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Integrating Ontario's Telehealth program into a provide-wide public health surveillance system: Evaluation and Recommendations

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INTEGRATING ONTARIO'S TELEHEALTH PROGRAM INTO A PROVIDE-WIDE PUBLIC HEALTH SURVEILLANCE SYSTEM: EVALUATION AND RECOMMENDATIONS

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

A&E	Accident and Emergency
CAS	Clinical Assessment System
CC	Chief Complaint
CCDR	Canadian Communicable Disease Report
CDC	Centre for Disease Control and Prevention
CIHI	Canadian Institute for Health Information
COPD	Chronic Obstructive Pulmonary Disease
CTAS	Canadian Triage Acuity Score
ED	Emergency Department
EDSS	Emergency Department Syndromic Surveillance
EHR	Electronic Health Record
ESRI	Environmental Systems Research Institute
ESSENCE	Electronic Surveillance System for the Early Notification of Community-based Epidemics
FSA	Forward Sortation Area
GI	Gastrointestinal
HMO	Health Management Organization
ICD	International Classification of Diseases
IM/IT	Information Management/Technology
KFL&A	Kingston, Frontenac and Lennox & Addington
MFIPPA	Ontario Municipal Freedom of Information and Protection of Privacy Act
MOHLTC	Ministry of Health and Long-Term Care
NACRS	National Ambulatory Care Reporting System
NHS	National Health Service (United Kingdom)
OTC	Over The Counter
PC	Postal Code
PHAC	Public Health Agency of Canada
PHIPA	Ontario Personal Health Information Protection Act
PHU	Public Health Unit
PSI	Physicians' Services Incorporated
QPHI	Queen's University Public Health Informatics
QUESST	Queen's University Emergency Syndromic Surveillance Team
RDIS	Reportable Disease Information System (Ontario, Canada)

REB	Research Ethics Board
RODS	Real-time Outbreak and Disease Surveillance
RSV	Respiratory Syncytial Virus
SARS	Severe Acute Respiratory Syndrome
SSH	Smart Systems for Health
UK	United Kingdom
US	United States
VPN	Virtual Private Network

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION AND EXECUTIVE SUMMARY

This compendium is a summary of the work performed on Telehealth Ontario data by the Queen's University Public Health Informatics (QPHI) Team based at Kingston Frontenac Lennox and Addington (KFL&A) Public Health and Queen's University. The Physician Services Incorporated Foundation funded this work over a two year period with anonymised data supplied by the Ministry of Health and Long Term care under a Queen's University Research Ethics Board approved project.

Our primary purpose is to inform decision makers regarding our retrospective evaluation of this data to enable informed decision making by Government. We believe a real time analytical system monitoring anonymised clinical guideline decision data from Ontario Telehealth calls will enhance Public Health surveillance in Ontario and lead to more timely and appropriate interventions to help protect the public.

Telehealth Ontario is often a first contact to the health system and hence it provides a very early warning of infectious illness activity for the Province which is confirmed and validated in our report. This data is collected by trained nurses using a computerized and standardized decision support system which could become part of an integrated real time comprehensive system that could include Emergency Departments, Primary Care and Laboratory surveillance.

Our work is informed by the numerous public health emergencies that have faced Ontarians recently including SARS, Walkerton, West Nile, Mung Bean sprout Salmonella outbreak and others. We have reviewed the National Advisory Committee on SARS reports chaired by Dr. David Naylor as well as the Expert Panel on SARS and Infectious Disease Control chaired by Dr. Walker and the reports of Mr. Justice Archie Campbell. As Justice Campbell's report stipulated " SARS crisis exposed deep fault lines in the structure and capacity of Ontario's public health system"

Operation Health Protection, a 3-year Action Plan to revitalize the public health system by preventing threats to our health and promoting a healthy Ontario, was also reviewed. The Ministry in this document outlined a goal to have a technologically advanced infrastructure for public health to deliver necessary information to health care practitioners and the public rapidly. Naylor in his report also outlined that real-time alert systems for respiratory illness need to be created and coordinated. His report also stated that public health capacity needs to be strongly linked to academic health institutions with collaborative research activities. In response to these recommendations, over the last four years we created an expertise at Queen's University in real-time data capture and analysis.

