
<td>27.7</td>
</tr>
<tr>
<td>Pediatric Surgery</td>
<td>310</td>
<td>14.1</td>
</tr>
<tr>
<td>Pediatric Medicine</td>
<td>224</td>
<td>10.2</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>67</td>
<td>3.0</td>
</tr>
<tr>
<td>Gynecology and Obstetrics</td>
<td>54</td>
<td>2.5</td>
</tr>
<tr>
<td>Other services</td>
<td>61</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Nurse Station</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICUs</td>
<td>1057</td>
<td>48.0</td>
</tr>
<tr>
<td>Non-ICUs</td>
<td>1041</td>
<td>47.3</td>
</tr>
<tr>
<td>Outpatient</td>
<td>104</td>
<td>4.7</td>
</tr>
</tbody>
</table>
Table 2. Five major other types of healthcare-associated infections (HAI) and pathogens, University of North Carolina (UNC) Hospitals, 2001-2011

<table>
<thead>
<tr>
<th>Five major other types of HAI</th>
<th>No.</th>
<th>%</th>
<th>Pathogen</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrointestinal System Infection</td>
<td>1061</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>843</td>
<td>79.5</td>
<td>Clostridium difficile</td>
<td>785</td>
<td>74.0</td>
</tr>
<tr>
<td>Peritonitis</td>
<td>135</td>
<td>12.7</td>
<td>Other microorganisms</td>
<td>74</td>
<td>7.0</td>
</tr>
<tr>
<td>Necrotizing enterocolitis</td>
<td>37</td>
<td>3.5</td>
<td>Unknown</td>
<td>72</td>
<td>6.8</td>
</tr>
<tr>
<td>Intraabdominal infections or involving multiple sites</td>
<td>16</td>
<td>1.5</td>
<td>Rotavirus</td>
<td>45</td>
<td>4.2</td>
</tr>
<tr>
<td>Gastrointestinal tract infection</td>
<td>10</td>
<td>0.9</td>
<td>Candida sp.</td>
<td>26</td>
<td>2.5</td>
</tr>
<tr>
<td>Other gastrointestinal system infections</td>
<td>7</td>
<td>0.7</td>
<td>Enterococcus sp.</td>
<td>19</td>
<td>1.8</td>
</tr>
<tr>
<td>Cholecystitis</td>
<td>6</td>
<td>0.6</td>
<td>CNS</td>
<td>17</td>
<td>1.6</td>
</tr>
<tr>
<td>Pancreatic abscess or other infection</td>
<td>3</td>
<td>0.3</td>
<td>Enterobacter sp.</td>
<td>12</td>
<td>1.1</td>
</tr>
<tr>
<td>Liver abscess or other infection</td>
<td>2</td>
<td>0.2</td>
<td>Escherichia coli</td>
<td>11</td>
<td>1.0</td>
</tr>
<tr>
<td>Splenic abscess or other infection</td>
<td>1</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subphrenic or subdiaphragmatic abscess</td>
<td>1</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin and Soft Tissue Infection</td>
<td>610</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burn wound cellulitis</td>
<td>273</td>
<td>44.8</td>
<td>Unknown</td>
<td>296</td>
<td>48.5</td>
</tr>
<tr>
<td>Other skin and soft tissue infection</td>
<td>147</td>
<td>24.1</td>
<td>Staphylococcus aureus</td>
<td>128</td>
<td>21.0</td>
</tr>
<tr>
<td>Open burn-related surgical wound infection</td>
<td>66</td>
<td>10.8</td>
<td>Other microorganisms</td>
<td>59</td>
<td>9.7</td>
</tr>
<tr>
<td>Cutaneous infection</td>
<td>60</td>
<td>9.8</td>
<td>Candida sp.</td>
<td>25</td>
<td>4.1</td>
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<tr>
<td>Cellulitis</td>
<td>28</td>
<td>4.6</td>
<td>Pseudomonas aeruginosa</td>
<td>23</td>
<td>3.8</td>
</tr>
<tr>
<td>Decubitus ulcer infection</td>
<td>9</td>
<td>1.5</td>
<td>CNS</td>
<td>23</td>
<td>3.8</td>
</tr>
<tr>
<td>Pustulosis in infant</td>
<td>6</td>
<td>1.0</td>
<td>Enterococcus sp.</td>
<td>18</td>
<td>3.0</td>
</tr>
<tr>
<td>Burn wound impetigo</td>
<td>5</td>
<td>0.8</td>
<td>Aspergillus sp.</td>
<td>14</td>
<td>2.3</td>
</tr>
<tr>
<td>Myositis</td>
<td>4</td>
<td>0.7</td>
<td>Mucor sp.</td>
<td>9</td>
<td>1.5</td>
</tr>
<tr>
<td>Burn infection</td>
<td>3</td>
<td>0.5</td>
<td>Streptococcus sp.</td>
<td>8</td>
<td>1.3</td>
</tr>
<tr>
<td>Necrotizing fasciitis/gangrene</td>
<td>3</td>
<td>0.5</td>
<td>Escherichia coli</td>
<td>7</td>
<td>1.1</td>
</tr>
<tr>
<td>Omphalitis in newborn</td>
<td>3</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsurgical skin infections pre '96</td>
<td>2</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lymphadenitis/lymphangitis</td>
<td>1</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular System Infection</td>
<td>295</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venous infection</td>
<td>264</td>
<td>89.5</td>
<td>CNS</td>
<td>59</td>
<td>20.0</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>15</td>
<td>5.1</td>
<td>Staphylococcus aureus</td>
<td>38</td>
<td>12.9</td>
</tr>
<tr>
<td>Arterial infection</td>
<td>8</td>
<td>2.7</td>
<td>Enterococcus sp.</td>
<td>33</td>
<td>11.2</td>
</tr>
</tbody>
</table>
Pericarditis                     5  1.7  *Pseudomonas* sp.    31  10.5
Other cardiovascular system infection 2  0.7  Gram negative rods  30  10.2
Mediastinitis                  1  0.3  *Enterobacter* sp.   21  7.1
                                      *Candida* sp.        20  6.8
                                      Other microorganisms 15  5.1
                                      *Acinetobacter* sp.  13  4.4
                                      Unknown              13  4.4
                                      *Escherichia coli*   6  2.0
                                      *Klebsiella* sp.     6  2.0
                                      *Serratia marcescens* 5  1.7
                                      *Streptococcus* sp.  5  1.7

