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Queen's University

Evaluation of an innovative, integrated syndromic surveillance system using Occupational Health & Safety and Emergency Department data

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List of Abbreviations

CAD	Computer-Aided Design
CD	Communicable Disease
CDC	Centers for Disease Control and Prevention
CTAS	Canadian Triage Acuity Score
Cusum	Cumulative Sum
EARS	Early Aberration Reporting System
ED	Emergency Department
EDSS	Emergency Department Syndromic Surveillance
EH	Environmental Health
ESRI	Environmental Systems Research Institute
ESSENCE	Eletronic Surveillance System for the Early Notification of Community-Based Epidemics
FRI	Febrile Respiratory Illness
FSA	Forward Sortation Area
GIS	Geographic information systems
HCWs	Health care workers
HDH	Hotel Dieu Hospital
HL7	Health Level 7
HPPA	Health Protection and Promotion Act
ICD	International Classification of Diseases
ICP	Infection Control Practitioner
ICU	Intensive Care Unit

ILI	Influenza-like Illness
KFL&A	Kingston, Frontenac, Lennox & Addington
KGH	Kingston General Hospital
MOH	Medical Officer of Health
MOHLTC	Ministry of Health and Long-Term Care
OH&S	Occupational Health and Safety
PHAC	Public Health Agency of Canada
PHIN	Public Health Information Network
PHIPA	Personal Health Information and Protection act
PIA	Privacy Impact Assessment
QΦ	QPHI – Queen's University Public Health Informatics
QREB	Queen's Research Ethics Board
RODS	Real –Time Outbreak and Disease Surveillance
RLS	Recursive Least Squares
SARS	Severe Acute Respiratory Syndrome
SSHA	Smart Systems for Health Agency
SSL	Secure Socket Layer
SSMIC	Saulte Ste. Marie Innovation Centre
UI	User Interface
VPN	Virtual Private Network
WHO	World Health Organization

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INTRODUCTION AND EXECUTIVE SUMMARY

This compendium is a summary of the development, implementation, and evaluation of an innovative, integrated, syndromic surveillance system using existing Occupational Health and Safety (OH&S) and Emergency Department (ED) databases. The various components have been completed by members of the Queen's University Public Health Informatics (QΦ) Team located at Kingston Frontenac Lennox and Addington (KFL&A) Public Health.

The QΦ Team promotes collaboration, innovation, and action. We are a multidisciplinary group of medical, scientific, academic and information technology professionals working on various surveillance projects in Kingston, Ontario, Canada. Our purpose is to develop, evaluate, and implement public health informatics systems strategically and effectively. QΦ actions include developing new technology solutions, educating stakeholders, informing policy, and conducting research on the suitable use of public health information systems. Our team has developed, implemented and evaluated an integrated syndromic surveillance system for monitoring of both community and hospital staff infectious diseases which may help to characterize the occurrence and transmission within the hospital and allow for rapid implementation of appropriate infection control procedures to minimize the risk to health care workers (HCWs) and patients.

In April of 2005 the PSI Foundation agreed to fund a 2-year pilot project. The purpose was to integrate and evaluate the OH&S database at Kingston General Hospital (KGH)[1] with an existing Emergency Department Syndromic Surveillance (EDSS) system. The main objective was to determine if the system could detect sentinel events such as nosocomial infection among employees or the effect of a community outbreak on staffing levels and absenteeism. We wanted to consider whether this tool would enhance communication, collaboration and coordination between Infection Control, laboratory systems, hospital administration, OH&S and KFL&A Public Health. Our goal is to enable prevention, mitigation, response and recovery from sentinel events in hospitals and potentially the community setting.

The motivation behind this project is a result of recent outbreaks affecting health care environments in Ontario, such as Severe Acute Respiratory Syndrome (SARS) in 2003, and Legionnaires Disease and Norovirus in 2005[2-6]. Various reports from the National Advisory Committee on SARS chaired by Dr. David Naylor, the Expert Panel on SARS and Infectious Disease control chaired by Dr. David Walker and Mr. Justice Archie Campbell have all highlighted the importance of surveillance and the significant impact an outbreak can have on health human resources, with particular note on the importance of OH&S and Infection Control. The value of accurate and timely reporting of infectious disease-related illness among HCWs has been recognized and is encouraged. The tool described in this compendium intends to effectively and efficiently monitor various data sources in hopes of improving the capture of sentinel events and outbreaks and for future pandemic and emergency planning. To our knowledge, there has been no development of an integrated system of this kind to date.

The following is a brief summary of the chapters included in this report. The work was completed by members of our team with expertise in epidemiology, economics, information technology, geographic information systems (GIS), Public Health surveillance and Emergency Medicine. We thank the Human Resources and OH&S departments at KGH for their cooperation in providing access to the OH&S data from the Parklane software system[7].

Chapter 1

- Describes the system development and implementation process and the expected goals including to detect sentinel events such as nosocomial infection among employees or the effect of a community outbreak on staffing levels and absenteeism. We consider whether the system would enhance communication, collaboration and coordination between Infection Control, laboratory systems, Hospital Administration, OH&S and Public Health.

Chapter 2

- A descriptive paper addressing the main objective; to determine if the system could detect a sentinel event such as nosocomial infection among employees or the effect of a community outbreak on staffing levels.

Chapter 3

- A cost-benefit analysis has been conducted to estimate the benefits and costs of increasing influenza immunization levels for hospital staff.

Chapter 4

- Describes a recently developed GIS tool capable of mapping the floors and departments of KGH, in order to assess the impact of OH&S visits related to gastrointestinal and respiratory illness among hospital employees.

Chapter 5

- Technical evaluation describing the approach taken for the integration of the OH&S data with the EDSS system. Provides an overview of the system, describes the system architecture, and then concludes with an evaluation of the system and recommendations for future improvements.

Chapter 6

- A process evaluation of the integrated system based on the Centers for Disease Control (CDC) Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks

Chapter 7

- A time-series analysis comparing weekly totals of ED and OH&S visits. While this study did not show a temporal correlation between the OH&S and the ED data, OH&S data has the potential to aid hospital-specific interventions and policy practices.

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CHAPTER 1: An integrated, occupational health reporting system to detect nosocomial infection

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Introduction

Syndromic surveillance is a newly emerging field in the realm of epidemiological research, developed to address timeliness of collecting and analyzing statistical sources of data on health trends – such as symptoms reported via sickness absence records, emergency department (ED) visits, and telephone medical help lines[1]. Its growth was encouraged in large part due to a response to potential bioterrorism threats and more currently with the effects of Severe Acute Respiratory Syndrome (SARS) and potential avian influenza risk. Electronic data capture of reasons for hospital employee absenteeism can aid in rapid detection of infectious disease outbreaks before they are detected through conventional surveillance methods.

The Walker Report emphasized Canadian post-SARS interest in syndromic surveillance as an approach for Ontario to manage communicable diseases more adequately[2]. A convenient feature of syndromic surveillance is the reliance on existing and available electronic data streams. The majority of syndromic surveillance systems have been based primarily in ED settings. This project aims to further this research by developing and evaluating an integrated surveillance tool using Occupational Health and Safety (OH&S) and ED visits, in order to provide enhanced early warning of communicable diseases outbreaks within both the hospital and potentially the community setting. The system has been developed in collaboration with stakeholders including the OH&S and Human Resources departments at Kingston General Hospital (KGH)[3], Kingston, Frontenac, Lennox and Addington (KFL&A) Public Health and Queen's University Public Health Informatics team (QΦ).

Occupational Disease and Surveillance

By definition, an occupational disease is one that is caused by or becomes worse due to an exposure to risk factors at work[4,5]. Immediate identification and investigation of potential outbreaks in the health care setting is crucial to limiting transmission of infection[6]. In order to decrease the impact of healthcare-associated infections, one must identify increases in endemic infection rates, recognize outbreaks and review the efficiency of interventions and control measures[6-9].

Health surveillance entails the tracking and forecasting of critical health events or determinants through the ongoing collection of pertinent data, and the establishment and dissemination of reports, advisories, alerts and warnings as required[10,11]. Maintaining accurate records of illness and injury data of hospital employees enables OH&S professionals to track trends and facilitates the development of effective surveillance programs[12]. However, most OH&S surveillance systems are incomplete, resulting in error and providing an inaccurate representation of the actual events occurring[13]. By monitoring infection/sickness-related absence of employees, there is an opportunity to track illness and identify outbreaks or trends of illness among workers in the health care setting.

Healthcare Worker Risk

Health care workers (HCWs), especially nurses who are primarily responsible for front-line patient care, are at high risk of acquiring infections from direct patient contact. In addition, there is greater risk of exposure to contaminated human blood and body fluids[7,16]. More than 15 airborne infections are reported to have been transmitted to HCWs, including but not limited to: influenza, tuberculosis, measles, varicella, respiratory syncytial virus infection and SARS[16]. A person's judgement regarding their ability to work or decision to be absent is determined by various factors including severity of illness, in addition to social, psychological, and physical factors[14,17.]

Nosocomial Infections

Within an acute health care setting, there is an increased risk of nosocomial infection[18]. Hospitals with effective surveillance and infection control programs have the lowest nosocomial infection rates[18-20]. Nosocomial infection is synonymously known as a hospital-acquired infection that can affect both patients and staff[11]. It is an infection originating in a medical facility that was not present at time of admission/entrance and may not appear until after discharge/exit[11]. Hospital patients have the ability to transfer illness to one another, but more notably to the employees who have the greatest amount of patient contact (front-line staff)[10,21]. Nosocomial infections are the second most frequent adverse events aside from medication errors, occurring in hospitalized patients[18]. The risk of transmission of infection from HCW to the patient is high, with outbreaks typically affecting elderly patients with chronic conditions. Other susceptible patients include those in renal, transplant and oncology units, neonatal intensive care units and pediatric wards[22].

Infection Control

Infection control involves measures completed by healthcare personnel in healthcare facilities to decrease transmission and acquisition of infectious agents[23]. These measures are based on the transmission ability of an infectious agent, including standard, contact, droplet and airborne precautions[23]. The majority of occupational transmission is associated with violation of at least one or more of the three basic principles of infection control: hand-washing, vaccination of HCWs and prompt isolation of infectious patients[16]. Outbreak associated attack rates range from 15% to 40% for various airborne infections as listed in *Health care worker risk*[16]. When outbreaks occur in health care institutions, absenteeism among HCWs may approach 30% to 40%, resulting in employment costs, staff shortages, and imperil of healthcare delivery due to an insufficient number of replacement workers available[24]. It is within this outbreak context that the importance of infection control is demonstrated as being key to decreasing transmission of illness and disease[10,21]. Analyses have indicated nosocomial infection prevention and control programs are both clinically effective and also cost-effective[6,25,26].

Respiratory Illness

Respiratory illness is one of the main contributors of absence in HCWs[27]. SARS is the most recent example of an emerging infectious disease, which clearly illustrated the potential threat to Canada with regards to serious epidemics[10]. The SARS outbreak occurred in March 2003, where 438 cases were reported in Canada (250 probable and 188 suspect) 375 (85.6%) of which were reported in Ontario and 44 Canadians died[28]. Over 25,000 greater Toronto area residents were quarantined, and a large segment of Ontario's health system experience a decreased level of functioning[10]. HCWs were particularly impacted, with more than a hundred falling ill, and three deaths resulting from SARS. Specifically, front-line workers were most affected due to their vital role in controlling the disease, which in turn exposed them to a heightened risk of disease transmission and subjected them to considerable physical and psychological stress[10]. Initially during the SARS outbreak, the process of intubation (insertion of a tube into the airway) was performed to alleviate respiratory distress among SARS patients, without the realization that this was a significant source of droplet production[10]. This placed HCWs present during the high-risk procedure at an increased risk of transmission, despite wearing personal protective equipment (mask, gloves, gown, eye protection)[10].

An investigation of SARS transmission in a Toronto hospital illustrates that HCWs are at greatest risk of exposure. Of the identified cases, 36.7% were hospital staff (accounting for the highest case percentage)[28]. Nurses working in the ED while a SARS case was present experienced an attack rate of 22.2% (8/36) or 13.6 cases per 1000 nursing-hours worked[28]. Intensive care unit (ICU) nurses encountered an attack rate of 10.3% (4/38), or 2.4 cases per 1000 nursing-hours worked. Nurses in the coronary care unit experienced an attack rate of 60% (6/10) or 31.3 cases per 1000 nursing-hours worked[28]. Following the initial investigation, contact and droplet precautions were implemented for all patients in the ICU and both the ICU and ED were closed[28]. Hand-washing, use of gown, gloves, and protective eye wear were implemented for all patient care, as well, quarantine procedures and pressure rooms were used. The additional precautions implemented were effective in ceasing transmission of SARS[28].

The role of both Human Resources and OH&S departments were reassessed post-SARS, specifically by The Expert Panel on SARS and Infectious Disease Control (established by the Ministry of Health and Long-Term Care (MOHLTC))[2]. This initial report sanctioned a review of occupational health and safety (OH&S) policies, procedures and resources, with the intent of developing best practices toward the cooperation of OH&S and Infection Control[2]. The real-life experience of SARS highlighted the need for Canada, together with other nations, to ensure the availability of appropriate resources to enable prompt detection and response to infectious disease epidemics[10].

Following SARS, the MOHLTC implemented heightened measures within the OH&S departments in an attempt to capture infectious illness[29]. Specifically, a new protocol is followed to detect employee Febrile Respiratory Illness (FRI) in all Ontario hospitals. KGH created and implemented a procedure to help identify FRI, involving a bookmark size card which is provided to all employees with step-by-step instructions to follow if particular signs and symptoms are evident. As well, on the fourth day of illness, OH&S nurses telephone the staff member who is absent to question whether they are experiencing FRI-related symptoms. The new protocol is intended to impact OH&S by increasing reporting of illness and to ensure follow-up of staff absenteeism.

Gastrointestinal Illness

In addition to respiratory illness exposure, HCWs are subjected to gastrointestinal illness via fecal-oral transmission; through direct contact with infectious waste, through ingestion of contaminated food, and direct person-to-person contact[15]. Insufficient hand-washing is likely the primary contributor of gastrointestinal illness transmission among HCWs[16]. Gastrointestinal illness of an acute nature is a serious concern for HCWs due to the potential for patient transmission[30]. Therefore, according to the Enteric Diseases Surveillance Protocol for Ontario Hospitals, all persons experiencing vomiting and/or diarrhea must report to the OH&S department when leaving and returning to work[30]. Reporting and monitoring of these symptoms among HCWs can help control transmission and ensure surveillance of gastrointestinal illness.

Norovirus' are a group of viruses that cause what is typically known as 'stomach flu' or gastroenteritis. Several outbreaks in the nursing home setting have resulted in staff transmission rates of 30-50%[16]. A Norwalk outbreak declared on March 12th, 2007 at KGH resulted in two adult general medicine ward closures[38]. A total of 20 patients developed gastrointestinal symptoms; 6 patients tested positive for norovirus. Infection Control declared the outbreak over on March 20th, 2007[31]. Refer to chapter 2 for a detailed report of the norovirus outbreak and the system capability in detecting sentinel events and or nosocomial infections.

Influenza

Febrile respiratory illnesses are a serious threat to a healthcare institution. In particularly an outbreak of influenza can substantially increase sickness absence from work and put a significant burden on health care administration when surge capacity is already an issue[21,32]. Influenza vaccination, especially for HCWs has been recommended by many Public Health agencies including the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), the National Foundation for Infectious Diseases, Public Health Agency of Canada (PHAC) and by the MOHLTC[33-36]. Programs should focus on those at high risk of influenza-related complications, those apt to transmit influenza to individuals at high risk of complications, and those who provide fundamental community services[21,35,37]. Influenza vaccinations are currently the most effective method of minimizing the risk of contraction and transmission of illness[37]. Current and emerging influenza virus strains have antigenic characteristics to provide the basis for selecting the strains included in each year's vaccine[35]. Influenza season is associated with increased ED utilization, especially by elderly patients aged 65 years plus, most of whom have major respiratory illness and require admission[38].

Avian Influenza A (H5N1) is highly pathogenic, and as a result has been highlighted as a potential cause of outbreak and possible pandemic threatening the world. This virus primarily affects wild birds but has also infected and caused substantial death among poultry[39]. Although human infection is rare, since November 2003, nearly 400 cases of human infection with highly pathogenic avian influenza A (H5N1) viruses have been reported by more than a dozen countries in Asia, Africa, the Pacific, Europe and the Near East[39]. The true threat of this disease will occur if the virus mutates and is able to sustain spread from person-to-person. This transmission has not officially occurred, but there are a few cases deemed probable by human transfer[39]. The CDC provides interim recommendations for infection control in healthcare facilities that may encounter patients with known or suspected Avian Influenza. This evolving danger is yet another example of the possibility of human transmission and the importance of monitoring and tracking symptoms and reasons for absence, in order to capture possible illness and outbreak among hospital employees. The Ontario health plan for an influenza pandemic

(June 2008) recommends ongoing HCW surveillance data as a necessary component of the overall surveillance plan for health units[40]. The data proposed to be collected in this project could assist decision makers and inform control measures in real-time allowing appropriate evidence-based outbreak management. A system of this kind has been developed for the potential use in future pandemic and emergency planning.

The purpose of this project was to integrate and evaluate the existing OH&S databases at KGH with the Emergency Department Syndromic Surveillance (EDSS) system. We sought to evaluate whether this tool would enhance communication, collaboration and coordination between Infection Control, laboratory systems, Hospital Administration, OH&S and Public Health. Our goal was to enable prevention, mitigation, response and recovery from sentinel events in hospitals and potentially the community setting. We aimed to detect sentinel events such as nosocomial infection among employees or the effect of a community outbreak on staffing levels and HCW illness and injury reporting.

Emergency Department Syndromic Surveillance System

Queen's University and KFL&A Public Health began a novel pilot project in September 2005 with funding support from the MOHLTC. The purpose of the project was to develop a regional, web-based early warning system that monitors ED visits in real-time, to create a community-based picture of health complaints.

ED visits are collected in real-time from KGH as a component of an existing EDSS system and housed in Real-time Outbreak and Disease Surveillance (RODS) open source software, originally produced by the University of Pittsburgh and installed at KFL&A Public Health. The system uses an existing private provincial healthcare network known as Smart Systems for Health Agency (SSHA), a secure, integrated, province-wide information technology infrastructure that connects healthcare providers. Data is sent in Health Level 7 (HL7) format to the facility's HL7 message router through secure transfer to a server located at KFL&A Public Health.

All data used in the RODS system is collected by the participating health care facilities during the registration/triage process; no additional workflow is required. During registration at an ED, details are collected and recorded, describing both the patient and the visit. Not all of the routinely collected data is required by RODS for the purposes of public health surveillance, thus in order to comply with the Personal Health Information and Protection Act (PHIPA), the HL7 message router deletes identifiable information from the data and transmits the following variables: date and time of visit, gender, age, 5-digit postal code, chief complaints, triage level (scoring system used to identify urgency of patient complaint) and FRI screening score (positive or negative). The data is automatically fed into RODS and Coco, a chief complaint classifier reviews the chief complaints of patients at the hospital and the system appropriately categorizes visits into various syndromes including Respiratory, Gastroenteritis, Fever/ILI, Asthma, Derm Infectious, Neuro Infectious, Other. At this point the ED visits can be viewed in various formats including graphs, line listings of cases or GIS spatial representation. More information on the EDSS system capabilities and functions can be found in Chapters 4 and 5.

Occupational Health and Safety Data

The OH&S department monitors the occurrence of illness and injury reported by all hospital staff and volunteers. The OH&S database is a Parklane software system specifically designed for OH&S department that enables management of employee health, safety, adverse events and workplace risk (www.parklanesys.com)[41]. In January 2007, the OH&S department began compiling a file which consisted of all OH&S visits for the previous day, stored in a secure folder on the KGH network. In addition, retrospective OH&S visit records from April 2nd, 2004 to December 31, 2006 were provided. Secure Virtual Private Network (VPN) access was granted at KFL&A Public Health to enable access to the daily OH&S record files. OH&S data has a one-day lag and is available on a daily basis (not in real-time).

The variables retrieved from the database include date and time of visit, gender, date of birth, 5-digit postal code, employee affiliated department, reason for visit (i.e. initial visit, follow-up visit) and symptoms and syndromes as reported by the employee and classified by the OH&S nurse. The OH&S nurse records ‘attributes’ or symptoms as self-reported by the employee/volunteer, and based on this information the nurse selects from 40 predetermined ‘conditions’ or syndromes in order to classify reason(s) associated with the visit; definitive diagnosis are rarely recorded. The OH&S nurses are trained to categorize appropriate syndromes based on symptom reporting and when deemed necessary will send appropriate cultures to the lab or refer a doctor’s visit.

Integration Process

To develop an integrated syndromic surveillance system, data collected from the OH&S department at KGH was integrated with the existing EDSS system. OH&S data retrieval is semi-automatic; the file containing the data must manually be extracted from Citrix Access Gateway (KGH remote login) and copied into a RODS file. From this point the data is automatically copied and parsed and transferred to the database. Once the data is in the RODS system, graphs can be generated which shows both ED and OH&S data. There is an option to pre-customize time frames or specifically select a start and end date for the epi-curve. In order to generate a real-time system, the OH&S data would require technical adaptation to enable automated retrieval from the Parklane system and automated transfer to KFL&A Public Health.

The integrated system provides an opportunity to monitor infectious disease activity among the public and the hospital staff by observing ED and OH&S visits respectively. This project focuses on condition-specific events, including upper/lower respiratory and gastrointestinal conditions in the OH&S database. The system provides an automatic, electronic, compiled database which assist in capturing outbreaks in a timelier manner. The system uses anomaly detection to identify when increased activity occurs. An investigation ensues to determine if an alert warrants further communication with responsible persons. Tracking sentinel events both in a hospital and community provides the opportunity to compare both settings and determine origin and/or transmission of illness between healthcare facilities and the local community.