The Queen's Public Health Informatics (QΦ) Team fosters collaboration, innovation, and action. We work alongside health practitioners to develop, evaluate, and implement public health informatics systems strategically and effectively. QΦ helps end-users (from local to international) collect, analyze, manage, and translate data into information to support disease surveillance, management, and response. QΦ efforts include developing new technology solutions, educating stakeholders, informing policy, and conducting research on the appropriate use of real-time public health information systems. Our multidisciplinary team has evaluated the use of Telehealth Ontario data for public health surveillance in Ontario. Our conclusions are very strongly in favor of a further real-time prospective evaluation of this anonymised data stream over five years for the protection of the public's health reporting back to government with a thorough process, outcome and technical evaluation. We believe that based on the evaluations contained in this document, real-time, province-wide surveillance for outbreak detection and situational awareness, can be created which could detect respiratory and gastrointestinal illness much sooner than traditional reporting and have significant representativeness of the population and vulnerable sub groups.

The Ontario Pandemic Plan has documented the need for Telehealth Ontario to report the number of influenza like illness calls as this could be an important system and data source to have in place for pandemic preparedness. But to our knowledge there has been no significant evaluation of this data stream nor real time analysis done. At present 33 of the 36 Health Units have no real-time acute care data collection capability. Enabling province-wide Telehealth Ontario surveillance would negate this inequity. The proposed system would have automated anomaly detection, temporal spatial analysis and GIS mapping to enable evidence based public health decision making and enhanced surveillance and response.

Our evaluation demonstrates that a rise in calls to Telehealth predates the rise in ED visits for respiratory infections and influenza like illness. There is a very good correlation between the reason for the Ontario Telehealth call and the diagnostic codes for respiratory illness in Emergency Departments. We have also demonstrated that you can map and monitor the spatial spread of respiratory infection across Ontario in real time using Telehealth Ontario data. This corresponds well to Influenza lab data and Emergency department visits. Hence you can have an early warning system prior to the surge of respiratory infections in any community in Ontario with minimal cost as the data is already collected for Ontario but not currently analysed. Our analysis on gastroenteritis calls also implies that we could have an Ontario wide surveillance system in place using this system.

The challenge as Dr. Naylor pointed out in his report is to be better prepared for the next epidemic and to renew Public Health. We the Queen's Public Health Informatics team believe in creating and evaluating new tools to enhance surveillance to protect and promote the health of our citizens. It is clear that Telehealth Ontario surveillance can be an important instrument in a new dashboard of real time tools for Public Health. As a result of our work we are immediately available to perform the second phase of this study which is a prospective epidemiological and technical evaluation.

The following is a brief summary of the chapters included in this report. These chapters were created by members of our team including experts in epidemiology, geographic information systems, Public Health surveillance, Emergency Medicine and Computer engineering. We thank the cooperation of John Hopkins University Applied Physic's Lab for allowing us access to their Electronic Surveillance System for the Early Notification of Community based Epidemics (ESSENCE) for which we did a technical and epidemiological evaluation.

Chapter highlights

Chapter 1

- Outlines a proposed study to evaluate the effectiveness of Ontario's telephone nursing helpline as a real-time syndromic surveillance system, and how its implementation, if successful, would have an impact on outbreak event detection in Ontario. Using data collected retrospectively, all 'reasons for call' and assigned algorithms will be linked to a syndrome category. Using different analytic methods, normal thresholds for the different syndromes will be ascertained. The next step will include the prospective monitoring of syndromic activity, both temporally and spatially.

- Project is important as it has the prospect of showing that province-wide surveillance is feasible, cost-effective and has the potential to positively impact public health practice.

Chapter 2

- This chapter gives a thorough description of Telehealth Ontario including an overview of who calls and when and why they are calling.

- Telehealth Ontario receives ~2700 calls daily with over 80% being categorized as a symptom call. The highest volume of calls is seen in winter months during the respiratory season and a majority of the calls are made on the weekend. Referral to a physician (42%), followed by self-care (31%), were the most common dispositions assigned to the Telehealth calls.