Ear, Nose, Throat, and Mouth Infection
(code as other)               118  100.0
                                      *Staphylococcus aureus* 24  20.3
Conjunctivitis                82  69.5
                                      Other microorganisms  16  13.6
                                      *CNS*               16  13.6
                                      *Enterobacter* sp.   6  5.1
                                      *Haemophilus* sp.    6  5.1
                                      *Escherichia coli*   9  7.6
                                      *Enterococcus* sp.   6  5.1
                                      *Serratia marcescens* 4  3.4
                                      *Streptococcus* sp.  4  3.4
                                      Diphtheroids         4  3.4
                                      *Acinetobacter* sp.  4  3.4
                                      *E. coli*            9  7.6
                                      *Enterococcus* sp.   4  3.4
                                      *Klebsiella pneumoniae* 5  7.1
                                      *Staphylococcus aureus*  8  11.4
                                      *Enterococcus* sp.   6  8.6
                                      *Klebsiella pneumoniae* 5  7.1
                                      *Enterobacter* sp.   5  7.1
                                      *Escherichia coli*   4  5.7

Intracranial Infection        70  100.0
                                      *CNS*              18  25.7
                                      *Staphylococcus aureus*  8  11.4
                                      *Enterococcus* sp.    6  8.6
                                      *Enterobacter* sp.    5  7.1
                                      *Klebsiella pneumoniae* 5  7.1
                                      *Acinetobacter* sp.   4  5.7
                                      *Escherichia coli*    4  5.7