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CHAPTER 2: The value of syndromic surveillance in monitoring gastrointestinal-related symptoms among staff during a hospital norovirus outbreak

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BACKGROUND

The Norwalk virus is the primary cause of acute viral gastroenteritis cases in humans[1]. Symptoms usually occur 15-48 hours after exposure and often include nausea, severe vomiting, watery diarrhea, abdominal cramps, fever, chills and myalgias; the mean duration of illness is typically 12-60 hours[1-3]. Norovirus transmission is primarily by the fecal-oral route, and infection is often associated with the consumption of fecally contaminated food or water or by direct person-to-person spread. Management of infection typically consists of replacing fluid and electrolyte loss via oral and intravenous fluid administration. Prevention is best achieved through good hygiene practices including safe food handling procedures and frequent hand-washing. It is generally believed that norovirus infection rates are increasing in Canada.[4]

Norovirus outbreaks occurring in health care institutions can have severe impacts to health care services and the risk of infection to patients and staff[5,6]. Implementation of evidence-based infection control procedures such as patient isolation, rapid environmental decontamination, frequent hand-washing or alcohol antisepsis, and use of masks, gloves and gowns among staff, patients, and visitors are encouraged in order to limit pathogen spread[5-7]. Norovirus hospital outbreaks often result in ward closures and additional expenses associated with increases in nursing care, microbiological testing, and environmental cleaning[5,7,8].

Syndromic surveillance

Syndromic surveillance involves the use of routinely collected and electronically managed data for identifying illness clusters earlier than would be otherwise expected using traditional laboratory-based surveillance[9-11]. Typically, automated syndromic surveillance systems generate syndrome-specific alerts when a threshold limit is breached. Various data streams have been explored for syndromic surveillance, including ED visits, over-the-counter drug sales, and school and work absenteeism[12]. The development and implementation of HCW syndromic surveillance at KGH was initiated in response to the Severe Acute Respiratory Syndrome Commission recommendations which highlight the importance of efficient and accurate reporting of illness among HCWs to OH&S programs[13]. Routine surveillance of OH&S visit data can provide valuable information on the occurrence of infectious diseases among staff, and in turn facilitate investigation, timely intervention and increased infection control procedures when appropriate. Furthermore, rapid awareness of an outbreak may improve communication and collaboration among health care professionals and Public Health staff, helping to further reduce the risk spread of illness among HCWs and the community.

Kingston General Hospital Outbreak

KGH is the major regional teaching tertiary care referral site in Southeastern Ontario, Canada, providing an array of acute and ambulatory clinical services to Kingston and the surrounding region[14]. The norovirus outbreak was first reported among Ward X patients by the Infection Control Department on March 12th, 2007. The ward was closed to new admissions and transfers, and restrictions were placed on visitor hours and numbers. Ill patients were isolated and all staff, physicians, and visitors were instructed to take precautions including hand-washing with alcohol gel and universal gloving. In addition, staff members who experienced gastrointestinal symptoms were requested to inform their manager, report to OH&S, and to remain off work as directed. By March 20th, 2007, the outbreak was declared over and all special precautions were removed. A total 12 patients on Ward X and 8 patients on Ward Y developed gastrointestinal symptoms; 6 patients tested positive for norovirus.

The purposes of this study are to evaluate the Early Aberration Reporting System (EARS) as a tool to examine daily reporting of symptoms to OH&S among KGH staff, as well as determine if the software captured increased reports of gastrointestinal-related syndromes from hospital staff during the patient outbreak of norovirus.

METHODS

The KGH OH&S department is responsible for collecting and monitoring the occurrence of illness, injury and exposure contamination (i.e. needlestick injuries) among all KGH staff and volunteers in the OH&S database. The OH&S nurse selects from a pre-determined list of ‘attributes’ and enters up to six symptoms as self-reported by the visitor. The nurse then selects up to 4 pre-determined conditions associated with the symptoms provided. Definitive diagnoses are rarely recorded in the database. The use of a drop-down list for symptoms and conditions helps standardize and control data quality as opposed to using chief complaint, ICD-10 codes, or other data sources. The data files also contain employee/volunteer demographic and job-related information as well as relevant details associated with their visit.

Commencing in January 2007, KGH provided KFL&A Public Health with daily OH&S visit data for all staff and volunteers at KGH. Retrospective 2005 and 2006 data were also provided. Aberration detection analyses were performed with EARS software (Microsoft Excel version [EARS-X])[15] on gastrointestinal-associated visits and all visits using data dating from November 1st 2006 (till May 31st, 2007) in order to get a better representation of baseline levels of reporting and trends. EARS first classified visits into syndromes based on recorded symptoms then used cumulative sums (CUSUMS) of three varying sensitivities (C1-least sensitive, C2-moderate, C3-ultra sensitive) to analyze the data[16]. All methods have shown high specificity under simulation; rates of false-positives are generally low though C3 tends to flag more non-clinical events due to its increased sensitivity[16,17]. With the help of a trained medical professional (KM), the received conditions were reclassified into nine distinct groups (Reason for Visit Not Provided; Respiratory; Gastrointestinal; Musculoskeletal/ Inflammatory; Neurological/ Psychological; Obstetrical/ Gynaecological; Mandatory Staff Procedures; Undefined; Other), and specific departments were grouped into general types. After removing weekend reports, descriptive analyses were performed using SAS statistical software version 9.1[18].

Queen’s University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board approval was obtained prior to this study. In addition, a privacy impact assessment was completed to ensure compliance with the federal Personal Information Protection and Electronic Documents Act.

RESULTS

Over the seven-month analysis period, there were a total of 29 weekend visits (nine Saturday; 20 Sunday), representing 0.40% of the total (7206) visits. As the OH&S department is not generally open on weekends, these dates were removed, resulting in a total of 7177 visits. There were significant differences in the frequency of visits by day of week, with most reports (21.7%) falling on Mondays ($\chi^2 = 17.11$; $p = 0.001$). Similarly, there were significant differences in the frequency of visits by month ($\chi^2 = 114.88$; $p < 0.0001$). Most visits occurred in November (16.8%) followed closely by March (16.5%). Musculoskeletal / inflammatory conditions were the most commonly reported (31.3%). The majority of visits (40.6%) came from staff classified as 'administration and support/ other', and was follow-up or document requests (58.3%).

Visits for gastrointestinal symptoms accounted for roughly 7.1% of all visits, and there were significant differences by day of the week ($\chi^2 = 16.23$; $p < 0.0001$) with Monday representing the majority (24.7%), and by month ($\chi^2 = 96.39$; $p < 0.0001$) with March having the most visits (29.2%). Administrative and support staff generated the most visits (47%), while the majority of gastrointestinal visits were initial visits to OH&S (42.3%). (See Tables 1 and 2)

Table 1: Number of Total Reported Visits by Day and by Month (All Visits and Gastrointestinal Only) to OH&S Department during a Seven-Month Period at KGH

Weekday	χ^2	**N**	**%**	**GI Only**		
				χ^2	**N**	**%**
Monday	17.11†	1556	21.68	16.23*	114	24.68
Tuesday		1419	19.77		98	21.21
Wednesday		1437	20.02		100	21.65
Thursday		1337	18.63		88	19.05
Friday		1428	19.90		62	13.42
Total		**7177**	**100**		**462**	**100**
		(μ=1435.4)			**(μ=92.4)**	
Month	χ^2	**N**	**%**	**GI Only**		
				χ^2	**N**	**%**
November	114.88‡	1205	16.79	96.39‡	39	8.44
December		813	11.33		59	12.77
January		1073	14.95		45	9.74
February		944	13.15		63	13.64
March		1181	16.46		135	29.22
April		940	13.10		73	15.80
May		1021	14.23		48	10.39
Total		**7177**	**100**		**462**	**100**
		(μ=1025.3)			**(μ=66)**	

* $p \leq 0.05$; † $p \leq 0.01$; ‡ $p \leq 0.001$

Table 2: Primary Reason for 6553 Reported Visits to OH&S Department during a Seven-Month Period at KGH

Primary Conditions Reported to OH	Number of Absences	% of Visits
Respiratory	703	10.73
Gastrointestinal	462	7.05
Musculoskeletal/ Inflammatory	2052	31.31
Neurological/ Psychological	441	6.73
Obstetrical/ Gynaecological	77	1.18
Undefined (No condition associated with OH visit)	210	3.20
Reason For Visit Not Provided	471	7.19
Mandatory Staff Procedures	1303	19.88
Other	834	12.73
Total	**6553**	**100**

* Frequency Missing = 624

During the first five months that KFL&A Public Health was receiving OH&S data, (January 1st, 2007, to May 31st, 2007), there was one alert produced for all symptoms combined on February 15th (33 counts) (Figure 1). A number of dates were flagged for gastrointestinal-related illness (Figure 2), including: February 5th (one count), 7th (one count), 9th (two counts), 15th (five counts), and 16th (five counts); March 15th (six counts) and March 16th (eight counts); April 10th (six counts) and 12th (four counts); and May 3rd (three counts), 7th (five counts), and 25th (two counts).

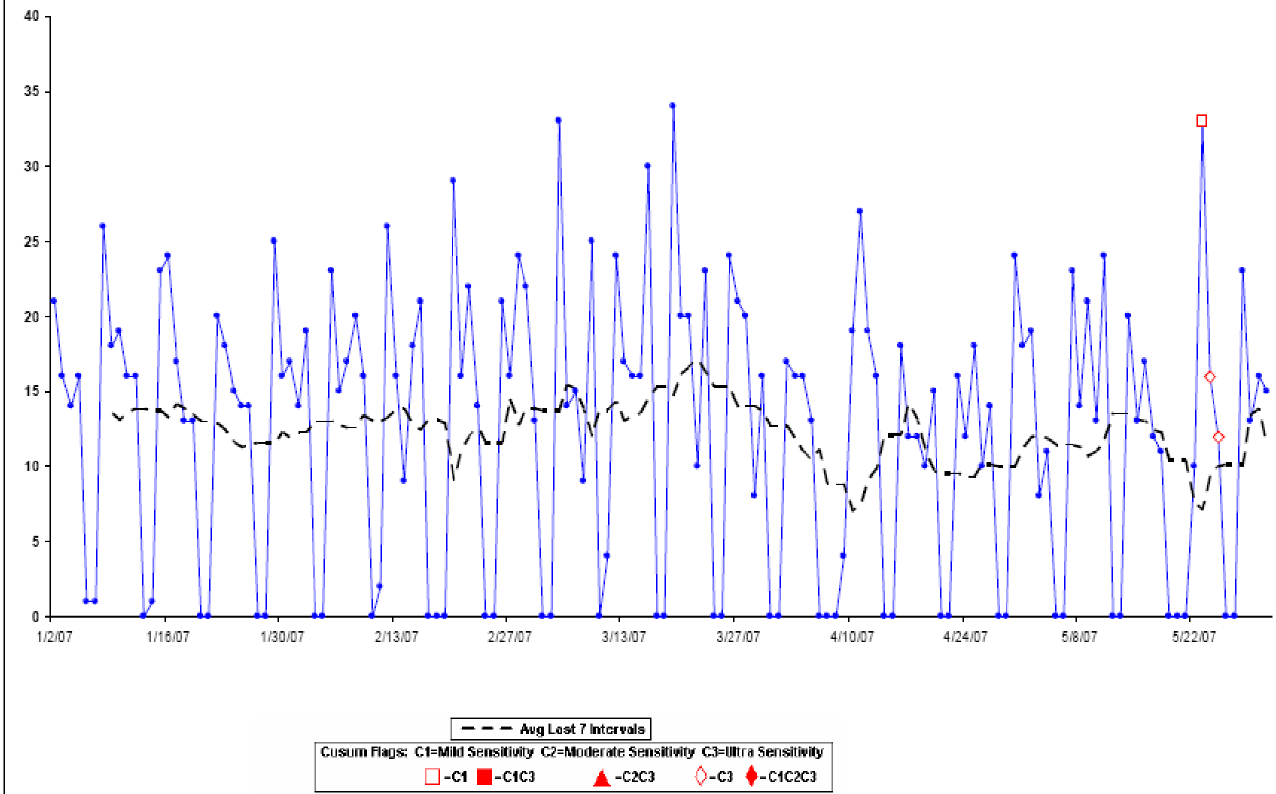

Figure 1: EARS Output for all Symptoms combined reporting, Jan 1 to May 31, 2007

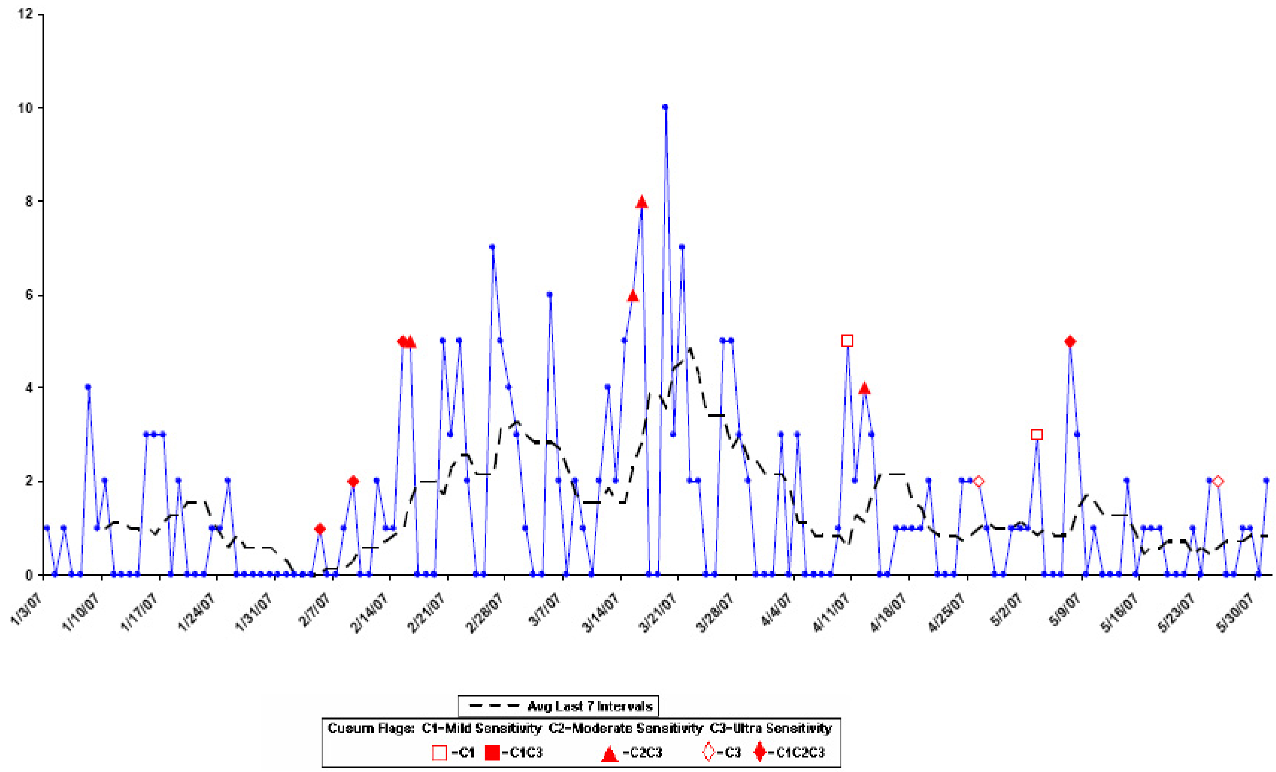

Figure 2: EARS Output for Gastrointestinal-related symptoms reporting, Jan 1 to May 31, 2007

DISCUSSION

During the seven-month study period, there were a total of 7177 visits (excluding weekends). A significant number of visits came on Mondays. This is most likely due to the OH&S department being closed on weekends and symptoms being reported on the following Monday. There was an average of roughly 1025 visits per month; November and March generated statistically more visits than the other months, with 1205 and 1181 visits, respectively. When looking at only gastrointestinal, these visits only accounted for approximately 7.1% of the total. There were also significant differences by day of the week, with Monday having the most visits. Furthermore, most likely due to the patient outbreak, the month of March had the most gastrointestinal visits (135 or 29.2%); most of these (58.5%) were initial visits/ reports.

There was one alert produced by EARS for all symptoms combined on May 23rd (33 counts) between January 1st and May 31st, 2007. As this is a low sensitivity alert for an aggregate count of all OH&S visits on that day, this alert should be interpreted with caution. Twelve dates were flagged for gastrointestinal-related illness. While no outbreak among patients was reported during the month of February, it is interesting to note that EARS generated multiple alerts and increased gastrointestinal-related illness reporting, particularly towards mid-late February. This may be indicative of the mechanism by which the virus first entered the hospital. These alerts may be important for conducting follow-up investigations with staff reporting illness, and initiating more rigorous infection control throughout the hospital earlier.

Though the outbreak in-hospital announcement occurred on March 12th, 2007 it was not until March 15th and 16th that any alerts were generated; with six and eight counts respectively. The delay in aberration detection in gastrointestinal symptom reporting by EARS is not likely an error of the program, but could be a natural aspect of the (possible) spread of infection from patients to staff within normal transmissibility periods (72 hours post-recovery). This is important as the increased reporting among staff following the March 2007 outbreak announcement may provide an indication of norovirus transmission between patients and staff; however without confirmed staff laboratory data, this is impossible to conclude. It is also possible that the increased reporting may also be an indication of staff compliance with illness reporting procedures. The highest number of gastrointestinal cases occurred on March 19^{th}, but no alert was established, due to the inclusion of the significantly higher counts of the previous two days in the baseline. Examining EARS line-listings indicates that many of the staff reporting gastrointestinal illness during the month of March were employees of Wards X, and Y, however, we are unable to officially determine the mechanism of spread between wards, nor confirm norovirus infection among staff that reported gastrointestinal symptoms.

There were five additional alerts after March: two in April, and three in May. The alerts in April may also warrant investigation as there was a sharp incline after a short period of non gastrointestinal-related reports. Because these dates follow a weekend, they may need to be interpreted judiciously. The alert on May 7^{th} also falls on a Monday, and may be indicative of reporting following a weekend, rather than a clinical event. Finally, at three and one counts, respectively, it is unlikely the May 3^{rd} and 25^{th} alerts require extensive follow-up. Despite this, when alerts do appear, it may be worthwhile to disseminate this information to important hospital units including Human Resources and Infection Control so they can determine if a more thorough investigation is necessary.

Limitations

This research is not without limitations. Due to low counts of OH&S visits on the weekend, there are often erroneous alerts on Mondays. One method of dealing with this issue could be to exclude weekend dates to ensure the data counts remain stable each consecutive day. Laboratory confirmed cases of norovirus infection among staff are unavailable and therefore patient-to-staff transmission or precise cause of infection cannot be established. Additionally, though line-listing reports from the OH&S database may implicate certain wards in generating most of the reports of gastrointestinal-related illness, we cannot conclude with certainty that these staff came into contact with infected patients during the outbreak.

CONCLUSION

At KGH, upwards of 1000 visits to the OH&S department occur every month. While it is likely that patient-to-staff transmission occurred and accounted for the increased gastrointestinal symptom reporting among staff during the patient outbreak of norovirus in March of 2007, this can not be concluded with certainty without laboratory data. Despite the limitations, this study has found EARS adept at capturing increased reporting of gastrointestinal-related illness to the OH&S department during a patient outbreak. Improved capture of reporting of illness among staff allows decision-makers to monitor all aspects of an outbreak and establish interventions such as increased infection control measures. Increased details about staff contact with infected patients, travel between departments, and adoption and continuation of infection control procedures would further clarify the impact of patient outbreaks on staff.

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CHAPTER 3: Estimating the benefits and costs of increasing influenza immunization levels for hospital staff

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Executive Summary

We were asked to explore the question of the costs and benefits of increasing the level of staff immunization against influenza in a large teaching hospital.

Hospital and Public Health authorities estimated that in recent years the level of hospital staff influenza immunizations has been approximately 30%. We were asked to estimate the costs and benefits of achieving increased levels of (a) 60% and (b) 80%.

The benefits of increased immunization are estimated as averted sick pay (plus 25% benefits) which would be paid to an absent employee with flu for a period of 5 working days.

The mean daily sick pay (plus 25% for benefits) for a staff member during these years is $29/hr x 1.25 x 7.5 hours per day = $244 per influenza absence day.

The costs of increasing immunization levels from 30% to 60% or 80% depend upon which agencies perform the immunization and where the immunization is administered. The average costs per individual staff member immunization are estimated to be $28.15. The expected benefits of an additional immunized staff member are $81.37 in averted sick pay.

The range of total annual net benefits (after deduction of immunization costs) range from:

- $3,719 to $20,616 for an immunization level increase from 30% to 60%
- $18,640 to $41,169 for an immunization level increase from 30% to 80%

The range reflects alternatives in how, where & by whom the immunization if performed.

% Staff Immunized	**Net Benefit (Low Estimate)**	**Net Benefit (High Estimate)**
from 30% to 60%	**$3,719**	**$20,616**
from 30% to 80%	**$18,640**	**$41,169**

This is a net benefit to the hospital from expanding influenza immunization levels among staff. This benefit arises from averted sick pay among staff that would otherwise get influenza. We don't estimate any other benefits, but would expect that a substantial benefit would arise from lower influenza rates among hospital inpatients.

Introduction

We were asked by KFL&A Public Health to join a research project and develop information about absences from work among employees at KGH, a large teaching hospital. The goal was to determine the annual rate of absence by cause and to estimate the cost of absent employees to the hospital.

The available data for this task turned out to be insufficient, and too expensive to upgrade in a short time frame. The project focus was modified to estimate the costs and benefits of achieving higher influenza immunization rates (and consequently fewer absences) among hospital staff. However, we could generate some insights from the overall data and so we present the description of employee health and the use made of OH&S services.