- The project's next steps will include quantitatively comparing Telehealth data with laboratory data and emergency department (A&E) visits, and, using the CDC Framework for evaluating public health surveillance systems for early detection of outbreaks, retrospectively determining whether the Telehealth system could be successful as an early-warning system.

Chapter 3

- Telehealth Ontario had 216 105 calls for respiratory complaints while 819 832 ICD-coded complaints from NACRS were identified with a comparable diagnosis of a respiratory illness. Telehealth Ontario call volume was heavily weighted for the 0-4 age group (49%), while the NACRS visits were mainly from those 18-64 years of age (44%). The Spearman rank correlation coefficient was calculated to be 0.97, with the time-series analysis also resulting in significant correlations at lags (semi-monthly) 0 and 1, indicating that increases in Telehealth Ontario call volume correlate with increases in NACRS discharge diagnosis data for respiratory illnesses.

- Telehealth Ontario call volume fluctuation reflects directly on ED respiratory visit data on a provincial basis. These call complaints are a timely, useful and representative data stream that shows promise for integration into a real-time syndromic surveillance system.

Chapter 4

- The period between July 2004 and March 2006 produced 30,417 EDSS visits and 4,247 calls to Telehealth Ontario related to local respiratory episodes. The NACRS had 19,315 respiratory disease diagnoses from the Kingston area. EDSS visits were significantly correlated with NACRS and Telehealth Ontario respiratory data (Spearman Correlation Coefficient = 0.98 and 0.91, respectively).

- Results of this study suggest that for a given time period, ED triage chief complaints accurately reflect the true conditions of patients as demonstrated by the strong correlation with NACRS discharge diagnoses. The strong correlations between ED triage chief complaints and NACRS discharge diagnoses and Telehealth Ontario calls, strongly suggest that the EDSS program in Kingston is able to accurately monitor the status of respiratory illnesses in the community.

Chapter 5

- The overall impact of the mapping exercise is positive. Not only do the respiratory data from NACRS and Telehealth Ontario closely follow the temporal sequence of confirmed influenza cases reported by CCDR for the province as a whole, but the temporal sequence of each data series are very similar at the PHU scale.

- Although an influenza epidemic can start in a variety of places in the province it moves to the large urban centres rapidly. The implication is that once the epidemic emerges in a specific locale in the province, all areas of the province should be alert for its potential arrival in their area within 1-2 weeks

- Both the NACRS and the Telehealth Ontario databases are valuable tools in the monitoring of the spread of influenza in the Province. Although both databases identify respiratory illness rather than influenza *per se*, the data track the temporal evolution of the CCDR confirmed cases so closely that there is much confidence in the ability to identify the upsurge in influenza cases in the community.

Chapter 6

- Telehealth Ontario recorded 184 904 calls and the NACRS registered 34 499 ED visits for GI illness. The Spearman rank correlation coefficient was calculated to be 0.90 ($p<0.0001$). Time-series analysis resulted in significant correlation at lag (weekly) 0 indicating that increases in Telehealth Ontario call volume correlate with increases in NACRS data for GI illness.

- Telehealth Ontario call volume fluctuation reflects directly on ED GI visit data on a provincial basis. Telehealth Ontario GI call complaints are a timely, novel and representative data stream that shows promise for integration into a real-time syndromic surveillance system detection of bioterrorism events.

Chapter 7

- Prompt detection of infectious disease events is a primary concern for Public Health. To address the issues of delayed outbreak recognition and intervention inherent in traditional health surveillance methods, efforts are currently underway in many jurisdictions in Canada and the United states to leverage timely non-traditional data sources. Although the Telehealth Ontario program was not originally designed for real-time surveillance, results of several analyses presented in this compendium support the integration of Telehealth Ontario data into a real-time province-wide surveillance system.