CNS: coagulase-negative staphylococci
2. Infection control activities after the Great East Japan Earthquake

2-1. Infection control campaign at evacuation centers in Miyagi Prefecture after the Great East Japan Earthquake

The Great East Japan Earthquake (magnitude 9.0) and subsequent tsunami on March 11, 2011 occurred¹⁰ while I was enrolled in the MPH Distance Education Leadership concentration of the Public Health Leadership Program. The most devastated area was Miyagi prefecture in the Tohoku region, especially the coastal area, due to the tsunami. The seismic damage to the Fukushima nuclear power plant is dispersing radioactive substances.¹¹ As of April 1, 2011, the death toll from the earthquake and subsequent tsunami exceeded 6,700, with more than 7,000 missing in Miyagi prefecture.¹² Approximately 71,000 people are living at 550 evacuation shelters. Many survivors are obliged to reside in the shelters under harsh and unsanitary conditions. Health care is likely to be insufficient for evacuees since there are few healthcare workers, including medical doctors, registered nurses, and public health nurses. There is a public health concern about the increased risk of infectious diseases, including acute respiratory infections, influenza, tuberculosis, and measles under crowded living conditions, and diarrheal diseases and water-borne diseases typically seen after natural disasters.¹³,¹⁴ In Japan, the increase in the morbidity rate for pneumonia after the 1995 Hanshin-Awaji earthquake has been previously reported.¹⁵ Therefore, we, Tohoku
regional infection control network, have begun infection control activities to support evacuation centers in their fight against infectious diseases.

People who have lost their homes are crowded into each evacuation center (Figure 6). In most cases, there is no housing available for evacuees to live in and the distance between families is less than 1 meter, suggesting the difficulty of conducting droplet precautions. Influenza was epidemic from February through March in Japan,\textsuperscript{16} and continuous monitoring of influenza at evacuation centers is needed. We found that some could not wear masks properly, even if the mask supply is sufficient for residents. Room ventilation also tends to be poor because it is still cold outside in Miyagi prefecture. If small rooms to isolate patients with influenza-like illnesses are unavailable in evacuation centers, at least partitioning family units by using corrugated cardboard may be acceptable.

Running water is unavailable or insufficient due to damage to the water supply system. Hand hygiene depends on using alcohol-based hand sanitizers despite the limited resources (Figure 7). In addition, many residents have little understanding of hand hygiene because they are not healthcare professionals. Poor compliance with hand hygiene increase the risk of cross infection, particularly in the following setting: cooking and eating, using temporary lavatories, and garbage and infectious waste processing. Education regarding the importance of hand hygiene before food preparation and after using toilets, and installing alcohol-based hand sanitizers in the most visible spots are needed.
Many evacuation centers still suffer from unsanitary conditions due to poor environmental maintenance. Floors and toilets remain dirty unless no outdoor shoes are allowed and regular cleaning is done. Inappropriate disposal of infectious waste including vomitus, feces, and diapers, can lead to the transmission of infectious pathogens. It is essential to disseminate basic knowledge and skills for cleaning and disinfecting the shelter environment.

To achieve effective infection control measures in Miyagi prefecture, we require the cooperation and contribution of many hospitals in the region. Tohoku regional infection control network was established in 1999 to fight against infectious diseases and promote infection control activities. The operation center is located in the infection control unit of Tohoku university hospital, connecting more than 100 regional healthcare facilities. The network works functionally and collaboratively on infection control activities at evacuation centers and hospitals in disaster stricken areas as follows: 1) Infectious diseases consultation; 2) Infection control educational program and training; 3) Infection control interventions; and 4) Regional cooperation with local government against infectious diseases. The network enables us to rapidly respond to infection control issues in efficient ways, especially in terms of information dissemination and resource allocation. Thus, the network has an important role to solve infection control issues and to better improve infection control practices in the Tohoku region. We will continue our infection control activities at evacuation centers after
the most disastrous earthquake on record. This section was included in the journal publication entitled: Kanamori H, Kunishima H, Tokuda K, Kaku M. Infection control campaign at evacuation centers in Miyagi prefecture after the Great East Japan Earthquake. Infection Control and Hospital Epidemiology 2011;32:824-826.
Figure 6. Crowded living condition in an evacuation center