Statistics of Employees and Visits to Occupational Health and Safety

Tables 1a and 1b present the numbers of employees (1a) and number of visits (1b) made by staff by reason for visit to the OH&S department in the hospital during a 12 month sampling period June 1, 2004 to May 31, 2005.

Table 1c shows discrete persons and visits to OH&S in each of 4 years for an expanded set of reasons for the visit. Table 2 is a graph of the cumulative cases of FRI over each fiscal year. The large variation from year to year means that benefits of higher levels of immunization will vary. Our estimate is based on the average of the four years.

Table 1a. Persons Making at Least One Visit to OH&S

during Sampled Year of June1, 2004 to May 31, 2005

Employee Work Location/Department	Reason for OHS Visit: 1.0 Preventive & Administrative	2.0 All Medical	2.1 Respiratory	2.2 Other Medical Conditions	3.0 Other & Unknown	Grand Total
Admin & Support	424	877	339	538	428	1,134
Critical Care	69	292	118	174	132	294
Diagnostic Imaging	44	218	89	129	96	216
Emerg Dept	33	96	40	56	43	102
General Medicine	126	378	140	238	199	449
OB/GYN	9	41	16	25	18	47
OutPat Clinic	90	291	110	181	146	309
Paediatrics	12	52	21	31	24	50
Resource Pool	58	274	99	175	121	255
Surgical	43	170	64	106	60	161
Grand Total	908	2,689	1,036	1,653	1,267	2,990

Table 1b. Total Visits to OH&S by Full Time Hospital Staff

during Sampled Year of June1, 2004 to May 31, 2005

Employee Work Location/Department		Reason for OHS Visit					
		1.0 Preventive & Administrative	2.0 All Medical	2.1 Respiratory	2.2 Other Medical Conditions	3.0 Other & Unknown	Grand Total
	Admin & Support	487	1,777	558	1,219	612	2,876
	Critical Care	92	552	187	365	189	833
	Diagnostic Imaging	50	398	143	255	136	584
	Emerg Dept	42	183	59	124	55	280
	General Medicine	166	745	225	520	280	1,191
	OB/GYN	14	69	25	44	24	107
	OutPat Clinic	102	593	199	394	214	909
	Paediatrics	15	90	31	59	36	141
	Resource Pool	76	627	156	471	181	884
	Surgical	53	347	108	239	108	508
	Grand Total	1,097	5,381	1,691	3,690	1,835	8,313

Appendix 1c.1. Visits and Discrete Persons to OH&S by Fiscal Year

Detailed Reason for OH&S Visit by Staff

Employee Work Location / Department		Abdominal		Cardiovascular		Deep Tissue		Ear		Exposure		Febrile Respiratory Illness		Gastrointestinal	
		Visits	People	Visits	People	Visits	People	Visits	People	Visits	People	Visits	People	Visits	People
Admin & Support	2004	7	7	48	34	30	29	24	23	16	16	22	22	239	175
	2005	5	5	60	38	19	16	26	24	36	35	46	43	182	144
	2006	7	7	54	37	29	28	15	15	32	31	12	12	192	142
	2007	7	7	49	30	18	18	10	10	33	32	2	2	102	84
4 Year Total		26	26	211	139	96	91	75	72	117	114	82	79	715	545
Percent of Total		0.3%	0.7%	2.5%	3.8%	1.1%	2.5%	0.9%	2.0%	1.4%	3.1%	1.0%	2.1%	8.4%	14.8%
Critical Care	2004		0	5	5	6	6	1	1	17	16	4	4	74	59
	2005	1	1	3	3	4	3	8	6	24	22	12	12	51	40
	2006	2	2	4	4	2	2	1	1	25	22	9	8	29	25
	2007		0	3	3		0		0	12	11	1	1	21	20
4 Year Total		3	3	15	15	12	11	10	8	78	71	26	25	175	144
Percent of Total		0.1%	0.3%	0.7%	1.6%	0.5%	1.2%	0.4%	0.8%	3.4%	7.4%	1.1%	2.6%	7.6%	15.1%
Diagnostic Imaging	2004		0	14	13	4	4	3	3	3	3	4	4	62	49
	2005		0	17	12	5	3	4	4	17	15	8	7	52	38
	2006		0	10	9	2	2	1	1	11	11			34	31
	2007		0	5	3	4	4	1	1	6	5	1	1	19	17
4 Year Total		0	0	46	37	15	13	9	9	37	34	13	12	167	135
Percent of Total		0.0%	0.0%	2.8%	5.2%	0.9%	1.8%	0.5%	1.3%	2.2%	4.8%	0.8%	1.7%	10.1%	19.1%
Emerg Dept	2004		0		0		0	2	2	10	8	5	4	21	17
	2005	2	1	3	3		0	1	1	5	5	3	3	25	20
	2006		0	2	2	2	2		0	19	19	3	3	16	14
	2007		0	2	2	1	1		0	5	5			8	8
4 Year Total		2	1	7	7	3	3	3	3	39	37	11	10	70	59
Percent of Total		0.3%	0.3%	0.9%	2.2%	0.4%	0.9%	0.4%	0.9%	5.2%	11.4%	1.5%	3.1%	9.4%	18.2%
General Medicine	2004		0	11	8	8	8	9	9	33	28	11	10	105	76
	2005	2	2	7	6	5	5	6	6	35	29	7	7	83	66
	2006	3	3	5	4	7	7	4	4	47	45	5	5	52	42
	2007	2	1	7	6	2	2	1	1	40	38	2	2	29	25
4 Year Total		7	6	30	24	22	22	20	20	155	140	25	24	269	209
Percent of Total		0.2%	0.4%	0.9%	1.6%	0.6%	1.5%	0.6%	1.3%	4.5%	9.3%	0.7%	1.6%	7.7%	13.9%
OB/GYN	2004		0	1	1		0		0	7	5	1	1	10	7
	2005		0	2	2		0	1	1	5	4	3	3	10	8
	2006		0		0	3	3	1	1	12	10			10	9
	2007		0		0		0		0	3	2			3	2
4 Year Total		0	0	3	3	3	3	2	2	27	21	4	4	33	26
Percent of Total		0.0%	0.0%	0.8%	1.9%	0.8%	1.9%	0.5%	1.2%	7.2%	13.0%	1.1%	2.5%	8.8%	16.0%
OutPat Clinic	2004	3	3	5	3	5	3		0	9	9	8	8	103	75
	2005	2	2	8	8	2	2	5	5	29	23	10	10	75	56
	2006	1	1	3	3	5	5		0	9	9	4	4	33	29
	2007	1	1	3	3	9	8	2	2	7	7	2	2	23	21
4 Year Total		7	7	19	17	21	18	7	7	54	48	24	24	234	181
Percent of Total		0.3%	0.7%	0.8%	1.7%	0.9%	1.8%	0.3%	0.7%	2.3%	4.8%	1.0%	2.4%	9.8%	18.0%
Paediatrics	2004		0	1	1		0		0	5	5	1	1	15	12
	2005		0	1	1		0		0	6	6	4	4	5	4
	2006		0		0		0		0	3	3	4	4	6	6
	2007		0		0		0	1	1		0			4	4
4 Year Total		0	0	2	2	0	0	1	1	14	14	9	9	30	26
Percent of Total		0.0%	0.0%	0.5%	1.2%	0.0%	0.0%	0.3%	0.6%	3.8%	8.2%	2.4%	5.3%	8.1%	15.2%
Resource Pool	2004	5	5	26	13	9	6	4	4	9	8	3	3	103	75
	2005	1	1	10	6	10	9	6	4	20	17	15	14	87	61
	2006	3	3	9	7	6	6	7	6	33	32	13	12	80	61
	2007	2	2	5	5	10	9	1	1	8	8	3	3	53	41
4 Year Total		11	11	50	31	35	30	18	15	70	65	34	32	323	238
Percent of Total		0.4%	1.1%	1.8%	3.2%	1.3%	3.1%	0.6%	1.5%	2.5%	6.7%	1.2%	3.3%	11.5%	24.5%
Surgical	2004	1	1		0	1	1	4	3	12	11	3	3	71	45
	2005	3	3	4	2	4	4	4	4	18	17	11	8	76	45
	2006	1	1	1	1	2	2	1	1	10	9	9	7	52	40
	2007	1	1	3	2	2	2	1	1	12	12	1	1	32	22
4 Year Total		6	6	8	5	9	9	10	9	52	49	24	19	231	152
Percent of Total		0.4%	1.1%	0.5%	0.9%	0.6%	1.6%	0.6%	1.6%	3.2%	8.8%	1.5%	3.4%	14.3%	27.2%
Fiscal Year Totals	2004	16	16	111	78	63	57	47	45	121	109	62	60	803	590
	2005	16	15	115	81	49	42	61	55	195	173	119	111	646	482
	2006	17	17	88	67	58	57	30	29	201	191	59	55	504	399
	2007	13	12	77	54	46	44	17	17	126	119	12	12	294	242
4 Year Total		62	60	391	280	216	200	155	146	643	592	252	238	2247	1713
Total		62	58	391	234	216	190	155	134	643	537	252	216	2247	1237
Percent of Total		0.3%	1.1%	1.6%	4.5%	0.9%	3.6%	0.6%	2.6%	2.7%	10.3%	1.0%	4.1%	9.3%	23.7%

Table 1c.2. Visits and Discrete Persons to OH&S by Fiscal Year

Employee Work Location / Department		Detailed Reason for OH&S Visit by Staff													
		Gynecological		Immunization /Testing		Inflammatory Condition		Musculo-skeletal		Neurological		Obstetrical		Ocular	
		Visits	People	Visits	People	Visits	People	Visits	People	Visits	People	Visits	People	Visits	People
Admin & Support	2004	16	14	32	30	9	7	346	211	111	80	6	5	47	35
	2005	13	13	242	212	10	9	397	228	146	84	19	9	40	36
	2006	9	7	237	213	7	5	334	208	81	58	9	8	34	31
	2007	6	6	206	180	8	6	240	164	65	41	2	2	35	30
4 Year Total		44	40	717	635	34	27	1317	811	403	263	36	24	156	132
Percent of Total		0.5%	1.1%	8.5%	17.3%	0.4%	0.7%	15.5%	22.0%	4.8%	7.1%	0.4%	0.7%	1.8%	3.6%
Critical Care	2004	11	9	6	5	1	1	123	78	32	30	8	7	5	5
	2005	5	4	54	44	8	6	149	91	43	31	14	9	10	8
	2006	3	2	40	34	2	1	107	79	29	20	6	6	7	7
	2007	1	1	35	34	2	1	63	48	5	5	10	9	3	3
4 Year Total		20	16	135	117	13	9	442	296	109	86	38	31	25	23
Percent of Total		0.9%	1.7%	5.9%	12.3%	0.6%	0.9%	19.2%	31.0%	4.7%	9.0%	1.7%	3.2%	1.1%	2.4%
Diagnostic Imaging	2004	10	9	2	2		0	61	45	26	19	3	3	6	5
	2005	11	2	55	46	1	1	74	47	25	14	4	3	10	7
	2006	6	3	34	32		0	56	42	8	5		0	6	5
	2007	2	2	26	20	1	1	56	45	8	7	5	4	8	6
4 Year Total		29	16	117	100	2	2	247	179	67	45	12	10	30	23
Percent of Total		1.8%	2.3%	7.1%	14.1%	0.1%	0.3%	14.9%	25.3%	4.1%	6.4%	0.7%	1.4%	1.8%	3.2%
Emerg Dept	2004	3	3	5	4	1	1	41	28	16	6	2	2	4	4
	2005	4	3	17	16	1	1	41	31	15	11		0	2	2
	2006		0	16	13		0	22	19	7	6	2	2	1	1
	2007	1	1	11	9		0	21	17	2	2	1	1	1	1
4 Year Total		8	7	49	42	2	2	125	95	40	25	5	5	8	8
Percent of Total		1.1%	2.2%	6.6%	12.9%	0.3%	0.6%	16.8%	29.2%	5.4%	7.7%	0.7%	1.5%	1.1%	2.5%
General Medicine	2004	8	7	17	15	3	3	167	106	64	45	12	10	12	11
	2005	6	6	67	61	3	3	232	125	89	60	5	3	9	8
	2006	6	5	97	87	1	1	180	122	29	18	9	8	7	6
	2007	4	3	78	69	2	2	129	100	18	15	6	5	5	3
4 Year Total		24	21	259	232	9	9	708	453	200	138	32	26	33	28
Percent of Total		0.7%	1.4%	7.5%	15.4%	0.3%	0.6%	20.4%	30.1%	5.8%	9.2%	0.9%	1.7%	0.9%	1.9%
OB/GYN	2004	1	1	2	2		0	12	11	8	5	4	2	1	1
	2005	2	2	5	4		0	13	11	4	4	6	2	4	3
	2006		0	7	6		0	19	14	6	3	3	2	1	1
	2007		0	4	4		0	11	8	3	3		0		0
4 Year Total		3	3	18	16	0	0	55	44	21	15	13	6	6	5
Percent of Total		0.8%	1.9%	4.8%	9.9%	0.0%	0.0%	14.7%	27.2%	5.6%	9.3%	3.5%	3.7%	1.6%	3.1%
OutPat Clinic	2004	8	5	12	12	2	2	98	68	52	38	5	3	16	14
	2005	10	9	57	49	5	3	104	68	40	32		0	13	10
	2006		0	51	48	1	1	84	58	18	12	6	2	2	2
	2007	2	2	50	46	1	1	69	46	8	7	4	3	12	11
4 Year Total		20	16	170	155	9	7	355	240	118	89	15	8	43	37
Percent of Total		0.8%	1.6%	7.1%	15.4%	0.4%	0.7%	14.8%	23.9%	4.9%	8.9%	0.6%	0.8%	1.8%	3.7%
Paediatrics	2004		0	2	2	1	1	14	11	7	6	3	1	1	1
	2005	1	1	6	5		0	14	6	2	2	5	4	3	2
	2006	1	1	9	8		0	6	5	1	1		0	1	1
	2007		0	11	11		0	7	7		0	4	3	1	1
4 Year Total		2	2	28	26	1	1	41	29	10	9	12	8	6	5
Percent of Total		0.5%	1.2%	7.5%	15.2%	0.3%	0.6%	11.1%	17.0%	2.7%	5.3%	3.2%	4.7%	1.6%	2.9%
Resource Pool	2004	7	7	8	8	2	2	137	77	34	28	4	2	7	6
	2005	3	3	33	30	3	2	163	90	49	33	4	3	12	11
	2006	5	4	40	35		0	115	87	25	21	3	2	8	6
	2007	4	4	42	34		0	116	88	13	11	5	5	11	11
4 Year Total		19	18	123	107	5	4	531	342	121	93	16	12	38	34
Percent of Total		0.7%	1.9%	4.4%	11.0%	0.2%	0.4%	19.0%	35.3%	4.3%	9.6%	0.6%	1.2%	1.4%	3.5%
Surgical	2004	7	6	3	2		0	51	36	24	18	4	3	3	3
	2005	3	3	21	18		0	102	54	48	25	4	3	8	8
	2006	1	1	12	12	1	1	75	43	18	11	8	4	2	2
	2007	2	2	27	22		0	56	35	14	11	1	1	4	3
4 Year Total		13	12	63	54	1	1	284	168	104	65	17	11	17	16
Percent of Total		0.8%	2.1%	3.9%	9.7%	0.1%	0.2%	17.5%	30.1%	6.4%	11.6%	1.1%	2.0%	1.1%	2.9%
Fiscal Year Totals	2004	71	61	89	82	19	17	1050	670	374	275	51	38	103	86
	2005	58	46	558	486	31	25	1289	751	461	296	61	36	111	95
	2006	31	23	543	488	12	9	998	677	222	155	46	34	69	62
	2007	22	21	490	428	14	11	768	552	136	102	38	33	80	69
4 Year Total		182	151	1680	1484	76	62	4105	2650	1193	828	196	141	363	312
Total		182	136	1680	1270	76	56	4105	1762	1193	622	196	121	363	281
Percent of Total		0.8%	2.6%	6.9%	24.3%	0.3%	1.1%	17.0%	33.7%	4.9%	11.9%	0.8%	2.3%	1.5%	5.4%

Table 1c.3. Visits and Discrete Persons to OH&S by Fiscal Year

Employee Work Location / Department		Detailed Reason for OH&S Visit by Staff											
		Post Surgery		Pre-placement		Psychological		Respiratory - lower		Respiratory - upper		Skin	
		Visits	People	Visits	People	Visits	People	Visits	People	Visits	People	Visits	People
Admin & Support	2004	6	6	363	339	68	51	38	34	433	290	102	82
	2005	16	15	282	259	61	46	26	26	355	262	74	60
	2006	20	19	181	177	35	30	22	22	237	170	78	59
	2007	18	17	90	89	43	36	34	31	190	143	58	56
4 Year Total		60	57	916	864	207	163	120	113	1215	865	312	257
Percent of Total		0.7%	1.5%	10.8%	23.5%	2.4%	4.4%	1.4%	3.1%	14.3%	23.5%	3.7%	7.0%
Critical Care	2004	4	4	55	45	21	16	17	11	142	101	12	12
	2005	7	7	45	40	18	14	19	16	105	77	12	12
	2006	3	2	30	30	20	15	5	5	48	38	7	6
	2007	2	2	29	28	21	17	10	10	26	23	11	11
4 Year Total		16	15	159	143	80	62	51	42	321	239	42	41
Percent of Total		0.7%	1.6%	6.9%	15.0%	3.5%	6.5%	2.2%	4.4%	14.0%	25.0%	1.8%	4.3%
Diagnostic Imaging	2004	6	5	25	24	8	6	9	8	116	78	15	15
	2005	8	8	13	13	8	7	3	3	95	65	16	14
	2006	1	1	20	19	7	6	7	5	42	34	14	14
	2007	5	4	11	11	13	10	12	11	30	23	13	13
4 Year Total		20	18	69	67	36	29	31	27	283	200	58	56
Percent of Total		1.2%	2.5%	4.2%	9.5%	2.2%	4.1%	1.9%	3.8%	17.1%	28.2%	3.5%	7.9%
Emerg Dept	2004		0	22	18	10	8	3	2	49	37	6	5
	2005	4	3	14	13	8	8	1	1	32	28	3	2
	2006		0	8	8	10	8	4	4	15	12	2	2
	2007	2	2	9	8	8	5	2	2	6	5	1	1
4 Year Total		6	5	53	47	36	29	10	9	102	82	12	10
Percent of Total		0.8%	1.5%	7.1%	14.5%	4.8%	8.9%	1.3%	2.8%	13.7%	25.2%	1.6%	3.1%
General Medicine	2004	2	2	87	73	27	19	16	13	168	123	21	18
	2005	9	9	102	83	19	17	17	14	153	99	25	20
	2006	8	8	56	54	26	18	7	6	65	53	13	13
	2007	5	4	79	79	16	13	7	6	29	23	9	9
4 Year Total		24	23	324	289	88	67	47	39	415	298	68	60
Percent of Total		0.7%	1.5%	9.3%	19.2%	2.5%	4.5%	1.4%	2.6%	11.9%	19.8%	2.0%	4.0%
OB/GYN	2004		0	2	2		0	1	1	21	14		0
	2005	1	1	7	5	3	2		0	16	12		0
	2006		0	4	4	3	3		0	15	12	5	5
	2007		0	1	1	3	3		0	11	8	2	2
4 Year Total		1	1	14	12	9	8	1	1	63	46	7	7
Percent of Total		0.3%	0.6%	3.7%	7.4%	2.4%	4.9%	0.3%	0.6%	16.8%	28.4%	1.9%	4.3%
OutPat Clinic	2004	5	4	72	68	15	12	9	7	152	91	22	21
	2005	6	5	68	65	30	20	10	8	119	80	15	12
	2006	5	4	38	38	11	9	12	7	77	54	7	6
	2007	5	5	11	11	15	12	12	12	51	42	14	14
4 Year Total		21	18	189	182	71	53	43	34	399	267	58	53
Percent of Total		0.9%	1.8%	7.9%	18.1%	3.0%	5.3%	1.8%	3.4%	16.7%	26.6%	2.4%	5.3%
Paediatrics	2004	1	1	8	7	2	1	1	1	24	16	4	4
	2005		0	4	4		0	4	4	21	11	5	4
	2006	1	1	8	7	1	1	3	3	17	13		0
	2007		0	4	4	2	2		0	8	6	1	1
4 Year Total		2	2	24	22	5	4	8	8	70	46	10	9
Percent of Total		0.5%	1.2%	6.5%	12.9%	1.3%	2.3%	2.2%	4.7%	18.9%	26.9%	2.7%	5.3%
Resource Pool	2004	7	6	43	36	30	21	8	8	131	83	30	24
	2005	7	6	54	40	30	22	8	7	116	83	33	26
	2006	7	6	57	56	14	12	15	15	59	47	19	17
	2007	2	2	86	84	13	10	9	8	55	46	21	18
4 Year Total		23	20	240	216	87	65	40	38	361	259	103	85
Percent of Total		0.8%	2.1%	8.6%	22.3%	3.1%	6.7%	1.4%	3.9%	12.9%	26.7%	3.7%	8.8%
Surgical	2004	2	2	29	24	10	10	11	10	75	49	12	12
	2005	4	3	31	27	14	10	2	2	74	52	7	5
	2006	2	2	24	23	17	12	6	5	50	37	4	4
	2007	3	3	27	25	6	6	6	5	39	29	5	5
4 Year Total		11	10	111	99	47	38	25	22	238	167	28	26
Percent of Total		0.7%	1.8%	6.9%	17.7%	2.9%	6.8%	1.5%	3.9%	14.7%	29.9%	1.7%	4.7%
Fiscal Year Totals	2004	33	30	706	636	191	144	113	94	1311	881	224	192
	2005	62	57	620	549	191	146	90	81	1086	769	190	155
	2006	47	43	426	416	144	114	81	72	625	470	149	126
	2007	42	39	348	341	140	114	92	85	445	347	135	129
4 Year Total		184	169	2100	1942	666	518	376	332	3467	2467	698	602
Total		184	164	2100	1894	666	397	376	293	3467	1650	698	523
Percent of Total		0.8%	3.1%	8.7%	36.3%	2.8%	7.6%	1.6%	5.6%	14.3%	31.6%	2.9%	10.0%