- Although additional analyses are needed to further investigate the surveillance capacity of Telehealth data, analyses conducted to date strongly suggest that Telehealth data are good proxies for both acute respiratory and gastrointestinal conditions. Results also suggest that Telehealth respiratory activity may be a good early warning for Influenza activity. Technical investigations to date suggest that little effort would be required to integrate Telehealth data into a real-time province-wide surveillance system.

Appendix A

- Preliminary report of a cost-benefit analysis looking at an influenza outbreak which relies on detection coming from suspected cases telephoning the Telehealth Ontario Helpline.
- It was concluded that quarantine effectiveness and intervention delays are critical to controlling an epidemic and that the isolation of cases is key to help protect the health of the public.

CHAPTER 1: Using Ontario's "Telehealth" health telephone helpline as an early-warning system: Introduction and study protocol

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Introduction

According to the Oxford Handbook of Public Health Practice[1], two of the principal objectives of an effective surveillance system are to “give *early warning* changes of incidence,” and “detect *outbreaks* early.” Unfortunately, the reality of public health practice is that monitoring agencies such as public health units routinely fall short of these objectives, whether it is due to lags/cuts in the passive surveillance communication between physicians and public health agencies[2-4], or because of delays in laboratory confirmation[5, 6]. This is even more of an issue in large and remote areas such as Northern Ontario.

A new era of surveillance research is attempting to address these issues while taking advantage of available data. Electronic data captured at the point of care provides an efficient means for the conversion of clinical data to surveillance information. This has resulted in a new area of research called syndromic surveillance. Syndromic surveillance is a newly emerging field in the science of epidemiological surveillance. Its growth has been encouraged in large part in the United States as a response to potential bioterrorism threats. In effect, it is a complementary surveillance system, in that it can provide prediagnostic data to rapidly detect infectious disease outbreaks before they are detected through conventional surveillance methods.

The Walker Report[7] highlighted Canadian post-SARS interest in syndromic surveillance as a method of increasing Ontario’s capacity to manage communicable diseases adequately. An important feature of syndromic surveillance systems is that they rely on existing data streams. In other words, it does not require the development of new datasets (and the challenges surrounding this), but rather makes use of available data streams and increases communications within the public health system. Data streams that are being investigated as part of the larger syndromic surveillance picture include:

- OTC drug sales[8-12],
- emergency department visits (coded either by ICD code or by chief complaint)[13-14],
- emergency (911) calls[15],
- ambulance dispatch[10],
- patient transfers[16],
- school/work absenteeism records[10],
- telephone medical helpline calls (e.g. *NHS Direct*, Ontario *Telehealth*) [10, 17-22],
- insurance/HMO claim data[23].

The science of syndromic surveillance is still very much in its infancy. While a number of syndromic surveillance systems are being evaluated in the US, very few have had success thus far in predicting an infectious disease event. However, syndromic surveillance can and has been able to assist in "determin[ing] the size, spread and tempo of an outbreak after it has been detected," [24]. It can also theoretically be useful in times of calm, "providing reassurance that a large-scale outbreak is not occurring," [23].

Currently, most systems are primarily based in an emergency department/room setting, where they rely on either chief complaint information recorded at onset of contact with a syndromic surveillance source (e.g. triage nurse), or ICD9/10 codes, following diagnosis by the physician. Although studies have shown that using ICD codes results in better sensitivity, positive predictive value and specificity[25, 26], there is often a lag between the contact with the case, and the coding of his/her information into an ICD case. In some settings, this can take up to a week[23, 27]. Consequently, the majority of emergency department syndromic surveillance systems rely primarily on chief complaint for the classification of visits into syndromes (symptom categories).

To date, the majority of syndromic surveillance systems have been based primarily in emergency department settings, with varying levels of enhancement from other data sources, such as the ones listed earlier. While research has been done on the value of telephone helplines on health care use and patient satisfaction[28], very few projects have looked at using a telephone helpline as a source of data for syndromic surveillance, and none have been attempted in Canada. The notable exception to this statement has been in the UK where research using the national NHS Direct system as a syndromic surveillance tool has been conducted.