Figure 7. Infection control poster and alcohol-based hand sanitizers put on a temporary toilet
2-2. Latent tuberculosis infection in nurses exposed to tuberculous patients cared for in rooms without negative pressure after the 2011 Great East Japan Earthquake

In aftermath of the Great East Japan Earthquake on March 11, 2011, our hospital was unable to provide negative pressure rooms due to lack of electricity and damage to our generator. Our hospital, Miyagi Cardiovascular and Respiratory Center, was located on high hills in northern Miyagi prefecture of the Tohoku region and was designated as a tuberculosis center, with 50 beds in the tuberculosis (TB) ward. In our TB ward, infection control measures are performed as follows: the use of N95 respirators by healthcare personnel (HCP), independent ventilation systems with rooms maintained at negative pressure with respect to the corridor and direct out exhausted air, and respiratory isolation of TB patients. Our hospital was not damaged by the tsunami, but was severely affected by the tremendous earthquake of magnitude 9.0, and the ventilation system in the TB ward was shut down due to seismic damage.

Despite evidence demonstrating the association between ventilation and the transmission of TB,19 there are no data assessing the importance of negative pressure rooms in the airborne transmission of TB following a natural disaster. In addition, HCP are at risk for TB exposure and infection when they care for patients in healthcare settings.20 In this study, we investigated the prevalence of latent tuberculosis infection (LTBI) in nurses who were exposed to patients with active TB in rooms that could not be maintained under
negative pressure after the earthquake.

All negative pressure rooms in the TB ward were unavailable during March 11 to 15 (five days) and April 7 (one day) because of seismic damage to the ventilation system. The ventilation system was not designed to be supplied by the backup power generation system. It was not possible to open room windows for ventilation because our hospital was located in a very cold area.

All study participants completed self-administered questionnaires about working time in the TB unit, while negative pressure rooms were not available, exposure time to active TB patients, exposure to aerosol-generating procedures such as tracheal aspiration, and personal risk factors for TB infection. The whole-blood interferon-γ release assay (IGRA) was performed to identify LTBI by using QuantiFERON®-TB Gold In-Tube (QFT-3G) (Cellestis, Victoria, Australia) on May 19 or 26, 2011 (10-11 weeks after the earthquake) since all nurses were already tuberculin skin test (TST) positive at baseline and had a previous history of bacille Calmette-Gue´rin (BCG) vaccination. We could not obtain IGRA results at baseline because of difficulties with processing the blood test just after the earthquake. Chest radiographs were obtained from participants who were IGRA positive and reviewed by two pulmonologists. Informed consent was obtained from participants.

Fortunately, we had stocked sufficient N95 respirators, but compliance of some nurses was poor. The nursing station in the TB ward was connected via a corridor to patient
rooms and most HCP did not wear masks while working at the station. At the time during which there was inadequate ventilation, there were 23 smear negative TB patients and 2 active TB patients: one was graded Gaffky 9 in sputum smear with a TB strain resistant to isoniazid; the other was graded Gaffky 2. Figure 8 shows a map of patient placement in the TB ward just after the earthquake. Nineteen female nurses worked in the TB ward before the earthquake, but four left after the earthquake. Fifteen nurses, including 6 in Team X, 7 in Team Y, and 2 other nurses, were recruited into this study. Team Y mainly provided care for patients with active TB.