Table 1c.4. Visits and Discrete Persons to OH&S by Fiscal Year

Employee Work Location / Department		Detailed Reason for OH&S Visit by Staff									
		Trauma		Urinary		Other, Specified*		Undefined, Unknown		Total	
		Visits	People	Visits	People	Visits	People	Visits	People	Visits	People
Admin & Support	2004	5	5	35	25	32	31	533	393	2568	1077
	2005	11	10	18	17	106	93	403	286	2593	1032
	2006	9	9	28	22	69	53	255	184	1986	856
	2007	5	5	12	11	25	24	69	63	1327	714
4 Year Total		30	29	93	75	232	201	1260	926	8474	3679
Percent of Total		0.4%	0.8%	1.1%	2.0%	2.7%	5.5%	14.9%	25.2%	35.0%	36.9%
Critical Care	2004		0	13	8	9	7	153	116	719	286
	2005	3	3	6	4	35	33	167	108	803	290
	2006	3	2	1	1	27	21	76	56	486	207
	2007	2	2	3	3	9	9	22	19	291	172
4 Year Total		8	7	23	16	80	70	418	299	2299	955
Percent of Total		0.3%	0.7%	1.0%	1.7%	3.5%	7.3%	18.2%	31.3%	9.5%	9.6%
Diagnostic Imaging	2004		0	10	8	13	12	108	83	508	203
	2005	2	2	4	4	15	14	117	78	564	207
	2006	1	1	9	5	11	11	46	32	326	151
	2007	1	1	6	6	10	10	12	11	255	147
4 Year Total		4	4	29	23	49	47	283	204	1653	708
Percent of Total		0.2%	0.6%	1.8%	3.2%	3.0%	6.6%	17.1%	28.8%	6.8%	7.1%
Emerg Dept	2004	1	1	1	1	7	6	40	31	249	98
	2005	3	3	3	3	16	13	47	30	250	95
	2006	1	1	1	1	5	4	22	17	158	77
	2007	1	1		0	4	3	2	2	88	55
4 Year Total		6	6	5	5	32	26	111	80	745	325
Percent of Total		0.8%	1.8%	0.7%	1.5%	4.3%	8.0%	14.9%	24.6%	3.1%	3.3%
General Medicine	2004	2	2	16	13	12	12	233	176	1044	416
	2005	5	5	9	9	50	42	208	148	1153	409
	2006	5	4	3	3	27	25	91	72	753	364
	2007	2	2	4	4	19	17	31	29	526	314
4 Year Total		14	13	32	29	108	96	563	425	3476	1503
Percent of Total		0.4%	0.9%	0.9%	1.9%	3.1%	6.4%	16.2%	28.3%	14.4%	15.1%
OB/GYN	2004		0	2	1	2	2	19	15	94	43
	2005		0	1	1	8	7	24	17	115	44
	2006		0	2	1	8	7	19	15	118	49
	2007	1	1		0	1	1	5	4	48	26
4 Year Total		1	1	5	3	19	17	67	51	375	162
Percent of Total		0.3%	0.6%	1.3%	1.9%	5.1%	10.5%	17.9%	31.5%	1.5%	1.6%
OutPat Clinic	2004		0	1	1	25	23	170	122	797	300
	2005	2	2	9	8	29	25	134	88	782	314
	2006		0	2	2	16	15	84	62	469	210
	2007	2	2		0	15	15	25	23	343	180
4 Year Total		4	4	12	11	85	78	413	295	2391	1004
Percent of Total		0.2%	0.4%	0.5%	1.1%	3.6%	7.8%	17.3%	29.4%	9.9%	10.1%
Paediatrics	2004		0		0	6	4	23	18	119	50
	2005	1	1	2	2	5	5	38	23	127	47
	2006		0		0	7	6	10	8	78	39
	2007		0		0	2	2	2	2	47	35
4 Year Total		1	1	2	2	20	17	73	51	371	171
Percent of Total		0.3%	0.6%	0.5%	1.2%	5.4%	9.9%	19.7%	29.8%	1.5%	1.7%
Resource Pool	2004	2	2	19	8	22	19	137	93	787	242
	2005	5	5	8	7	46	41	128	86	851	248
	2006	3	3	7	5	31	22	87	66	646	231
	2007	4	4	4	4	21	16	26	23	514	249
4 Year Total		14	14	38	24	120	98	378	268	2798	970
Percent of Total		0.5%	1.4%	1.4%	2.5%	4.3%	10.1%	13.5%	27.6%	11.6%	9.7%
Surgical	2004		0	2	1	7	7	76	49	408	145
	2005	5	5	1	1	29	23	100	61	573	158
	2006	1	1		0	18	15	47	36	362	132
	2007	1	1	2	2	9	5	22	20	276	124
4 Year Total		7	7	5	4	63	50	245	166	1619	559
Percent of Total		0.4%	1.3%	0.3%	0.7%	3.9%	8.9%	15.1%	29.7%	6.7%	5.6%
Fiscal Year Totals	2004	10	10	99	66	135	123	1492	1092	7294	2841
	2005	37	36	61	56	339	296	1366	925	7812	2845
	2006	23	21	53	40	219	179	737	548	5382	2312
	2007	19	19	31	30	115	102	216	196	3716	1980
4 Year Total		89	86	244	192	808	700	3811	2761	24204	9978
Total		89	86	244	162	808	608	3811	1978	24204	5224
Percent of Total		0.4%	1.6%	1.0%	3.1%	3.3%	11.6%	15.7%	37.9%	100%	100%

*** Includes: Chronic Pain, Derangement, Dysfunction, Posture, Other**

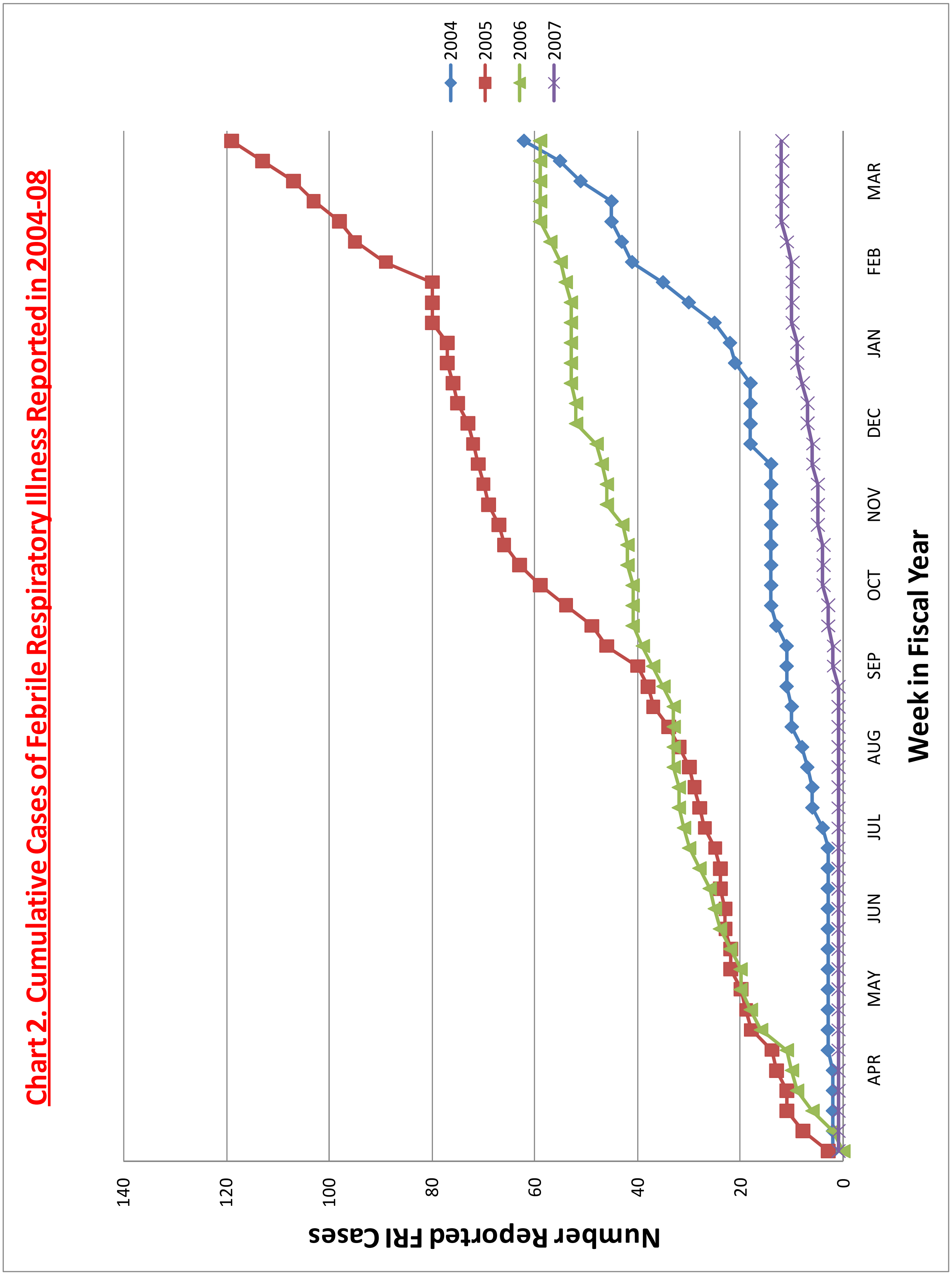

Chart 2. Cumulative Cases of Febrile Respiratory Illness Reported in 2004-08

Statistics of Pay, Hours and Absences

Table 3 shows the earnings and absences of employees for the sampled year June 1, 2004 to May 31, 2005. This is the only time period for which this data was available to the project.

Data is available for the mean and median of each variable. As this data is highly skewed to higher durations of absences, the mean is the appropriate statistic to use for analysis; however, we show the median values for comparison (and to show its inferiority as an estimator).

The average employee was absent twice in the year, for a total of 11 days (or 85 hours) and received $2,476 in sick pay and benefits. The hospital spent $6,062,000 on sick pay and benefits during the year, which was 5% of the hospital's compensation payments.

Table 3: Statistics of Pay, Hours and Absences

Characteristics of Full-time Employees in a
Canadian Tertiary Care Hospital [Human Resources Data]

Sampled Year of June 1, 2004 to May 31, 2005

Variable	Mean	Median
All Employees	1,964	1,964
Age	43	43
Annual Pay	$50,594	$52,378
Avg Hourly Pay (260 days x 7.5 hrs)	$29.13	$26.86
Avg Daily Pay (260 days) + 25% Benefit	$244	$251
Ann Hours Worked (7.5/day)	1,737	1,950
Number of Absence Episodes	2	1
Hours absent	85	23
Compensation for Hrs Absent	$2,476	$618
Days Absent	11	3
Compensation for Days Absent	$2,141	$604

Employees with at least one absence	1,411	1,411
Number of times absent	3	2
Hours absent	118	51
Compensation for Hrs Absent	$3,437	$1,370
Days absent	16	7
Compensation for Days Absent	3,113	1,410
Total Compensation for Absence*	$6,062,032	$2,416,137

*based on hours absent, plus 25% benefits

Total Compensation & Benefits	$124,208,270	$128,587,990

Sick Pay as % of Total Compensation	4.9%	1.9%

Absences and Compensation by Hospital Department

Table 4 shows absence and compensation for the sampled year June 1, 2004 to May 31, 2005 for each department. Absences per 1000 hours worked averaged 1.24, and ranged from, 0.81 to 1.90. Absence compensation per 1000 hours worked averaged $1,767 and ranged from $1,151 to $2,710.

Table 4: Departmental Hours Worked, Absences and Estimates of Absence Compensation

for the Sampled Year of June 1, 2004 to May 31, 2005

Work Location	# of Employees	Total Hours Worked	Hours worked per Employee	Number of Staff Absences	Absences per 1000 hours worked	Absences per Employee	*Estimated Compensation for Absences including 25% benefits	Absence Cost per 1000 hours worked
Admin & Support	750	1,326,013	1,768	1,233	0.93	1.64	$1,758,383	$1,326
Critical Care	199	357,370	1,796	642	1.80	3.23	$915,557	$2,562
Diagnostic Imaging	256	457,106	1,786	369	0.81	1.44	$526,231	$1,151
Emerg Dept	59	102,128	1,731	143	1.40	2.42	$203,933	$1,997
General Medicine	266	458,419	1,723	871	1.90	3.27	$1,242,134	$2,710
OB/GYN	53	96,382	1,819	148	1.54	2.79	$211,063	$2,190
OutPat Clinic	198	317,785	1,605	364	1.15	1.84	$519,101	$1,633
Paediatrics	28	50,349	1,798	88	1.75	3.14	$125,497	$2,493
Resource Pool	72	117,039	1,626	188	1.61	2.61	$268,107	$2,291
Surgical	83	146,809	1,769	204	1.39	2.46	$290,925	$1,982
Total	**1,964**	**3,429,400**	**1,746**	**4,250**	**1.24**	**2.16**	**$6,060,931**	**$1,767**

* includes10% upward balancing adjustment

Gains from Increasing Influenza Immunization

We were asked to explore the question of the costs and benefits of increasing the level of staff influenza immunization in a large teaching hospital.

Hospital and Public Health authorities estimated that the level in recent years had been approximately 30% of staff immunized. We were asked to estimate the costs and benefits of achieving increased levels of (a) 60% and (b) 80%.

We worked with data provided to us by the hospital management for the fiscal years 2004-2005 to 2007-2008. This data was unfortunately quite unreliable --- incomplete in number of employees, illness reports to OH&S, and immunization levels. The quality of the data might have been improved, but at some cost; it was agreed to proceed using our estimates of parameters.

We have calculated the costs and benefits of increased immunization for each of the four fiscal years, and for the combined years. These calculations and estimates are shown in the Table 5. In view of the incomplete data and the short (four year) horizon, we have not included processes such as present values of flows, or attempted any significance tests of financial results.

The number of influenza cases is estimated as 100% of FRI cases plus 10% of Upper Respiratory Infection cases reported to the hospital OH&S department.

For the four years combined there were 6,725 full-time equivalent (FTE) employees, an average of 1,681 per year. Beginning with the base line level of 30% immunization, we estimate the number of staff immunized in each year, and the consequent number getting influenza in the immunized and not immunized groups (Table 5, columns 2, 7, 8, 9).

The benefits of increased immunization are estimated as averted sick pay (plus 25% benefits) which would be paid to an absent employee with flu for a period of 5 working days.

The mean daily sick pay (plus 25% for benefits) for a staff member during these years is $29/hr x 1.25 x 7.5 hours per day = $244 per influenza absence day (Table 5, columns 10, 11).

The expected benefits of an additional immunized staff member are $81.37 in averted sick pay. We make no estimate of the additional benefits arising from reduced influenza risks to patients, but they are probably substantial.

The costs of increasing immunization levels from 30% to 60% or 80% depend upon which agencies perform the immunization and where the immunization is done. The costs per individual staff member immunization are estimated to be $28.15.

Cost of Immunization	**Low**	**High**	**Average**
Immunization Agent Cost	**$8.00**	**$14.00**	**$10.53**
Nursing Time and Supplies	**$5.00**	**$8.50**	**$6.75**
Hospital Staff Time to Receive Shot	**15 Minutes $7.25**	**30 Minutes $14.50**	**$10.87**
Total	**$20.25**	**$37.00**	**$28.15**

The range of total annual net benefits to the hospital (after deduction of immunization costs) range from:

- $3,719 to $20,616 for an immunization level increase from 30% to 60%
- $18,640 to $41,169 for an immunization level increase from 30% to 80%

The range reflects alternatives in how, where & by whom the immunization if performed.

% Staff Immunized	Net Benefit (Low Estimate)	Net Benefit (High Estimate)
For 30% to 60%	**$3,719**	**$20,616**
For 30% to 80%	**$18,640**	**$41,169**

This is a net benefit to the hospital from expanding influenza immunization levels among staff. This benefit arises from averted sick pay among staff that would otherwise get influenza.

We don't estimate any other benefits but we would expect that a substantial benefit would arise from lower influenza rates among hospital inpatients.

Table 5.

Benefits and Costs of Increasing Influenza Immunization Levels of Hospital Staff

Staff Immunization Level	Fiscal Year	1 FTE Staff	2 Number of Staff Immunized	3 Number of Staff Not Immunized	4 Attack Rate	5 Percent Staff Immunized Getting Flu	6 Percent Staff NOT Immunized Getting Flu	7 Number Immunized Getting Flu	8 Number Not Immunized Getting Flu	9 All Staff Getting Flu
30%	2004-05	1,723	517	1,206	10.0%	3.33%	10.0%	17	121	138
30%	2005-06	1,846	554	1,292	10.0%	3.33%	10.0%	18	129	148
30%	2006-07	1,661	498	1,163	10.0%	3.33%	10.0%	17	116	133
30%	2007-08	1,495	449	1,047	10.0%	3.33%	10.0%	15	105	120
30%	4 Year Total	6,725	2,018	4,708	10.0%	3.33%	10.0%	67	471	538
30%	4 Yr Avg	1,681	504	1,177				17	118	134
60%	2004-05	1,723	1,034	689	10.0%	3.33%	10.0%	34	69	103
60%	2005-06	1,846	1,108	738	10.0%	3.33%	10.0%	37	74	111
60%	2006-07	1,661	997	664	10.0%	3.33%	10.0%	33	66	100
60%	2007-08	1,495	897	598	10.0%	3.33%	10.0%	30	60	90
60%	4 Year Total	6,725	4,035	2,690	10.0%	3.33%	10.0%	134	269	403
60%	4 Yr Avg	1,681	1,009	673				34	67	101
80%	2004-05	1,723	1,378	345	10.0%	3.33%	10.0%	46	34	80
80%	2005-06	1,846	1,477	369	10.0%	3.33%	10.0%	49	37	86
80%	2006-07	1,661	1,329	332	10.0%	3.33%	10.0%	44	33	77
80%	2007-08	1,495	1,196	299	10.0%	3.33%	10.0%	40	30	70
80%	4 Year Total	6,725	5,380	1,345	10.0%	3.33%	10.0%	179	135	314
80%	4 Yr Avg	1,681	1,345	336				45	34	78

Table 5. (continued)

Benefits and Costs of Increasing Influenza Immunization Levels of Hospital Staff

Staff Immunization Level	Fiscal Year	10 Overall Total Sick Days at 5 days per Case	11 Total Absentee Cost at $244 per day	12 Immunizations over 30% Baseline	13 Gross Benefits of Additional Staff Immunizations	14 Gross Benefits per Immunized Staffmember	15 Min Total Cost of Immunization	16 Max Total Cost of Immunization	17 Max Net Benefit to Hospital of Higher Immunization	18 Min Net Benefit to Hospital of Higher Immunization
30%	2004-05	689	$ 168,144				$ 10,467	$ 19,125		
30%	2005-06	738	$ 180,147				$ 11,214	$ 20,491		
30%	2006-07	664	$ 162,093				$ 10,091	$ 18,437		
30%	2007-08	598	$ 145,894				$ 9,082	$ 16,595		
30%	4 Year Total	2,690	$ 656,278				$ 40,854	$ 74,648		
30%	4 Yr Avg	672	$ 164,069				$ 10,214	$ 18,662		
60%	2004-05	517	$ 126,082	517	$ 42,062	$ 81.37	$ 20,934	$ 38,251	$ 21,128	$ 3,812
60%	2005-06	554	$ 135,082	554	$ 45,065	$ 81.37	$ 22,429	$ 40,981	$ 22,636	$ 4,084
60%	2006-07	498	$ 121,545	498	$ 40,549	$ 81.37	$ 20,181	$ 36,874	$ 20,368	$ 3,674
60%	2007-08	448	$ 109,398	449	$ 36,496	$ 81.37	$ 18,164	$ 33,189	$ 18,332	$ 3,307
60%	4 Year Total	2,017	$ 492,106	2,018	$ 164,172	$ 81.37	$ 81,709	$ 149,295	$ 82,463	$ 14,877
60%	4 Yr Avg	504	$ 123,026	504	41,043	$ 81.37	$ 20,427	$ 37,324	$ 20,616	$ 3,719
80%	2004-05	402	$ 98,040	862	$ 70,104	$ 81.37	$ 27,913	$ 51,001	$ 42,191	$ 19,103
80%	2005-06	430	$ 105,039	923	$ 75,108	$ 81.37	$ 29,905	$ 54,642	$ 45,203	$ 20,467
80%	2006-07	387	$ 94,512	831	$ 67,581	$ 81.37	$ 26,908	$ 49,166	$ 40,673	$ 18,416
80%	2007-08	349	$ 85,067	748	$ 60,827	$ 81.37	$ 24,219	$ 44,252	$ 36,608	$ 16,575
80%	4 Year Total	1,568	$ 382,658	3,363	$ 273,620	$ 81.37	$ 108,945	$ 199,060	$ 164,675	$ 74,560
80%	4 Yr Avg	392	$ 95,664	841	68,405	$ 81.37	$ 27,236	$ 49,765	$ 41,169	$ 18,640

CHAPTER 4: A novel tool for occupational health surveillance

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Introduction

Each year, millions of workers are injured or become ill on the job from exposure to hazards at work resulting in substantial health and economic costs for workers and employers[1]. HCWs are at a particular risk to exposure from a wide range of hazards, particularly infectious agents including (among others) tuberculosis, influenza, norovirus, and *Clostridium difficile*; the risk of occupationally acquired infection is often an unavoidable part of daily patient care[2-4]. Most occupational transmission is associated with violation of one or more basic principles of infection control: hand-washing; vaccination of HCWs; and prompt placement of infectious patients into appropriate isolation. While uptake of influenza vaccination has previously been reported as low among HCWs, insufficient hand-washing probably contributes the most to the transmission of infectious agents[2,3,5].

The need for occupational health surveillance

Occupational health surveillance or the tracking of occupational injuries, illnesses, hazards, behaviours, and exposures is paramount in guiding efforts to improve worker safety and health and to monitor trends and progress over time[6]. For example, if there are increased reports of back injury to the OH&S department, programs to improve lifting techniques may be directed towards affected staff. Each hospital is required to have by-laws that establish and provide for the operation of a health surveillance program, including a communicable disease surveillance program, in respect of all persons carrying on activities in the hospital[7]. Communicable disease outbreaks can have severe impacts to health care services and the risk of infection to patients and staff, and often result in ward closures and additional expenses from microbiological testing and environmental cleaning[8-9]. Knowledge of staff illnesses from communicable diseases can prompt implementation of evidence-based infection control procedures such as patient isolation, rapid environmental decontamination, and frequent hand-washing or alcohol antisepsis in order to limit pathogen spread to both patients and staff. In terms of monitoring, it is valuable to collect data on both communicable diseases and non-communicable work-related injuries. For example, influenza exhibits seasonal trends, and it may be valuable to increase monitoring of respiratory illnesses among staff during peak months. This would help to capture worker illness and implement precautions rapidly.

The OH&S nurse plays an important role in the health surveillance of workers at risk, and quality data collection management aids in decision making and accurate and timely record keeping[10]. However, there may be no centralized system, which leads to a lack of data integrity and re-entry of data, increasing the cost and time needed to perform surveillance procedures. This in turn makes it impossible to implement an automated response or warning system. In order to improve data integrity, increase the capacity to gather and manage more data with less effort and cost, and allow visualization and analysis tools, geographic information systems (GIS) can be applied to OH&S information management[11]. GIS is a collection of computer hardware and software that integrates maps and graphics with a database related to a defined geographical space – an integrated set of tools within an automated system capable of collecting, storing, handling, analyzing, and displaying geographically referenced information[12]. Some functions of GIS software include: displaying layers of data; displaying data in map, table, and chart form; drawing a variety of thematic maps; performing spatial selections and spatial queries; performing simple database operations, and more[13]. In these ways, GIS can assist in supporting health situation analysis and surveillance for the prevention and control of health problems, for example: by creating temporal-spatial maps of outbreaks, Public Health workers can visualize the spread of cases as the outbreak progresses; spatial/database queries allow for selection of a specific location or condition to focus Public Health resources.

A novel tool for Occupational Health surveillance

KFL&A Public Health, in conjunction with the Sault Ste. Marie Innovation Centre (SSMIC), developed a GIS tool capable of mapping the floors and departments of KGH, in order to assess the impact of gastrointestinal and respiratory illness on OH&S visits at the hospital. SSMIC operates the Community Geomatics Centre which provides GIS consulting services and products to health and human services organizations, government and private sector organizations[14]. KGH is the major regional tertiary care referral site in South-Eastern Ontario, Canada, providing an array of acute and ambulatory clinical services to Kingston and the surrounding region[15]. The KGH OH&S department is responsible for collecting and monitoring the occurrence of illness, injury and exposure contamination among all KGH staff and volunteers in an OH&S database. The OH&S nurse selects from a pre-determined list of ‘attributes’ as self-reported by the visitor, then selects conditions associated with the symptoms provided (e.g. respiratory). The use of a drop-down list for attributes and conditions allows GI and respiratory-related visits to be grouped together and later selected from the database. The drop-down menus also help standardize and control data quality as opposed to using chief complaint, ICD-10 codes, or other data sources. Definitive diagnoses are rarely recorded in the database. The data files also contain employee/volunteer demographic information as well as relevant details associated with their visit. Commencing January 2007, KGH provided KFL&A Public Health with daily OH&S visit data for all staff and volunteers; retrospective data starting from April 2004 to December 2007 was also provided. Queen’s University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board approval was obtained prior to obtaining this data. In addition, a privacy impact assessment (PIA) was completed to ensure compliance with the provincial Personal Health Information Protection Act (PHIPA).

The tool developed by SSMIC makes use of Environmental Systems Research Institute's (ESRI) ArcGIS suite of mapping software. Using ArcMap, two dimensional (2D) floor plans of the hospital can be visualized; creating a three dimensional (3D) model of the hospital required use of ArcScene. KFLA provided SSMIC with computer-aided design (CAD) files for KGH floors and departments, which were converted to a GIS compatible format. Ortho-rectified aerial photo of the City of Kingston was also used by SSMIC to tie the GIS data generated from the CAD drawings to real world coordinates. The level of detail to be visualized was departments, wards, and floors; rooms, beds, sinks and other high-level hospital details were not captured in the scope of this model[16]. Data from the OH&S database for gastrointestinal and respiratory illness were aggregated into weekly rates of OH&S visits, and this data was linked to spatially referenced departments within the hospital representing how many staff were reporting gastrointestinal or respiratory illness in a given week. The data was represented using a staff denominator, or the total number of staff employed in each department at any given time. This allowed KFL&A staff to display a rate of gastrointestinal and/or respiratory-related illness for each specific department or ward. SSMIC also developed a custom toolbar within the Arc software to use in both 2D and 3D environments, enabling KFLA staff to use the data quickly and easily by automatically loading data, custom symbology, labels and 3D properties. Options for loading the data into a map include: illness and year of data (e.g.: 2007 gastrointestinal); in the 2D environment, which level or floor of the hospital to display; dates of OH&S data; and labeling options (i.e. percent illness, ward) for the data[17]. (Sambol C. Personal communication, Jun 6, 2008)

The information learned from the created maps (both 2D and 3D) is intended to help visualize different areas within the hospital to determine how illnesses may be spreading between departments and to provide enhanced early warning for communicable disease outbreaks among staff. This may help to characterize the occurrence and transmission of infectious diseases within the hospital and allow for rapid implementation of appropriate infection control measures. As a result, this information may be used to decrease the spread of infectious disease within the hospital and minimize the risk to HCWs thus reducing HCW absenteeism[16]. (Sambol C. Personal communication, Jun 6, 2008) In this sense, the GIS platform acts as a form of syndromic surveillance. Syndromic surveillance involves the use of routinely collected and electronically managed data for identifying illness clusters earlier than would be otherwise expected using traditional laboratory-based surveillance[18-20]. Typically, automated syndromic surveillance systems generate syndrome-specific alerts when a threshold limit is breached. The GIS platform provides an additional level of OH surveillance for KFL&A staff that currently performs daily aberration analyses on OH&S visit data provided by KGH. The project will also be used in conjunction with the EDSS surveillance system of KFL&A, which actively monitors respiratory and gastrointestinal illness activity in Kingston ED and those in the surrounding communities. This combination of surveillance activities intends to provide enhanced early warning for infectious disease outbreaks, allowing for increased infection control measures and implementation of emergency plans within both the community and the hospital.

Concluding remarks

There is a need for OH surveillance for HCWs due to the unavoidable exposures that they encounter on a daily basis. Using a syndromic system enhanced by GIS capabilities can enhance not only OH&S response to a potential HCW outbreak, but also provide a spatial component to the outbreak and help determine how the outbreak may be spreading in the hospital. The KGH mapping tool allows both 2D and 3D mapping of the hospital, and simple toolbars to assist in the analysis of OH&S visits. Adding automated data entry and visualizations would further enhance the tool.

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CHAPTER 5: Technical evaluation of an innovative, integrated syndromic surveillance system

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Technical Progress Report

Work Performed To Date

The technical team began the project by evaluating the Real-time Outbreak Disease Surveillance (RODS) and The Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE II) systems as possible host systems for the OH&S data. It was found that OH&S data, given its sparse counts and the fact that the cases were centered at a hospital instead of in the general population that the algorithms and mapping currently provided by these systems would have to be heavily tailored to incorporate this data source. It was decided that a new interface would be designed to host the OH&S data rather than to use the existing EDSS system. The development work to date on this interface has been focused on the design and integration of the OH surveillance interface into the existing EDSS data screens already existing in RODS. Integrating the database with the user interface (UI) has been completed and the final design is presented in this report. Initial work has also begun on looking at the feasibility of fully automating the data transfer process. Presently the data is transferred semi-automatically and there will be manual steps needed to obtain the data from the hospital. Further, enabling the system to produce line listings of the OH&S visits is being considered. These steps are outlined in this document. A fully automated system is outside the scope of this grant but it is hoped that additional funding can be secured for further upgrades in the future.

Deliverables

The UI for the OH Surveillance along with the database have been completed as of February 2009. A semi-automated transfer system is in place.

Action Items

The scripts to automatically insert the OH&S data into the database can be constructed. Alert thresholds and enabling the system to show line listings of OH&S visit data is being considered.

Introduction

KFL&A Public Health conducted a two year pilot project to develop and evaluate an innovative, integrated surveillance tool linking routinely collected electronic OH&S visit data from KGH with an existing EDSS System – which captures ED visits and admissions from nine local area hospitals in real-time. The integrated surveillance system, developed in collaboration with stakeholders (KGH OH&S department, KFL&A Public Health and QΦ), is an electronic, integrated monitoring tool intended to provide enhanced early warning for communicable disease outbreaks within both the hospital and community setting.

The key objective of this project was to develop and evaluate a real-time, integrated syndromic surveillance system to determine its ability to monitor hospital employee OH&S reporting and to detect outbreaks of a gastrointestinal or respiratory illness well in advance of traditional reporting systems in Ontario. The secondary objective was to evaluate the ability of the integrated system to detect a sentinel event such as a nosocomial infection or the effect of a community outbreak on the staffing levels at KGH.

This technical evaluation describes the approach taken for the integration of the systems, provides an overview of the integrated system, describes the system architecture, and then concludes with an evaluation of the system and recommendations for future improvements.

Technical Approach

This section describes the evaluation work that took place to determine the best way to integrate the ED and OH&S data sources. It also outlines the approach to the system design and the functionality requested by the epidemiological team. It concludes a listing of the project team and roles created for this project.

Evaluation of Syndromic Surveillance Systems for Integration

The technical team began the project by evaluating the RODS and ESSENCE II systems as possible host systems for the OH&S data. It was found that OH&S data, given its sparse counts and the fact that the cases were centered at a hospital instead of in the general population that the algorithms and mapping currently provided by these systems would have to be heavily tailored to incorporate this data source.

The ESSENCE interface is very statistical and algorithm driven, and has been designed to host both over-the-counter and ED data. There is logic in the system to handle sparse counts but the interface was deemed too complicated and would require too much customization by the ESSENCE team at John Hopkins University to incorporate the OH&S data and provide the simple plots and hospital level mapping that was desired by the epidemiology team.

The RODS interface is straightforward and more intuitive. However the RODS source code is extremely challenging to build on because it has not been well designed and is not very modular or extensible. Further, changing the RODS source code to accommodate OH&S data by improving the design and modularity of the product comes at a high price in that releases of the product have been seen to drastically change the products design. This would mean that if the team went to upgrade its version of RODS, it would then again have to spend considerable effort integrating in the customization for the OH&S data source.

In the end it was decided that building our own interface for OH&S data, and integrating that into the RODS system loosely by having a separate page for combined OH/ED plots was the best way to proceed. It meant that mapping would not be achieved in this first implementation of an OH interface but it is hoped that hospital level maps of the OH&S cases can eventually be developed into our own interface.

System Design

The approach to the system design has been to develop a module that is loosely integrated into RODS, but can offer future extensibility and enhancements. Separate html pages outside the RODS application host the interface. A separate database was created for just the OH&S data. Epiplots were developed for the ED and OH&S data by tapping the existing RODS database for the EDSS counts.

Epidemiological Functionality

The major areas requested by the lead epidemiologists were that the OH&S data should be plotted and these plots compared to the existing ED data. Beyond that it was felt that maps of the OH&S data should be focused on the hospital instead of the general population because of the sparse counts and that the cases are hospital specific. Algorithms operating on OH&S data can be basic since the data is sparse, and could be as minimal as generating an alert when a certain count threshold for a single day is exceeded or using a moving average and 2 or 3 standard deviations. The complicated algorithms seen in RODS or ESSENCE are not needed for this data source.

Project Team and Roles

The project tasks were broken down as follows:

Tara Donovan – Lead Epidemiologist

Tara was responsible for developing the requirements for the epidemiological functionality of the interface and also was the overall project lead.

Dillan Fernando – Lead Developer

Dillan was tasked with the system design, the system automation, and the development of the interface including UI and database design.

Glenn Guthrie – Research Associate

Glenn was responsible for evaluating the existing surveillance systems, providing analysis on the feasibility of integration, and for writing this technical evaluation at the end of the project.

Technical Solution Overview

Data Collection

A semi-automated solution including one manually driven user step is being implemented for this project at present. Currently data is retrieved from the hospital via manual entry into Citrix Access Gateway which permits secure access to a shared OH&S data folder. The user is required to login and then the file is then manually downloaded and saved as a CSV file at KFL&A Public Health to a specific folder. Once the file is saved the file is immediately uploaded into the database and resulting graphs in the interface will show the updated counts immediately. Only initial visits for respiratory and gastrointestinal illness reporting are included in the O&S data. The variables included when you select the 'get cases' button in the OH interface are visit date and time, sex, age, department, condition (i.e. respiratory upper/lower, Febrile Respiratory Illness (FRI) and gastrointestinal), and visit type (i.e. initial visit or initial reporting by phone).

Epidemiological Functionality

It was decided that first version of the interface should be focused on creating plots that allow for comparison of the OH&S to ED data. The best way to do this comparison was to create a plot that included both OH&S and ED data together on one graph. The user can define the date range of the plots. The second version includes the ability to view the line listings for the OH&S cases that generated the counts.

Syndrome Groupings

The data currently is grouped into two syndromes (gastrointestinal and respiratory) and the UI will allow for plots of each of these syndromes which show OH&S and ED data on the EPI plot.

Security

The security settings for the implementation of the OH interface will differ from the RODS interface. Currently, the OH application uses a security mechanism similar to

RODS, but associated with KFL&A Public Health access via the intranet, protected by activedirectory login authentication. Only registered users can login.

Architecture

This section presents a high level description of the architecture, an overview of the integration with RODS along with screen UI, and the database schema of the OH database.

High Level Design

The OH&S and ED integration is achieved by tapping both the existing EDSS database in RODS and the newly developed OH&S database. The systems are separate in that they have separate databases and the UI screen developed is not actually part of the RODS application. But the UI for the OH and ED combined data plots has been given the same look and feel as RODS and the solution will be web based and is hosted on the same server as RODS is hosted on.

Integration with Existing Syndromic Surveillance System (RODS)

Screenshots of the UI for the integration of the existing RODS interface for ED data and the newly developed screen for viewing both ED and OH plots are presented here. The existing RODS interface for the Epiplot tab allows for more functionality in filtering the resulting plots around factors such as age and geography. It was felt that given the sparse counts for OH&S data the filtering of the data could be done only by date range and syndrome (i.e. respiratory or gastrointestinal). EDSS data in RODS has eight standard syndromes but of those only two are provided currently for the OH&S data and are included in the interface. The ED/OH integrated screen shows a plot with OH&S and ED data according to the syndrome. The second phase of the project enabled an option to click a ‘get cases’ button to view the OH&S cases for the selected date range.

Existing RODS Interface for EDSS

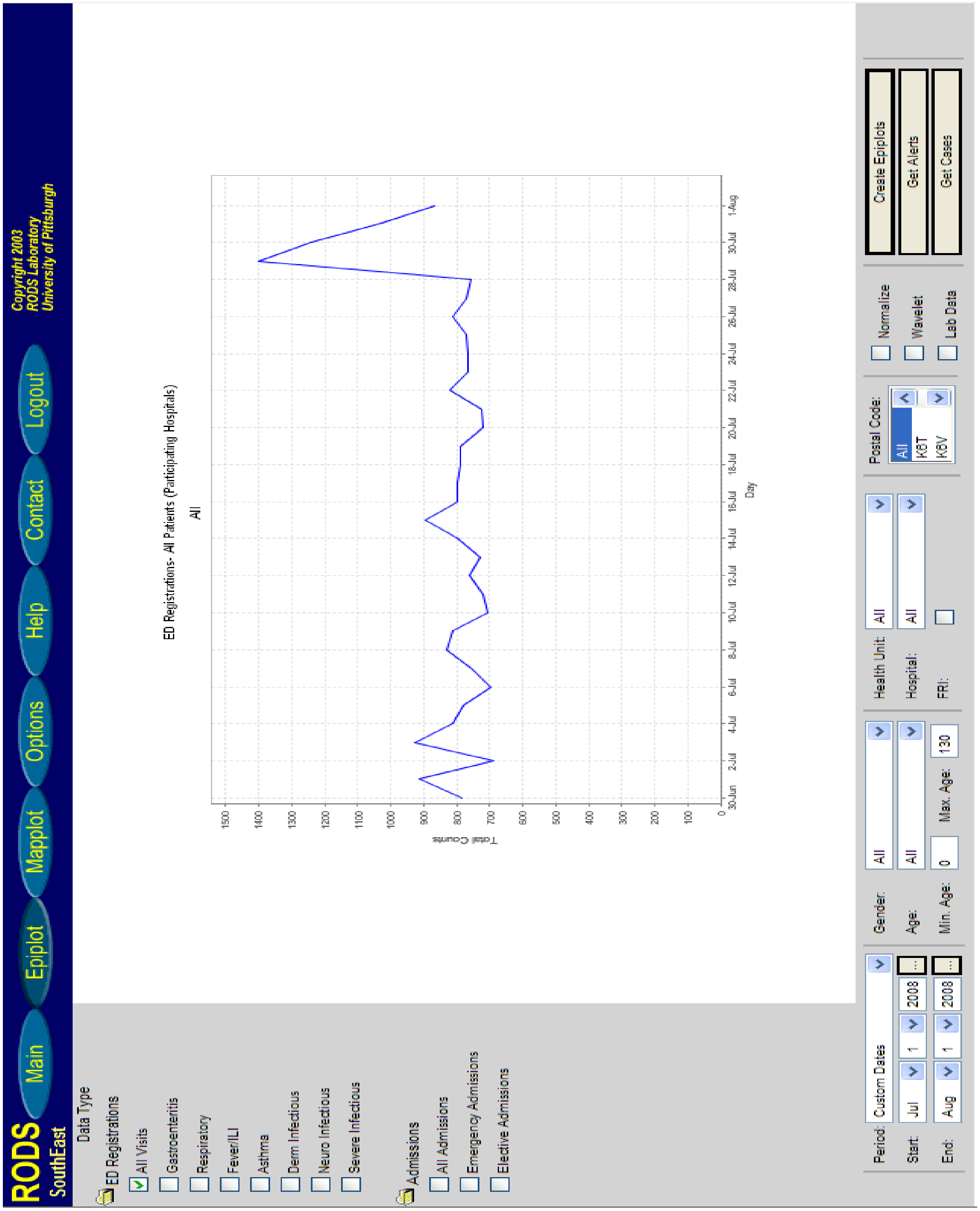

Figure 1: Existing RODS Interface for the EDSS Epiplot tab

OH Data Screen UI Design

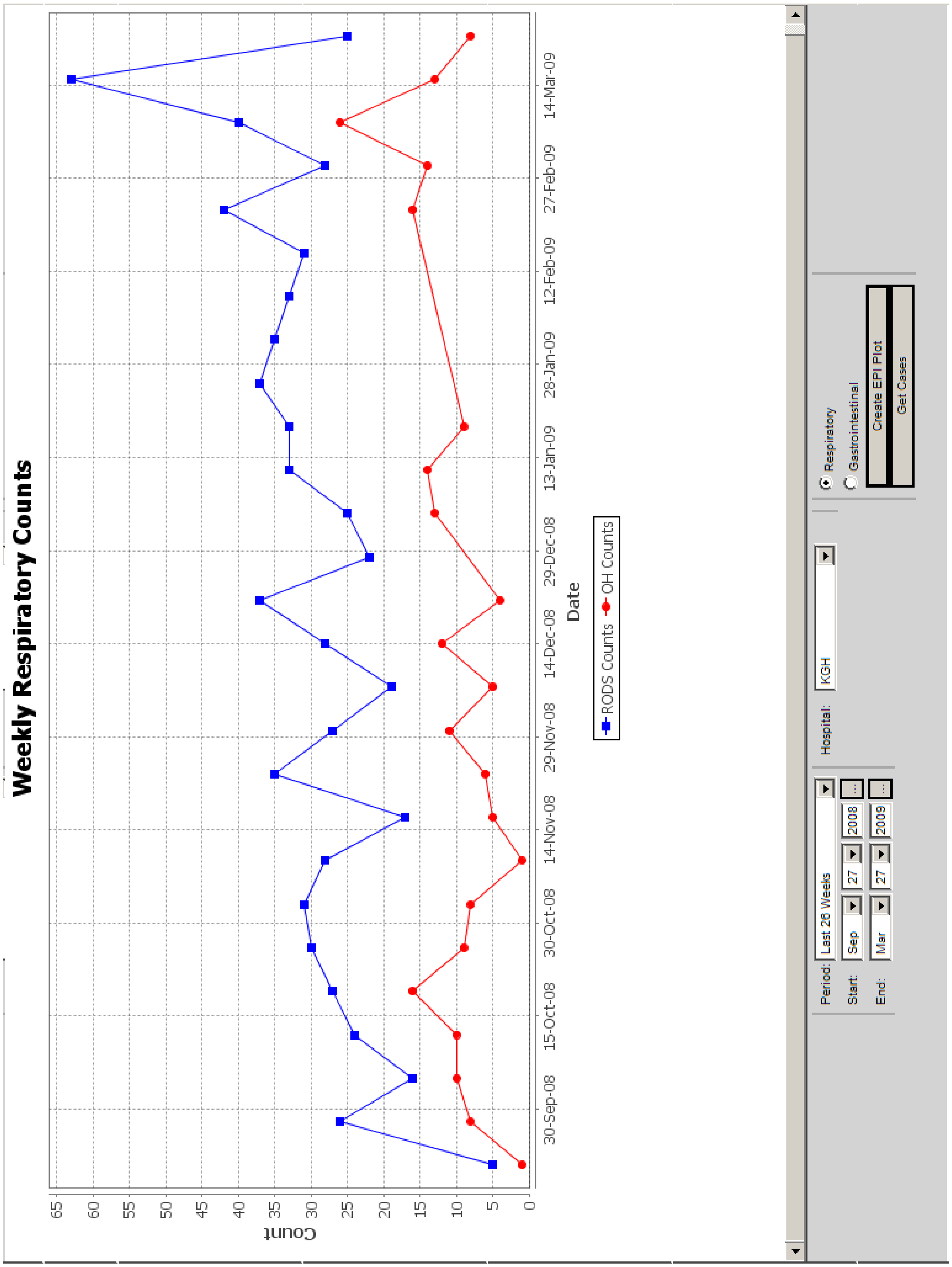

Figure 2: UI Design for the Integrated Syndromic Surveillance Functionality

Database Design Schema

Figure 3 shows the database schema for the OH database. The database has been designed to eventually incorporate multiple hospitals. The database has also been designed to eventually support more advanced functionality such as mapping of hospital cases with the inclusion of the dept code/name of the case.