The questionnaire demonstrated that no participants had a history of TB and none had a risk factor for TB infection, including HIV infection, immunodeficiency, use of high-dose steroids or immunosuppressive drugs, diabetes mellitus, or malignancy. IGRA results were available for all 15 participants recruited into the study. Overall, three (20%) were IGRA positive (Table 3). Two IGRA positive nurses were derived from team Y, while all nurses in team X were IGRA negative. Two (50%) of the four nurses who were exposed to active TB for more than 9 hours were IGRA positive, while one (9.1%) of the 11 nurses who were exposed to active TB for less than 5 hours. Chest radiographs revealed no findings characteristic of active TB.

After a physician explained risks and benefits to three IGRA positive nurses, one nurse in her 50s refused LTBI treatment because of concern about side effects, and the
treatment for the second nurse who was in her 60s was not recommended due to casual
contact with active TB patients. One nurse who was in her 40s had a close contact with a
patient with active TB infected with an isoniazid-resistant strain and chose to receive
rifampicin therapy for LTBI. As of August 1, there have been no active TB cases observed
among nurses in our TB ward.

Nurses were exposed to active TB due to the unavailability of negative pressure
rooms following the earthquake. In the present study, three (20%) of 15 nurses were IGRA
positive. Menzies D et al. reported that the prevalence of LTBI among HCP was 63% in low-
and middle-income countries and 24% in high-income countries.\textsuperscript{21} It is estimated that a
prevalence of LTBI among Japanese HCP is approximately 10%.\textsuperscript{22} In our study, two of the
three nurses who were IGRA positive had a 9 hours exposure time to active TB patients.
Although airline passengers who are seated for more than 8 hours in the same or adjoining
row are more likely to be infected than other passengers, the optimal cut-off duration of
exposure is undetermined in evaluating the likelihood of TB infection at close contact in
healthcare setting.\textsuperscript{23}

TST has very limited value for screening LTBI\textsubscript{s} among HCP in Japan according to
the possibility of false-positive results in people who have received BCG vaccination (Harada,
2006), while QFT-G distinguished between persons with TB infection and uninfected persons
who have received BCG vaccine with a high sensitivity (89.0\%) and specificity (98.1\%).\textsuperscript{24}
We identified LTBIs using IGRA after laboratory centers being recovered when TB exposure occurred among nurses at the earthquake. IGRA in lieu of TST would be useful in LTBI screening and contact tracing, especially among HCP who have been vaccinated with BCG or in populations with high BCG vaccination coverage.

We have recognized the importance of a functioning ventilation system through this experience. It has been reported that tuberculin conversion among HCP was strongly associated with inadequate ventilation in general patient rooms. The electricity supply to ventilation system in our TB ward was not obtained from both public and private power generation system after the earthquake. It is important to inspect the electricity supply system and ventilation system, and to monitor negative pressure rooms regularly. It is also important to provide training for respirator fit testing among HCP at convenient times to ensure the ability of HCP to adhere to appropriate airborne precautions. Given the unexpected closure of the ventilation system and insufficient supply of respirators at natural disasters, we need to consider TB infection control under limited resources and to make a disaster preparedness plan in healthcare settings. This section was included in the journal publication entitled: Kanamori H, Aso N, Weber DJ, Koide M, Sasaki Y, Tokuda K, Kaku M. Latent tuberculosis infection in nurses exposed to tuberculous patients cared for in rooms without negative pressure after the 2011 great east Japan earthquake. Infection Control and Hospital Epidemiology 2012;33:204-206.
Figure 8. Map of patient placement in tuberculosis ward just after the earthquake


* This room was set aside for a more severe or infectious patient who is expected to be transferred from affected areas after the earthquake.
Table 3. Exposure time to patients with active tuberculosis among nurses and result of interferon-\(\gamma\) release assay

<table>
<thead>
<tr>
<th>Nurse</th>
<th>Age</th>
<th>Total working time under no negative pressure room (hours)</th>
<th>Total exposure time to active TB (hours)</th>
<th>Total time of aerosol-generating procedures for active TB (hours)</th>
<th>IGRA result</th>
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References


22. Harada N, Nakajima Y, Higuchi K, Sekiya Y, Rothel J, Mori T. Screening for tuberculosis