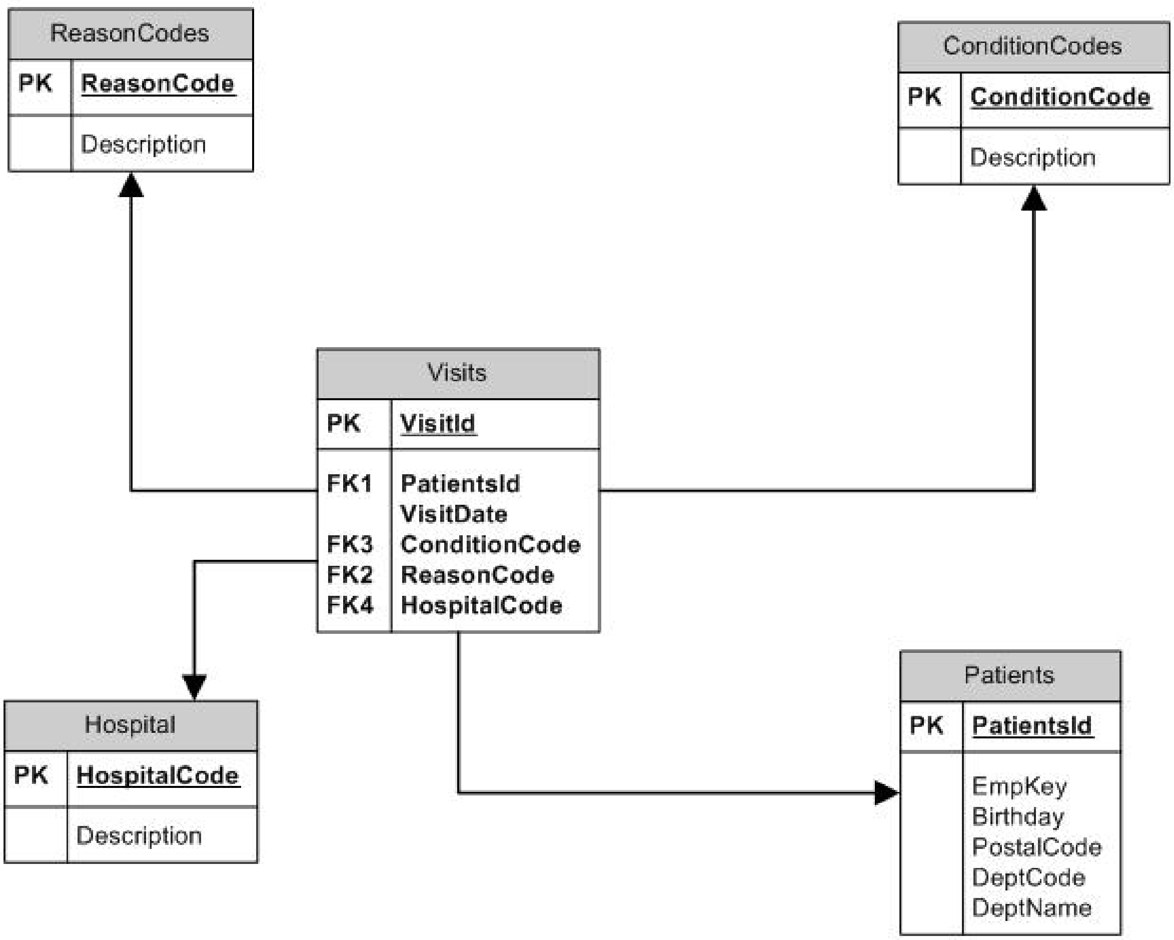

Figure 3: Occupational Health Database Design Schema

Evaluation and Recommendations

This section includes an evaluation of the current OH/ED integration and suggestions for improving the OH&S data integration and automation in the future.

Future Enhancements

The level of automation of this project should be improved to remove the step of manually copying over the data from the hospital. This would involve automating the data transfer from the hospital to KFL&A Public Health. This has already been achieved for the ED data and is certainly technically feasible and its difficulty would depend on the security and networking infrastructure already in place at the hospital. Further investigation into fully automating the system will continue and discussions are underway with the hospital information technology staff.

The current implementation is simple but powerful in that it allows for the direct comparison of ED to OH&S visits. However what the system fails to achieve is the functionality needed for the detection of hospital outbreaks that are specific not to the general population or to the general hospital staff, but rather to the hospital staff confined in one area of the hospital. Maps have been manually created in GIS systems that show that mapping of count visits to the actually hospital areas on a floor by floor basis can help to identify areas of higher than normal case activity.

Increased Automation

Figure 4 shows a schematic of how a fully automated OH and EDSS system could be implemented. The ED portion has already been implemented as is shown below. Achieving this automation for OH&S data is almost solely dependent on the hospital information technology staff and infrastructure. Implementing the O&S data the same way would involve the hospitals setting up the transfer of the data to a server connected to the Smart System for Health (SSH) network and then writing scripts to automate the transfer. On the KFL&A Public Health side, the only change required would be to change the directory of our database insertion scripts which currently inject the OH&S data into the database.

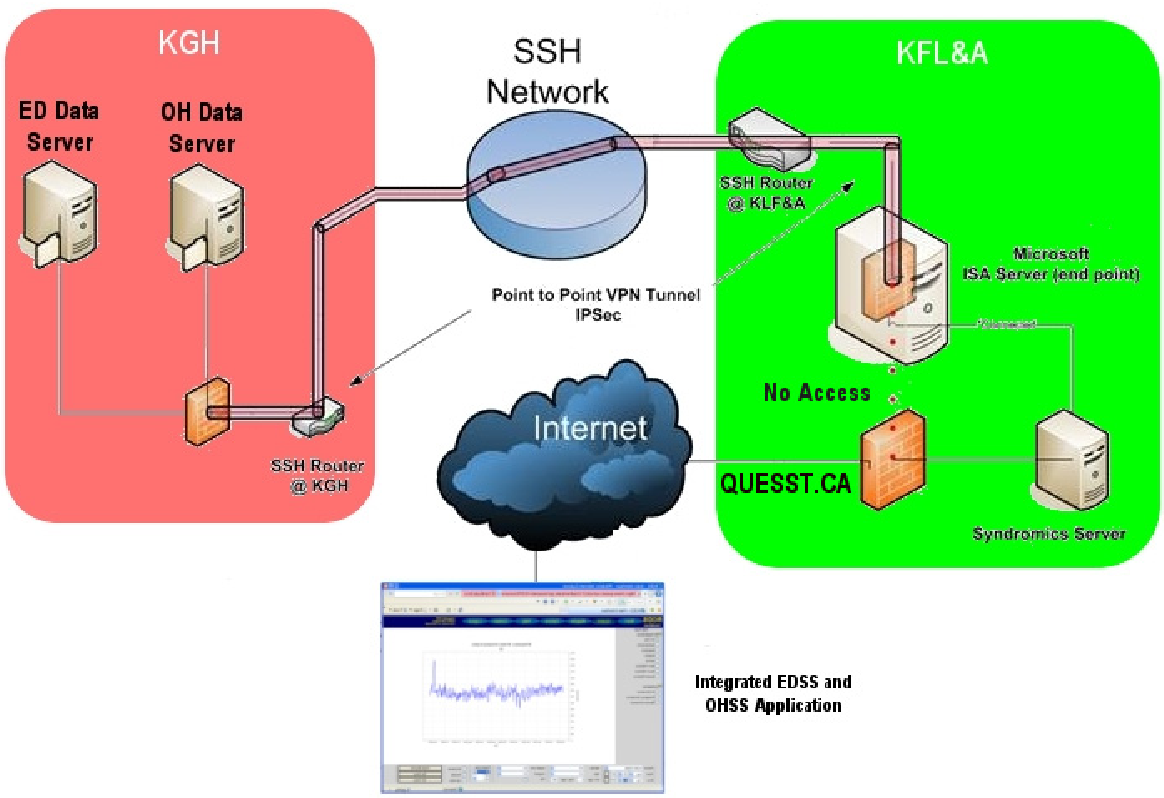

Figure 4: Schematic for a Fully Automated System Following the EDSS Project Template

Increased Epidemiological Functionality

Future versions of the OH interface should incorporate simple algorithms such as hard counts or moving averages utilizing standard deviations to monitor both the aggregated counts per syndrome and also on a hospital department by department or area by area basis. GIS mapping capabilities should also be developed in the system as prototyped in Figure 5. The screen below shows color codes for where the case visits are originating from. For this particular period most of the cases are originating from waste management.

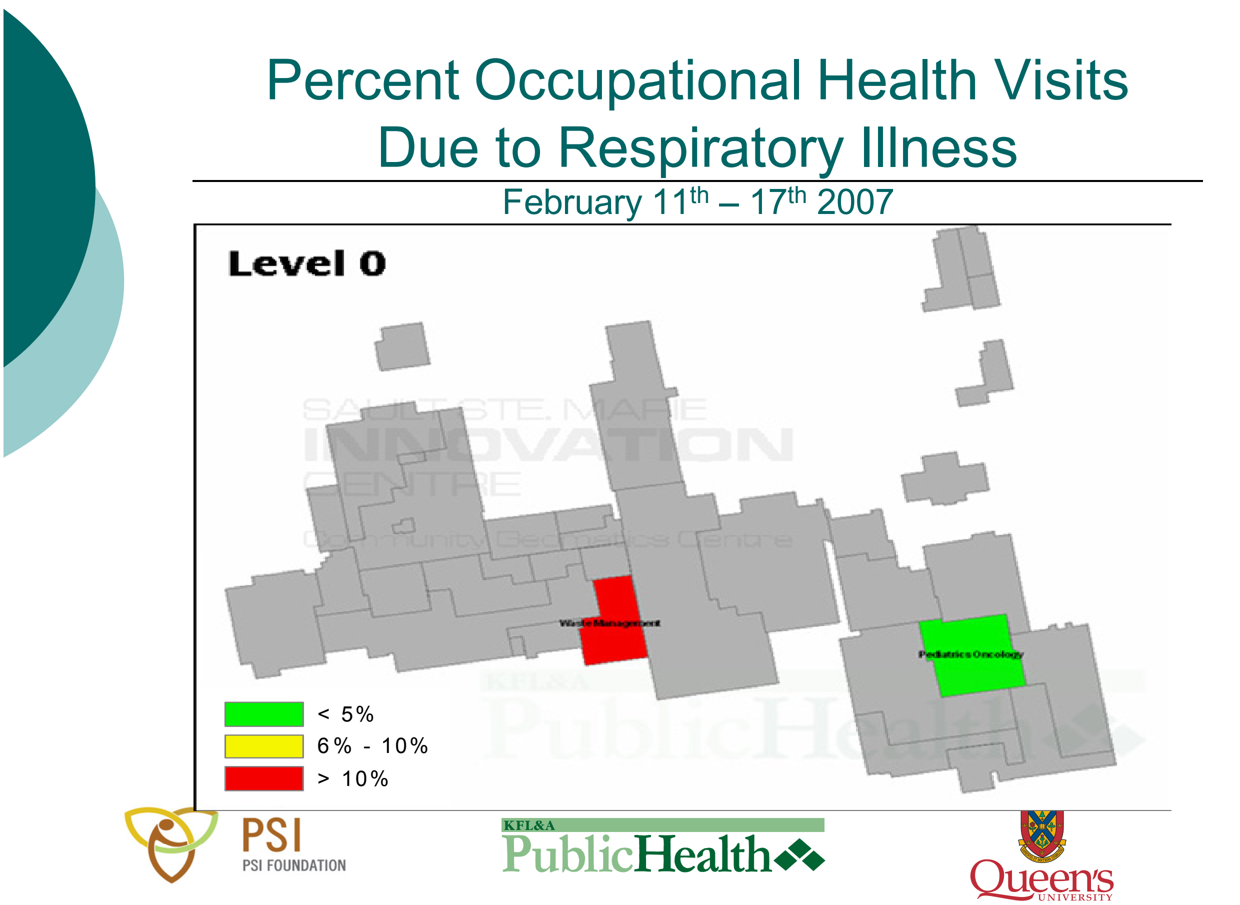

Figure 5: The Mapping Functionality with Future Enhancements of the OH Project

CHAPTER 6: Evaluation of an innovative, integrated, syndromic surveillance system

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Framework Adapted From:

The Centers for Disease Control (CDC) - Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks

A. System-wide Issues

A1. Activity: Describe the political, administrative, and geographic context for the system

Outcome/Measure: KFL&A Public Health, located in Kingston, Ontario, Canada, conducted a two year pilot project (May 06 – June 08) to develop and evaluate an innovative, real-time, integrated surveillance tool linking routinely collected electronic OH&S visit data from KGH with an existing EDSS system – which captures ED visits and admissions from nine local area hospitals in real-time. The integrated surveillance system, developed in collaboration with stakeholders (KGH OH&S Department, KFL&A Public Health and Queen's Public Health Informatics), is an electronic, integrated monitoring tool intended to provide enhanced early warning for communicable disease outbreaks within both the hospital and community setting.

The key objective of this project is to develop and evaluate an innovative, real-time, integrated syndromic surveillance system to determine its ability to monitor hospital employee OH&S reporting and to detect outbreaks of a gastrointestinal or respiratory illness well in advance of traditional reporting systems in Ontario. Further, the integration of OH&S and ED visits provides a broader picture of hospital employees and the community's illness and injury events. Hopefully by monitoring both populations' reporting activity will provide Public Health officials valuable time to perform appropriate investigations and implement necessary interventions including enhanced prevention and control of infectious diseases.

A secondary objective would be to evaluate the ability of the integrated system to detect a sentinel event such as a nosocomial infection or the effect of a community outbreak on the staffing levels at KGH. The system may potentially enhance communication and collaboration between the OH&S and ED departments and Public Health. Additionally, information available through the system may be used by hospital administration to monitor employee illness and injury reporting as well as admissions and surge capacity in order to facilitate human resources with staff planning and resource allocation.

Stakeholders of the system include participating acute care hospitals within the South East Ontario Local Health Integrated Network, triage nurses, hospital clerks who enter the data at triage, ED physicians, OH&S director and nurses, Human Resources, Public Health staff including Communicable Disease (CD) and Environmental Health (EH) teams, and patients or residents of the South East Local Health Integrated Network.

⇒ Provide a process model that describes the data flow of the system

Supporting Documentation: Refer to Figure 1; section B7.

A2. Activity: Who inputs the data into the system?

Outcome/Measure: ED data is automatically fed into the RODS system from the participating hospitals through the SSH network. OH&S data is semi-automatic; the file containing the data must manually be extracted from Citrix Access Gateway and copied into a RODS file. From this point the data is automatically copied and parsed and transferred to the database. OH&S data has a one-day lag and is available on a daily basis (not in real-time).

A3. Activity: Who can view the data?

Outcome/Measure: Data can be viewed ONLY by registered individuals who have signed, authorized access to the system including a user log on and password. Access by authorized users is logged by date/time/location into the system to monitor access.

Supporting Documentation: Signed authorization forms for user access to RODS securely stored at KFL&A Public Health and can be provided if required.

A4. Activity: Who can manipulate the data?

Outcome/Measure: At this point, only the database administrator. This is never done. Eventually, system modification may enable changes in categorization.

A5. Activity: Indicate where processing occurs centrally and where at distributed sites

Outcome/Measure: All data is processed in a central system. De-identification happens at the hospital level.

A6. Activity: Indicate where steps are automated and where manual

Outcome/Measure: Regarding ED data entry, once HL7 transmission is begun, the only thing which is not completely automated is error recovery; conducted manually at this time. The retrospective OH&S data underwent a one-time manual entry into the system. Currently the OH&S visit data is manually retrieved daily through a secure website (i.e. Citrix Access Gateway). OH&S data is quasi-automatic; the file containing the data must manually be extracted from Citrix Access Gateway and copied into a RODS file. From this point the data is automatically copied and parsed and transferred to the database. *(*Refer to Figure 1; section B7 for a description of Data Flow within the system.*)*

A7. Activity: Indicate which steps are managed on-site and which can be done remotely

Outcome/Measure: Everything for the existing EDSS system can be done remotely, unless the remote access is lost (as in the case of internet downtime). The OH&S data can only be transferred on site at KFL&A Public Health.

A8. Activity: Estimate the time required for each step of the data flow

Outcome/Measure: Average time from an admission being recorded in ED to being received by RODS system, parsed and entered: 1.2 minutes (from our receipt to parsing/entering is less than a second). Sometimes this is delayed by internet/database downtime. Maximum of 6 hours until data is counted and detection algorithms run. Alert generation is every six hours at which time an email is immediately sent to a list serve (includes project director, epidemiologist, information technology specialist and a generic mailbox for back-up storage) if an alert occurs. The retrieval and copying of the OH&S data file takes approximately 3 minutes.

A9. Activity: Indicate whether source data are produced in the course of routine workflow or specifically for the purpose of syndromic surveillance

Outcome/Measure: Source data is produced routinely (by law). De-identification and variable selection is syndrome specific.

⇒ Describe data and messaging standards:

A10. Activity: Identify standards used to facilitate interoperability

Outcome/Measure: We do not have multiple processes that require interoperable standards; however the data transfer happens via ASCII (American Standard Code for Information Interchange).

A11. Activity: Identify standards used to facilitate data sharing

Outcome/Measure: HL7 is used for the ED data in RODS. To allow anonymity, some minor changes are required (shortening of address, calc of age, deletion of name) – this is all completed at the hospital level.

A13. Activity: Describe how the system interfaces with other surveillance systems from the same sites to limit reporting burden

Outcome/Measure: No interface to other surveillance systems is currently in place.

A14. Activity: Cite relevant Public Health Information Network (PHIN) standards and ability to meet them (http://www.cdc.gov/phin/)

Outcome/Measure: PHIN standards do not apply since the system is based in Ontario and uses data sanctioned to the province. The system meets the provincial government requirements and is addressed in A15-20.

A15. Activity: Provide legal documentation allowing data sharing

Outcome/Measure: The collection and use of OH&S data received original Queen's University Research Ethics Board (QREB) approval on November 8th, 2005 with annual re-approval until August 12th, 2009.

With regards to the ED data, in order to share anonymised patient information for the purposes of syndromic surveillance, a Privacy and Security Charter as well as a Privacy Impact Assessment were drawn up to outlined the data capture and sharing process. Submissions of these documents were made to the QREB which granted approval on October 15th, 2004. In addition, a data sharing agreement has been signed on behalf of the board of Governors at KGH (most recent document signed June 18, 2008).

Privacy and Security Charter - In September 2004, prior to project commencement, the EDSS Project Directors, in consultation with legal council, developed a document entitled 'Privacy and Confidentiality for Health Information for Emergency Department Chief Complaint, Syndromic Surveillance Privacy and Confidentiality Charter (dated September 2004)'. This Charter contained an executive summary of the project as well as the principles, policies and procedures necessary to meet the intent of Personal Health Information Protection Act (PHIPA).

Privacy Impact Assessment Document

A Privacy Impact Assessment (PIA) document was also prepared which specifically addressed privacy issues as they related to the syndromic surveillance project. The PIA addressed the following areas:

- Strategic plan addressing privacy protection
- Privacy procedures, guidelines and controls
- Physical security and access control documentation
- Records management policies and procedures for personal information
- Project summary and description
- Listing of all personal data elements for project
- Personal Information Data flow diagram
- Personal Information access documentation (Access Matrix)
- Statutory authority documentation

⇒ Describe procedures to maintain security:

A16. Activity: Indicate security procedures employed for transmission of data between sites and for data management at the central repository

Outcome/Measure: for the purpose of remote login, Citrix has its own security structure and is username/password protected. RODS uses SSL (Secure Socket Layer) for authentication and cryptocard for authorization.

A17. Activity: Describe security measures to protect data integrity at the central repository

Outcome/Measure: Data integrity is maintained by an oracle database server.

A18. Activity: Describe procedures to assure privacy and confidentiality:

Outcome/Measure: Data does not include name or address of patient/staff. All data is securely transferred and stored. System access is username and password safe and has not been compromised.

A19. Activity: Identify the legal authority under which the surveillance activity is being conducted

Outcome/Measure: *Health Protection and Promotion Act (HPPA)* - Public Health in Ontario is governed by the HPPA. Section 2 of this act is as follows: “The purpose of this Act is to provide for the organization and delivery of public health programs and services, the prevention of the spread of disease and the promotion and protection of the health of the people of Ontario. R.S.O. 1990, c. H.7, s. 2”. The custodian of the health information collected in this pilot project is KFL&A Public Health. The pilot project adheres to all privacy policies and procedures of KFL&A Public Health. We collect this information under the authority of the Medical Officer of Health to protect the health of the people of Ontario against infectious disease outbreaks.

Privacy Background - On November 1st 2004, Ontario’s new healthcare privacy legislation, PHIPA came into effect. This law was designed to govern the collection, use and disclosure of personal health information within the health care sector. The act further provides a set of comprehensive and consistent rules for the health care sector to ensure that personal health information is kept confidential and secure.

In September 2004, in anticipation of PHIPA, policies were developed by both KGH and Hotel Dieu Hospital (HDH) to ensure that all future projects involving personal information would require a detailed business plan, privacy impact assessment and, where applicable, written approval from the QREB.

A20. Activity: Indicate the rules, procedures, and tools used to assure privacy and confidentiality, including methods for de-identification and re-identification, if used, and the points in the data flow where statistical disclosure limitation methods are applied

Outcome/Measure: For both datasets all names are deleted, only age (ED data) or date of birth (OH&S data), gender and 5 digit postal codes are captured. This de-identification is done prior to being sent to the user.

B. Data Sources

⇒ Describe the following:

B1. Activity: Data producing facility

Outcome/Measure: KGH produces both the ED and OH&S data

Supporting Documentation: Refer to Figure 1; section B7 for a description of Data Sources and Data Flow within the system.

B2. Activity: Data type

Outcome/Measure: The data streams currently collected are ED visit data and Admissions data (ED and Elective) from participating hospitals. In addition, visits to the OH&S department by all staff and volunteers at KGH are collected.

B3. Activity: Data format

Outcome/Measure: HL7 (ED data) and text (OH&S data).

B4. Activity: Data element definitions

Outcome/Measure: ED data - chief complaint and triage level or reason for admission, hospital, date and time of visit or admission, postal code, age, and gender.
OH&S data – date and time of visit, gender, date of birth, 5-digit postal code, department, reason for visit (i.e. initial, follow-up), and symptom(s) and condition(s) associated with reason for visit. Only initial visits for respiratory and gastrointestinal illness reporting are included in the O&S data. The variables included when you select the 'get cases' button in the OH interface are visit date and time, sex, age, department, condition (i.e. respiratory upper/lower, Febrile Respiratory Illness (FRI) and gastrointestinal), and visit type (i.e. initial visit or initial reporting by phone).

B5. Activity: Code sets (e.g., International Classification of Diseases (ICD) codes) used to describe the response categories

Outcome/Measure: None yet – hope to have admission diagnosis (ICD10) eventually, if available.

B6. Activity: Data captured for geographic location (e.g.,zipcode, geocode)

Outcome/Measure: A 5-digit postal code is captured for each patient visiting the emergency and OH&S departments. The 5-digit postal code included in the ED data is used in rural areas where it can be mapped to the location of the post office from which mail delivery originates. In urban areas, only the first 3 digits known as Forward Sortation Areas (FSA) are used as the first 3 digits accurately define an urban geographical area. Postal codes in the OH&S data are not used at this time.

B7. Activity: Provide a data model describing the relationship between data elements and the code sets

Outcome/Measure:

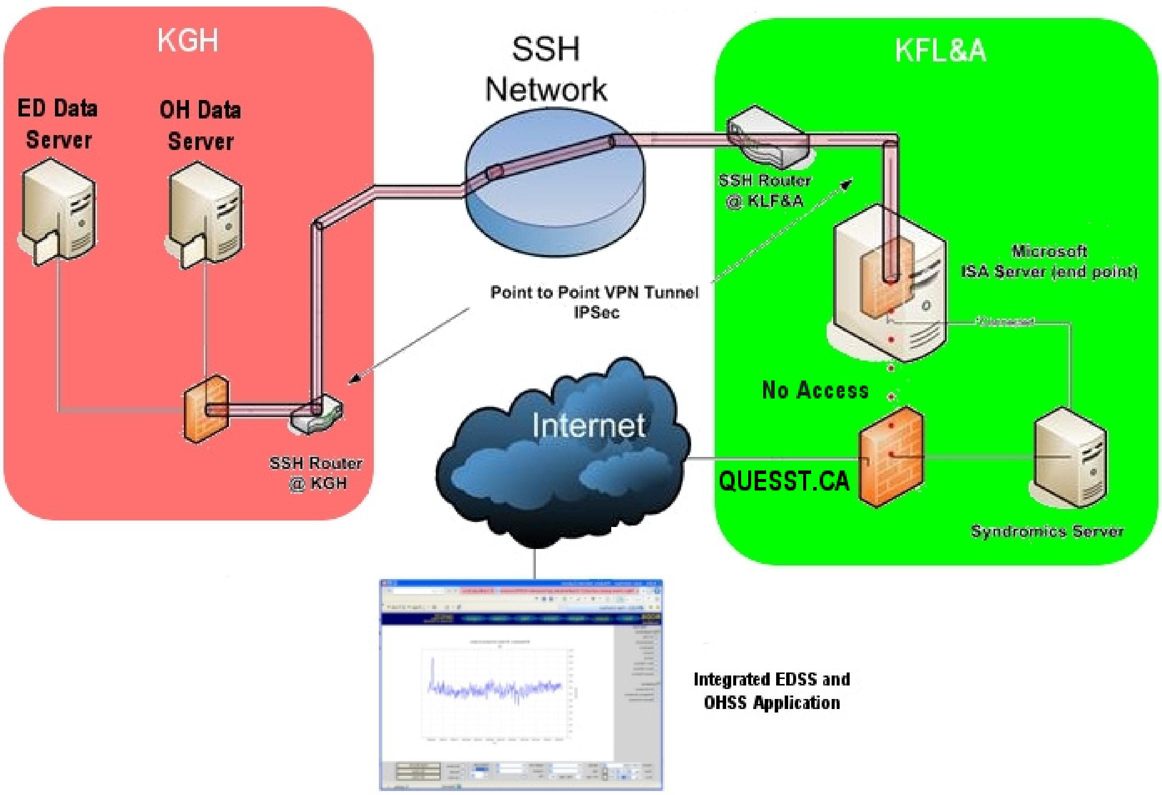

Figure 1: Schematic for a Fully Automated System Following the EDSS Project Template

B8. Activity: Indicate which data standards are used and whether they are proprietary

Outcome/Measure: N/A

B9. Activity: Identify the standards used for assembling data documentation (i.e. metadata)

Outcome/Measure: RODS verifies its data against a standard HL7 template. OH&S data is not validated against metadata.

C. Data Preprocessing

C1. Activity: Indicate the steps taken to share data between information systems and indicate the responsible organization for assuring each step (e.g. clinical facility, data clearinghouse, local health department, state health department)

Outcome/Measure: the HL7 message router deletes identifiable information from the data by removing unique identifiers and sends the data to the SSH network. Parklane, the OH&S database runs a query that automatically collects all necessary variables excluding name and identifying information.

C2. Activity: Indicate the frequency of data collection

Outcome/Measure: ED data collection is continuous, in real-time. OH&S data is retrieved on a daily basis with a one-day delay.

C3. Activity: Indicate the volume of data (e.g., average number of records per day)

Outcome/Measure: Approximately 180 records are collected per day for KGH hospital and 350 for all of KFL&A region. This includes both visits and admissions. Approximately 25 OH&S visits are collected per day.

C4. Activity: Indicate how the accumulation of data is handled

Outcome/Measure: Incoming messages are logged; data is processed and added to database. This is handled by the oracle database server.

C5. Activity: Describe how different data streams or data elements are assembled, subset, and manipulated to prepare them for analysis

Outcome/Measure: A Bayesian text classifier categorizes the visit into one of seven syndromic categories, based on the chief complaint; Respiratory, Constitutional, Gastrointestinal, Rash, Neurological, Botulinic or Hemorrhagic. If unable to classify the chief complaint, it is entered into the Other category. Data are classified into geographical location as described above. The OH&S data is pre-classified prior to receipt; an OH&S nurse selects condition(s) associated with an employee's visit based on symptoms reported. The OH&S database, a Parklane software system includes an electronic flip-down chart with various pre-categorized conditions such as respiratory – upper/ lower, gastrointestinal, musculoskeletal, psychological, and more. The RODS system has a built-in query that selects certain codes to obtain only initial visits that are respiratory or gastrointestinal-related.

C6. Activity: Indicate whether a relational database is formed to link datasets and the unique identifier(s) used for linkage

Outcome/Measure: - No unique identifiers used. There is no linking of datasets.

C7. Activity: Indicate the health-related events, syndromes, or constellation of findings under surveillance, including the derivation of the case-definitions

Outcome/Measure: All ED visits as well as admissions (ED and elective) from participating hospitals are collected. Syndrome classification for ED visits is as described above. The case definitions for these syndrome classifications are based on RODS software. The RODS 3E system was trained to classify syndromes using historical data for the KFL&A area. The OH&S visits are classified by OH&S nurses - they select pre-determined conditions based on employee/volunteer symptoms reported.

C8. Activity: Identify who has authority to determine the criteria for case definitions and how case criteria are applied to the data

Outcome/Measure: The criteria for case definitions may be modified as deemed appropriate by the QΦ Project Director, an Emergency Medicine physician. Case criteria was based on a review of ICD 9 coding definitions and a thorough review of retrospective data to establish what syndrome labels were appropriate for corresponding symptoms reported. The criterion for case definitions in the OH&S data is at the discretion of the nurses, who receive training in order to critique and identify accordingly.

C9. Activity: Provide a description of any algorithms used to establish the status of a potential case

Outcome/Measure: The chief complaint is a free-text field entered by the triage nurse during registration. Based on a manually created training set, CoCo, a chief complaint classifier, estimates the probability of each word occurring within each syndrome. Using these probabilities, CoCo is able to determine the most likely syndrome for any free text complaint with reasonable accuracy. The main drawback of CoCo is that it relies on the assumption that the data on which it is trained represents the data that it will classify in the future. New facilities and individual triage nurses who use terms or acronyms which were not in the training data pose a problem for the classifier. The OH&S database has a sliding window algorithm applied.

C10. Activity: Indicate the frequency of editing and updating the electronic file

Outcome/Measure: RODS electronic file is constantly updated in real-time. The OH&S data is conducted once daily.

C11. Activity: Indicate how incomplete records are handled in analysis and reports

Outcome/Measure:
ED data -No chief complaint: classified as other
-No date: not used

-No gender: will count towards total, neither gender subset
-No Age: same
-No postal code: will not count towards any health unit
OH&S data – only respiratory and gastrointestinal-related visits are integrated in the system. All other types of OH&S visits are excluded from the system.

C12. Activity: Describe how data archiving and disposal is managed

Outcome/Measure: ED data is never disposed. Any OH&S visits that are not respiratory or gastrointestinal-related are excluded from the system. There are regular daily and weekly back-ups conducted. Archiving is done at a system level, not at an application level. Data archiving is completed for the entire server.

C13. Activity: Describe how new data sources or necessary changes in data sources are identified and incorporated in the system

Outcome/Measure: None at this time.

D. Statistical Analysis

⇒ Describe how the health outcome baseline is established:

D1. Activity: Describe the population under surveillance

Outcome/Measure: ED Data - Any patient who visits the ED at KGH. Patients who are admitted for emergency or elective purposes are also captured. Typically, patients reside within the KFL&A Public Health jurisdiction, however individuals from neighboring Health Units (Leeds, Granville and Lanark and Hastings Prince Edward Counties) may also visit hospitals outside their Health Unit's jurisdiction and finally visitors or travelers who go to the emergency room are captured. OH&S Data – includes any staff or volunteers at KGH, as well as any employees contracted through KGH or visiting from another site but require OH&S assistance.

D2. Activity: Describe the source, the criteria, and the methods for establishing the background frequencies used to detect aberrations

Outcome/Measure: Data from ED visits for KGH hospital from 2001-2004 (4 years of historical data) was used to train the RODS system. The OH&S data begins in April 2004, providing over 4 years of baseline to date.

D3. Activity: How much baseline data are managed in the analysis database

Outcome/Measure: 120 days of historical data are used for analysis purposes (i.e. RLS and Cusum aberration detection).

⇒ Describe analytic methods used in automated analyses (i.e., aberration detection):

D4. Activity: Describe in mathematical and statistical detail the algorithms intended to signal an event requiring further investigation

Outcome/Measure:

Detection Algorithms

Currently, two anomaly detection algorithms are used: Recursive-Least-Square (RLS) and Cumulative Sum (Cusum). These have been run retroactively on the historical data, as though the data were arriving in real-time. For current data supplied in real-time the algorithms are run every six hours, immediately upon completion of the count caching process. When an anomaly is detected, an alert is generated. This consists of a log entry, containing the time, syndrome, count, and the threshold which was exceeded to generate the alert. These log entries can be queried and viewed in the User Interface (see below). In addition, an e-mail message is sent to the appropriate user(s).

The Cusum method compares the number of recorded or observed events in each time period with the expected number. Traditionally, Cusum control charts have been utilized in industry as a monitor of production quality. It is the Cusum of the deviations between the observed and the expected, which creates an alarm if the positive deviations are greater than x standard deviations from a defined threshold. Cusum is designed to recognize gradual increases in counts and unlike RLS, it can detect changes in variance rather than changes in value alone. However, false alarms may result from a steady rise in the mean[1].

The RLS algorithm computes an expected count for each syndrome category. An alarm in RLS results when an observation is above the 95% confidence interval of the predicted value. It is very sensitive to rapid increases in a time series of events such as daily surveillance data counts[1]. RLS continuously updates its parameters by minimizing the prediction error where possible, thus it is able to learn from the time series data and does not require extensive historical data[2].

Recall that the detection algorithms in RODS 3E currently run every 6 hours. Both Cusum and RLS alerts are based on 7-day moving windows. The most recent 7 days are compared to 120 days of historical data, and an alert is created if results exceed a defined threshold. The parameters that define these thresholds are being investigated to determine those best suited for the current data and the integration of multiple data sources.

The OH data does not have an alerting mechanism in place. A trained epidemiologist reviews the data on a daily and weekly basis and will note increases in data and communicate and collaborate with key stakeholders as deemed necessary.

D5. Activity: Describe adaptations in analytic methods to account for different outbreak patterns that might be anticipated in different data sources and types and for different outbreak scenarios

Outcome/Measure: We currently are not considering any adaptations to the analytic methods. An adjustment to the RODS system, particularly with regards to anomaly detection is highly challenging and would incur high costs which we can't accommodate at this time. We continue to work at comprehending and developing the RLS and Cusum methods already in place.

D6. Activity: Indicate how reporting delays are corrected for in the analysis

Outcome/Measure: Reporting delays will be noted, and algorithms rerun.

D7. Activity: Describe the method of adjusting results for potential confounding factors

Outcome/Measure: Seasonal variations are accounted for by using 120 days of historical data for comparison. Day of the week variations are accounted for by using a 7-day moving average to calculate the observed count.

D8. Activity: Describe how the system adapts over time and the empirical basis for modifications in the methods

Outcome/Measure: RODS calculates its expected values from 120 days of historical data to account for seasonality and sudden spikes in syndromes.

⇒ Describe the detection process:

D9. Activity: The frequency of data analysis

Outcome/Measure: Detection algorithms are run every 6 hours at 12:05am, 6:05am, 12:05pm and 6:05pm (4 times daily). Manual analysis can be conducted at any time.

D10. Activity: How an alarm is generated

Outcome/Measure: An alarm is generated if the observed count for the day is greater than the expected amount for that time period as determined by some threshold.

D11. Activity: Where the alarm goes

Outcome/Measure: The alarm is recorded directly in the RODS system, and an email is sent to a list-serve of key persons including the director, epidemiologist, information technology assistant and a storage email address.

D12. Activity: The type of alarms generated by the system

Outcome/Measure: Currently, both RLS and CUSUM detection algorithms generate alarms.

D13. Activity: What is done to ensure that signals are not being missed?

Outcome/Measure: RODS and the OH interface are monitored on a daily basis by the epidemiologist and IT team members to ensure the system is working properly. All syndrome counts are examined daily, such that in the event of an outbreak or unusual event, it would be picked up.

⇒ Describe the report generation process:

D14. Activity: What routine reports are generated?

Outcome/Measure: Bi-weekly reports are created; one report solely consists of ED data, the other includes a combination of OH&S data graphs and OH/ED combined graphs.

D15. Activity: Whether data are presented graphically or in tables

Outcome/Measure: Data is presented in both ways.

D16. Activity: Whether data can be manipulated to get a specific table/chart
Outcome/Measure: Yes, within the constraints of the system.

D17. Activity: How often are charts and tables refreshed with new data?

Outcome/Measure: Charts and tables can be refreshed at any time.

D18. Activity: Indicate training level of personnel needed to manage the detection methods

Outcome/Measure: Individuals assessing alert detection methods are trained in epidemiology, information technology and/or medicine. Familiarity with the system is required to examine the detection methods.

E. Epidemiologic Analysis, Interpretation, and Investigation

⇒ Describe the process for managing system alarms:

E1. Activity: Describe the special procedures instituted when the alarm is generated (e.g., review for data errors, in-depth manual analysis of the specific conditions within the syndrome category, manual epidemiological analysis to identify subgroups responsible for an alarm, examining data from other systems, increasing the frequency of reporting from affected sites)

Outcome/Measure: When an alarm is generated or an increase is observed, the epidemiologist will review the visits to check for data errors and will note the type of alarm (i.e. CUSUM or RLS) and syndrome of interest (e.g. respiratory, gastrointestinal). The observed and threshold values are documented and any common or unusual chief complaints. Demographics are also investigated including age, gender and department of employment. Finally, the mapping tool is used to consider geospatial locations or clusters of cases.

E2. Activity: Estimate the person-hours that are devoted to review and analysis each day and the interval at which data are analyzed

Outcome/Measure: Approximately a half hour is devoted to daily review and analysis of the data. On a bi-weekly basis a full day is devoted to conducting a more detailed review with the creation of graphs/tables and generation of reports.

E3. Activity: Indicate documented procedures for managing system alarms.

Outcome/Measure:
When an increase is noted, an investigation of the associated visits is conducted and key variables are reviewed to determine if any commonalities exist that may indicate an outbreak. The steps taken are mentioned in E1. Any pertinent information deemed necessary for dissemination is relayed to the OH&S department director and staff, to provide awareness of any potential situations. Public Health staff and/or other key stakeholders will be notified if deemed necessary.

In the event of a RODS alert: The Syndromic surveillance project listserve (including the director, epidemiologist, Information technology specialist) will be notified via email that an alert threshold has been reached through one of the detection algorithms meaning that the observed count for a particular syndrome exceeds the 'expected' by a pre-determined amount. For the initial stages, the epidemiologist or director will investigate the alerts and then where warranted, will pass on the alert via email to CD and/or EH teams.

Steps in the investigative process are as follows:

1. Confirm the syndrome classification. Verify by viewing the cases (via the 'Get Alert' and 'Get Cases' links) that the syndrome classification correctly corresponds to the chief complaint. Review the OH&S data line listings.
2. If syndrome classification is incorrect or inconsistent, please make note of the discrepancies and contact RODS staff member(s).

   If syndrome classification is correct, examine the cases. Look at the time period (date and time), demographics (age, gender), and department of employment and area specifics (hospital, health unit, and postal code) to see if any patterns or anomalies exist.
3. Plot the cases using Epiplot to examine trends.
4. Map the ED cases using Mapplot to observe the location of residence of the cases. This information may be valuable, depending on the type of infection and its communicability, to examine spread of disease and clustering. If clustering is evident, the investigator may examine schools, daycares, long-term care facilities, etc. in the area and contact information will be available (Note: steps 3 and 4 are interchangeable).
5. Determine who is at risk (e.g. employees in certain hospital departments/ wards, children, elderly living in long-term care facilities, individuals residing in an area defined by a postal code or FSA, etc) from the above steps.
6. NOTIFY Hospital(s), Physicians (Doc Alert), Branch Offices (Cloyne, Napanee, Sharbot Lake) and potentially other health units depending on the scope that this may be an outbreak situation and further investigation is required. Contact the OH&S department with any pertinent information. Public Health can raise awareness among hospital(s) of concerns related to infectious disease, such that cases may be more readily diagnosed and the necessary precautions such as infection control procedures taken (where appropriate). The hospital(s) may also provide additional information to aid the investigation such as identifying additional cases.

The Hospital Infection Control Practitioner (ICP) is the contact for Public Health at the hospital and/or the OH&S department director. The call Nurse on the floor may be contacted for information pertaining to admitted patients.

The Patient Care System (PCS) is accessible through VPN (Virtual Private Network) at KFL&A Public Health. This allows Public Health to access patient information that may be useful for investigative purposes including: admission diagnosis, demographics, family doctor, lab results, x-ray results, patient history, and bed history. The downfall to this data source is that access is unreliable and there is a time lag for entry (approximately one day). Similarly, information is available from patient records, but it is approximately one day delayed.

[NOTE THAT NO LAB TEST HAS BEEN IMPLICATED IN STEPS 1-6 OF THE INVESTIGATION AS OUTLINED ABOVE. The early lead time provided by a RODS Alert may be crucial to preventing and controlling an outbreak within a healthcare setting/institution, the community, or both]

7. CONTACT Hospital Laboratory (for ED visits or admitted patients), Public Health Laboratory (for samples related to outbreak investigation and tests outlined on the Ontario Public Health Laboratory Testing Menu), and/or private laboratories to request number of test requisitions, positive results (preliminary or otherwise), negative results, type/species identification, etc. Access to information and timeliness of results will depend on the laboratory and the outbreak.

8. Continue to monitor RODS for visits of syndrome of interest, particularly to observe changes in patient demographics, disease severity (acuity levels will be captured soon), geographical spread of infection, etc. Monitor the admissions (primarily ED admissions) to detect any patterns or anomalies in demographics or reason for admission. Contact Hospital(s) as required.

E4. Activity: Document how RODS is used as an investigative tool for Public Health

Outcome/Measure: In the event that Public Health is notified of a respiratory or gastrointestinal outbreak occurring within the community (How RODS can help):

- Public Health staff will be notified via telephone call, fax and/or mail from a laboratory, an institution such as long-term care or daycare, physician, etc. of an infectious disease event requiring further investigation. In most cases, this notification is concerning a reportable disease, which must be reported by law to Public Health. Public Health investigation is warranted for most reportable diseases, unusually high incidence of disease (particularly in institutions), new or emerging diseases or any other infectious disease event deemed to be a threat to the health of the public.
- Notification may come to any of the appropriate CD or EH team members during regular business hours Mon-Fri 8:30am-4:30pm or to the Medical Officer of Health (cell phone/pager) or assigned back-up during evenings and weekends.
- RODS may be utilized **CONCURRENTLY or IN ADDITION TO** standard investigative processes as follows:

    - Following notification to Public Health - examine the syndrome of interest, time period, demographics and location of interest. One or more of these features may be explored individually to characterize the potential outbreak.
    - Use Epiplot or Mapplot to display the desired information
    - Contact ED of OH&S for additional case finding
    - NOTIFY Hospital(s), Physicians (Doc Alert), Branch Offices (Cloyne, Napanee, Sharbot Lake) and potentially other health units depending on the scope that this may be an outbreak situation and further investigation is required. Contact the OH&S department when deemed relevant. Public Health can raise awareness among hospital(s) of concerns related to infectious disease, such that cases may be more readily diagnosed and

the necessary precautions such as infection control procedures taken (where appropriate).

- Monitor RODS on a regular basis to assess visits of syndrome of interest – use Epiplot and Mapplot to track changes in disease patterns.

E5. Activity: Indicate communication method that staff is alerted of alarms (e.g., whether they get paged at home, receive an automated e-mail, etc.?)

Outcome/Measure: An email message of alerts is automatically generated and sent to the RODS listserve. Or in the case of an increase in OH visits, the epidemiologist will manually make note of this. Either the epidemiologist or project director from the response team is designated to check the system during evenings and weekends. If further communication is warranted, a call may be placed to the CD nurse on-call, the Medical Officer of Health (MOH), and/or staff in the ED department(s).

E6. Activity: Indicate the expectations and schedule of staff to actively check the system and schedule, including nights and weekends

Outcome/Measure: *RODS DAILY MONITORING:*

RODS is monitored DAILY for the following to ensure that the system is functioning properly and also to provide information to Public Health and Hospital Administration on infectious disease events:

- ED & OH&S Registrations – examine visits by syndrome, demographics, department of employment, area and time period. Specifically for ED data, check acuity level (urgency of care associated with reason for visit) and FRI screening data which is provided and is monitored for positive results, particularly for patients who are admitted to hospital. An alert will be generated automatically in the event of an aberration, however daily monitoring can provide Public Health with a good indication of baseline incidence, weekly and seasonal trends, etc. and also ensure the system is classifying appropriately.

- ED Admissions – examine trends or anomalies by demographics, area and/or reason for admission. Hospital administration can monitor ED volume and prepare for added volume in the event of an outbreak.
- Elective Admissions – examine volume of patients admitted, reason for admission, predict admission volume given surgery days (primarily for use by Hospital administration).
- Occupational Health Data –This data is collected daily (with a 24 hour delay) and retrospective data (April 2, 2004 to June 30, 2008) is available through RODS for both Public Health and hospital administration.

RODS and OH&S BI-WEEKLY MONITORING:
Bbi-weekly reports are generated and distributed to CD and EH teams as well as to participating hospitals (ICPs, Emergency Departments, Physicians and residents, Nurses) and interested municipal and provincial public health persons. From the Public Health standpoint, these reports provide the impetus for further investigation into areas of interest and also raise awareness of trends and unusual events such that Public Health can continue to monitor for these trends or anomalies.

E7. Activity: Indicate the response options to an alarm and the factors that influence the choice (e.g. wait for an alarm in another system, initiate an onsite investigation, alert clinicians to gather information)

Outcome/Measure: Any time an alert is generated it is investigated by RODS response team. Immediate investigation is required for all alerts. Respiratory or gastrointestinal illness potential outbreaks will be communicated to Public Health staff and/or OH&S department staff for assistance.

E8. Activity: Describe the process for identifying cases for investigation when the data analyzed routinely are unidentified
Outcome/Measure: Routine review of OH&S visits and ED visits and admissions can alert the response team to sentinel cases requiring follow-up or further investigation.

When particular chief complaints or syndromes indicate symptoms related to infectious diseases, these cases are shared with the project director, CD team and when deemed appropriate, the MOH or hospital Infection Control Staff. Some examples include symptoms of bloody diarrhea (potential gastrointestinal illness), query meningitis, necrotizing fasciitis, supraglotitis, MRSA, measles, etc. With early identification of these potentially serious cases, communication and awareness between key stakeholders can be initiated earlier than may otherwise occur.

E9. Activity: Describe how independent data types are integrated in the analysis for improved decision making

Outcome/Measure: The inclusion of OH&S data into the EDSS system intends to provide a more representative picture of infectious diseases among the staff at the local hospital and the patients (provided via admissions) and community (provided via ED visits) and enables a comparison of the two data sources.

E10. Activity: Describe the rules, procedures, and tools for communication

Outcome/Measure: All alerts or cases of interest are first reviewed by the epidemiologist and director who decide if any further action should take place. Only once this initial review is completed are the CD and EH teams notified. From this point, all these stakeholders communicate and decide whether to notify IC, the ED department, the OH&S department or Medical Officer of Health. Email and phone are the primary methods used for communication.

E11. Activity: Indicate the mechanisms used and content guidance provided for sharing results with 1) reporting sources, 2) response community, and 3) the public;

Outcome/Measure: The generation of bi-weekly reports is the consistent method used to disseminate results to stakeholders and persons who have an interest in the surveillance system data. The response to community and the public is assigned to responsible persons at the health unit when deemed necessary and appropriate. This can include any or all of the following: CD team/ manager, the EH team/ manager, the Director of Infectious Diseases, the MOH and the communications officer.

E12. Activity: Describe how decisions are made for sending urgent communications and the methods for sending urgent communications

Outcome/Measure: An urgent communication to the community is decided by the Medical Officer of Health. If the message is sent to colleagues and non-public persons it is predominantly via email, listserve or telephone. A press release will be generated by the communications staff at KFL&A Public Health only on the recommendation of the Medical Officer of Health.

E14. Activity: Indicate whether receipt of a communication is acknowledged and how unacknowledged receipt is managed

Outcome/Measure: A notification is sent back when emails are not received. When phone conversations and meetings are conducted there is certainty that acknowledgement is received. Follow-up of any meetings and issues is carried out.

E15. Activity: Indicate how often urgent communications and routine reports are sent

Outcome/Measure: Routine reports are sent bi-weekly. Any specific inquiries from media or interested parties are dealt with upon request – approximately once a month. Seasonal activity (i.e. increased respiratory and/or Fever/ILI in fall and winter and asthma in the fall and spring are noted when appropriate). Approximately once a year an event occurs which requires urgent communication.

E16. Activity: Describe the protocol for conducting surveillance during outbreak management, if one exists

Outcome/Measure: see E4 response.

E17. Activity: Indicate how often data will be updated and analyzed

Outcome/Measure: ED data is updated in real-time and is analyzed on a daily basis. The retrospective OH&S data was integrated into the RODS system at one time, but various analyses will be performed when required. OH bi-weekly reports are generated regularly with up-to-date data, but the process is conducted in Excel; independent from the RODS surveillance system.

E18. Activity: Describe how the system can be modified or customized to meet special data needs

Outcome/Measure: The systems functions can't be modified at this time. But various data analyses can be conducted to extract pertinent information including, the creation of graphs/epi plots including both ED and OH&S data, the retrieval of ED line listings, and spatial analyses of ED data. Having the ability to change the system so it properly classifies new chief complaints and symptoms would be advantageous. In addition, the ability to create new syndromes of interest could facilitate novel uses of the system. For example, the creation of a musculoskeletal syndrome would enable monitoring of this common complaint among hospital employees.

E19. Activity: Describe how the system will monitor the impact of prevention and control measures

Outcome/Measure: If an infectious disease outbreak is declared among patients on a particular ward, the OH&S data can be monitored to determine if hospital staff is similarly experiencing an increase in illness activity – if there is no corresponding increase, this likely is an indication of effectively implemented prevention and control measures. Conversely, if staff shows increased rates of illness, there is an opportunity to increase infection control procedures.

If patients from the community are presenting to the ED with similar symptoms that may indicated infectious disease, the project director may contact the ED department and encourage enhanced specimen collection in hopes of obtaining results quickly and capturing an outbreak at an earlier point. In addition, case follow-up(s) and investigation(s) can be conducted by ED staff, ICPs, and Public Health nurses to determine if an outbreak is occurring and/or if further Public Health action is deemed appropriate.

E20. Activity: Describe how and how often system components are tested for operational readiness (e.g., ‘spiked’ data or modeling exercises)

Outcome/Measure: We do not currently have an operational testing component, but we monitor our system closely and maintain them regularly.

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Chapter 7: Time-series comparison of Occupational Health and Emergency Department visits

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INTRODUCTION

The detection of health events as early as possible is critical to Public Health to enable control and mitigate interventions before health impacts are widespread. Real-time syndromic surveillance systems have the potential to detect disease outbreaks before they are identified through conventional diagnostic/laboratory-based surveillance methods by making use of alternative, electronic data sources[1]. Many of these alternative data, such as over-the-counter drug sales, OH&S visits, and ED triage data are already routinely collected. This paper describes an investigation to verify and validate the utility of OH&S data from KGH in Kingston, Ontario as a monitoring tool for respiratory and gastrointestinal illness by comparing it retrospectively to data from a triage chief complaint based EDSS system.

An occupational disease is one that is caused by or becomes worse due to an exposure to risk factors at work[2,3]. Immediate identification and investigation of potential outbreaks in the health care setting is crucial to limiting transmission of infection[4]. Within an acute health care setting, there is an increased risk of nosocomial infection[5]. Hospitals with effective surveillance and infection control programs have the lowest nosocomial infection rates[5-7].

Respiratory and gastrointestinal illnesses were chosen as study variables because of how easy and commonly transmission occurs. Respiratory illness is one of the main contributors of absence in HCWs[8]. SARS is the most recent example of an emerging infectious disease, which clearly illustrated the potential threat to Canada with regards to serious epidemics[9]. Specifically, front-line workers were most affected due to their vital role in controlling the disease, which in turn exposed them to a heightened risk of disease transmission and subjected them to considerable physical and psychological stress[9]. HCWs are also subjected to gastrointestinal illness via fecal-oral transmission; through direct contact with infectious waste, through ingestion of contaminated food, and direct person-to-person contact[10]. Insufficient hand-washing is likely the primary contributor of gastrointestinal illness transmission among HCWs[11]. According to the Enteric Diseases Surveillance Protocol for Ontario Hospitals, all persons experiencing vomiting and/or diarrhea must report to the OH&S department when leaving and returning to work[12]. Reporting and monitoring of these symptoms among HCWs can help control transmission and ensure surveillance of gastrointestinal illness.

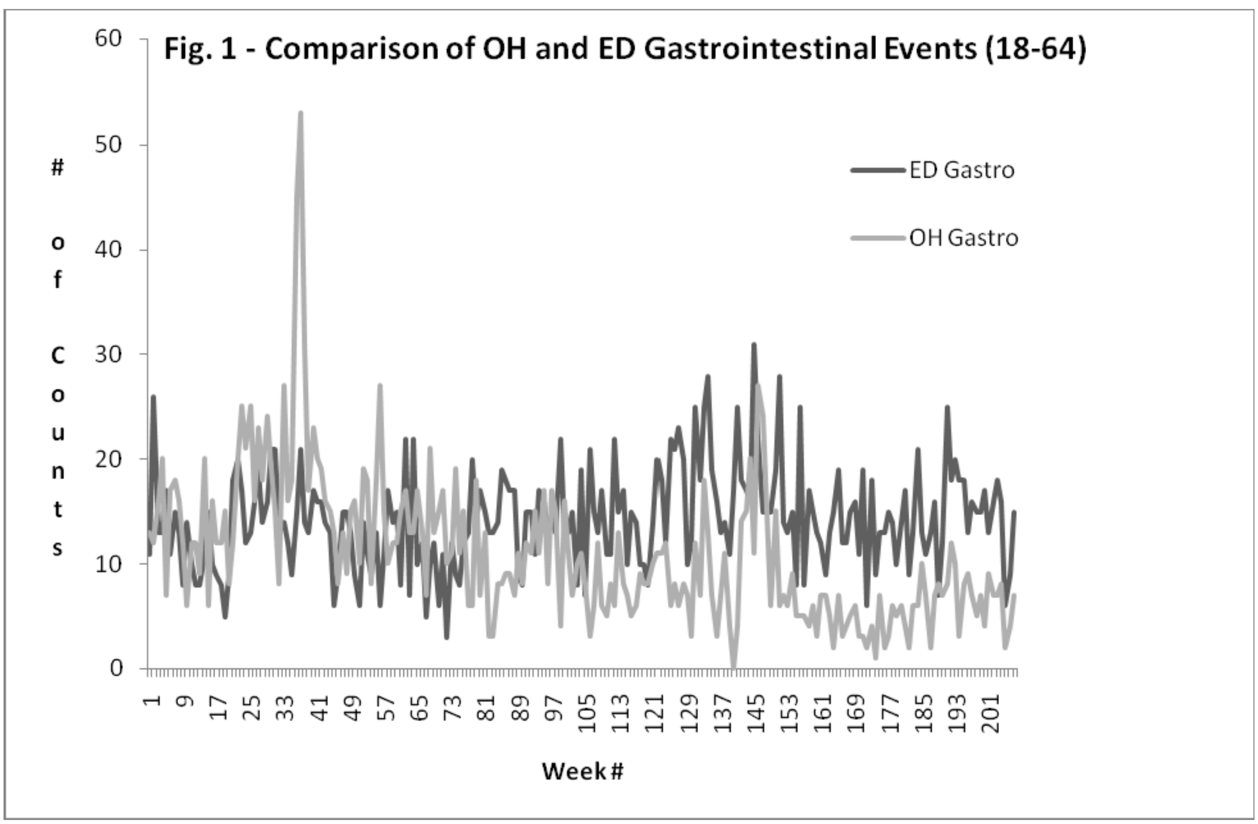
In September 2004, a real-time EDSS system was created to monitor respiratory and gastrointestinal chief complaint incidence temporally and spatially. Nine area hospitals feed electronic chief complaint data into the system. Routine, non-nominal patient data elements collected includes date and time of visit, demographics, five-digit postal code of residence, Canadian Triage Acuity Score (CTAS), and chief complaint or reason for visit. In January 2007, the OH&S department at KGH began compiling a file which consisted of all OH&S visits for the previous day, stored in a secure folder on the KGH network. In addition, retrospective OH&S visit records from April 2nd, 2004 to December 31, 2006 were provided. Secure VPN access was granted at KFL&A Public Health to enable access to the daily OH&S record files. OH&S data has a one-day lag and is available on a daily basis. The variables retrieved from the database include date and time of visit, gender, date of birth, 5-digit postal code, employee affiliated department, reason for visit (i.e. initial visit, follow-up visit) and symptoms and syndromes as reported by the employee and classified by the OH&S nurse. The PH nurses are trained to categorize appropriate syndromes based on symptom reporting and when deemed necessary will send appropriate cultures to the lab or refer a doctor's visit.

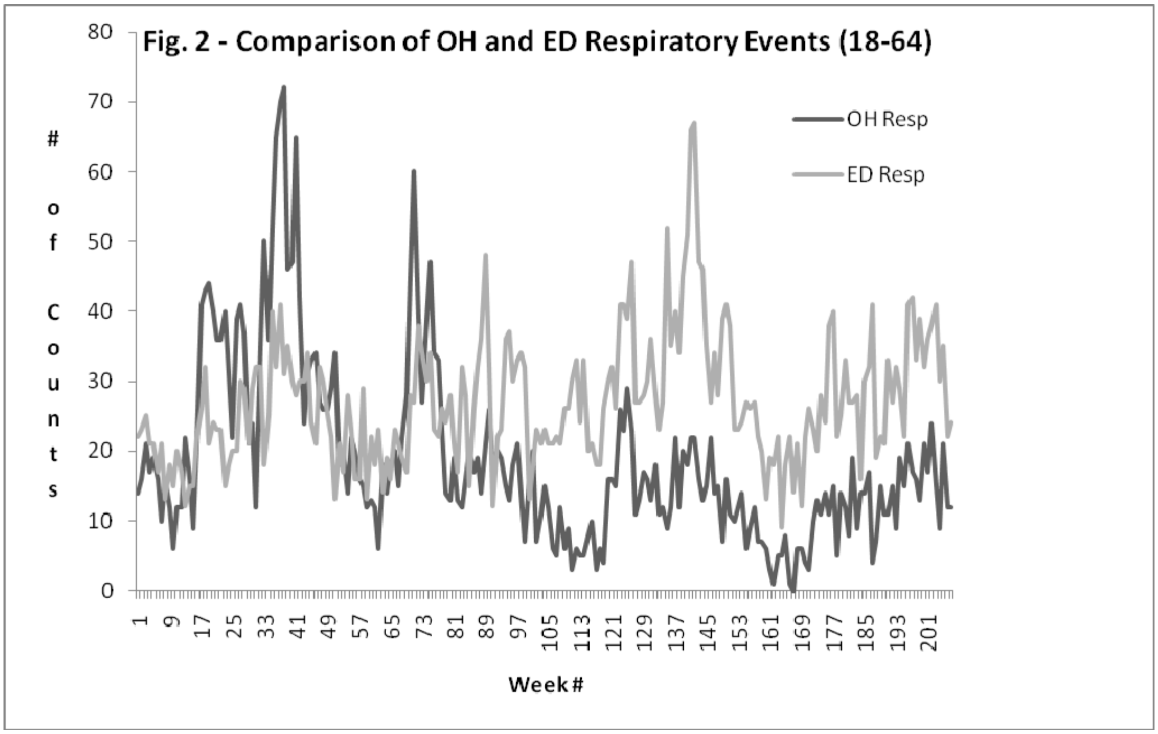
METHODS

This study was part of a broader research project which was approved by the QREB and adheres to the principles and policies for the protection of personal health information charter. Retrospective study dates were from June 2004 to May 2008, and all data was from KGH. Daily counts of respiratory and gastrointestinal related chief complaints were collected from the EDSS for KGH. Daily data from OH&S at KGH were also compiled for those health care workers reporting a respiratory or gastrointestinal related illness. All of the data were compiled into weekly totals (Sunday to Saturday), from each of the two non-identifiable data sets. All statistical procedures were carried out using SAS software, version 9.1 (SAS Institute, Cary, NC, USA). The significance of the weekly lags were considered using time series analysis and the PROC ARIMA procedure. Spearman correlation coefficients were produced using PROC CORR.

RESULTS

During the period of June 2004 to mid May 2008, the EDSS system contained 2,947 gastrointestinal-related cases and 10,983 respiratory-related cases presenting to KGH. In the same time period, the OH&S department received 2,276 gastrointestinal-related visits and 3,896 respiratory-related visits from KGH employees. Figures 1 & 2 show how each syndrome compares between the two data sources. Analysis comparing the KGH EDSS respiratory chief complaints to the OH&S respiratory visits resulted in a Spearman Correlation Coefficient of 0.20 (p-value <0.005), indicating poor correlation. Analysis comparing the KGH EDSS gastrointestinal chief complaints to the OH&S gastrointestinal visits resulted in a Spearman Correlation Coefficient of 0.03 (p-value = 0.65) indicating essentially no correlation. Correlations were highest and most significant when no time lags were included in the models.





DISCUSSION

This study shows that OH&S visits for respiratory and gastrointestinal related illness are not a good indicator of what is going on in the community. This does not however mean that there is no value in the OH&S data. OH&S data is available and will still be added to the EDSS system for ongoing monitoring. The greatest value of this data set is to KGH hospital administrators as there will always be a need for OH surveillance for health care works due to the unavoidable exposures that they encounter on a daily basis.

The large peak in Figure 1 for OH&S gastrointestinal visits was investigated further and it was seen that this peak corresponded with a norovirus outbreak in the hospital during that year. This indicates that for monitoring hospital staff, the OH&S data can be extremely useful to hospital administrators. When a sudden rise like this one is seen, intense hand washing campaigns can be implemented. These spikes can also help with staffing issues to ensure that extra help is procured in advance of a widespread outbreak. The nature of the OH&S data may not allow for in-depth comparisons to ED data but the data does have value to KGH staff, if it is monitored on a frequent basis.

A severe limitation of the OH&S data is that even when aggregated into weekly counts there just isn't enough data to allow for meaningful analyses. When looking at Figures 1 and 2 one can tell by the 'jagged' nature that the data is extremely variable from day to day and this contributes to the difficulty in properly assessing how closely the OH&S data mimics what is going on the in the community. One way to possibly fix this problem is to gather OH&S data from each of our 9 hospitals from the EDSS system which would give researchers a bigger database to work with.

CONCLUSION

This study showed no temporal correlation between the OH&S and ED datasets. Further, we were unable to validate the OH&S data against the ED data due to a lack of confirmed laboratory results. Despite this, continued monitoring of both OH&S and ED data is advised as reporting activity will provide Public Health officials valuable time to perform appropriate investigations and implement necessary interventions including enhanced prevention and control of infectious diseases. OH&S data has the potential to aid hospital specific interventions and policy practices but further analysis is need with a larger data set.

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