The NHS Direct national telephone helpline was established in the UK in 1998 to provide both health information as well as medical referral to callers. The country has 21 regional calling sites in England and Wales[29]. In order to address calls pertaining to medical referrals, a clinical decision support software package (NHS CAS) with over 200 clinical algorithms is used. Each of these 200+ algorithms has a set of questions attached to them; their purpose is to ascertain the caller's symptoms and provide them with the most appropriate advice and course of action[28].

Since 1999, researchers in the UK have been retrospectively and prospectively investigating the use of NHS Direct as a syndromic surveillance method for a number of syndromes[18, 19, 28, 30], including influenza[21, 30, 31] and gastrointestinal illness[22]. To date, their results have been optimistic about the long-term use of NHS Direct as an "early warning system," but acknowledge that work continues to be required to fine-tune the system.

Due to its central database structure, Ontario's Telehealth system should theoretically be better suited as a source for a syndromic surveillance system than its UK counterpart. While the UK system relies on regional calling centers with local databases to deal with call volumes from their proprietary calling region, the Ontario Telehealth System has four call centres that manage the call loads for the province as a whole, but decision rules are identical for all four centers, and all data are stored within one central database. This ensures that triage algorithms are the same for all regions, which is not the case in the UK.

The Ontario Teleheath System (henceforth referred to as "Telehealth") is a toll-free telephone helpline provided by the Ontario Ministry of Health and Long-term Care, and is available to all residents of Ontario. The Telehealth program was initiated as a pilot in 2001 in the Greater Toronto (416 and 905 calling areas) and Northern areas (705 calling area). The program became province-wide at the end of 2001. The Telehealth services are provided by a private contractor (currently "Clinidata") hired by the Ministry of Health and Long-Term Care. Telehealth operates 24 hours a day, 7 days a week and all calls are answered by Registered nurses who have at least three years of recent clinical experience[32]. Calls are answered in both official languages, but translators are available via three-way call within 60 seconds for 110 languages[32]. The most commonly requested languages other than English and French are Mandarin, Cantonese, Farsi, Italian and Portuguese[32, 33]. An average of 3,100 calls are recorded daily[33], with the highest call volumes occurring during the evenings and holidays. Seasonally, the busiest months are the winter months (January-March), which coincide with cold and influenza seasons[34]. The average call length is approximately 10 minutes[32], and calls are classified in one of five categories[35]:

1) priority (call 911 immediately);
2) emergent (see physician within hours – routinely directed to a hospital emergency department);
3) urgent (contact family physician within 24 hours);
4) referral 72 (contact family physician with 72 hours);

5) self-care.

According to information on the Ontario Ministry of Health and Long-Term Care website, the volume of calls attributed to these different categories is as follows:

> "about 43 per cent of callers received self-care advice; 35 per cent if callers were advised to visit their physician; 14 per cent were referred to a hospital emergency department; two per cent were considered urgent calls and were connected to 911," [33].

To date, 40% of callers have been parents, primarily mothers, calling about symptoms being displayed by their children. Overall, the top five reported symptoms have been: nausea/vomiting, abdominal pain, fever in children aged 3 months-3 years, cough/cold, and rash[32].

Currently, Ontario has a broad syndromic surveillance agenda, which includes pilot studies of over-the-counter drug sale monitoring[10], and emergency department visits[17]. Telehealth is expected to be a part of this overarching surveillance strategy, supplementing current syndromic surveillance systems, as well as potentially identifying call volume and type aberrations before they also occur in hospital emergency departments.

Research Methods/Design

Using data collected by Clinidata as part of the Ontario Telehealth program since December 2001, we will attempt to determine Telehealth's effectiveness as a real-time surveillance system. As no research has been done in this area in Canada, and international research to date is very limited, the development of this translational tool is innovative and will add significantly to the limited state of knowledge on syndromic surveillance.

This project will have both a retrospective and a prospective component. In the first stage, our research will be retrospective in nature. Using data collected retrospectively by Clinidata, we will link all "reasons for call" ("chief complaint") and assigned algorithms to one of the following syndromes: gastrointestinal, constitutional, respiratory, rash, hemorrhagic, botulinic, neurological, and other (Table 1). These syndromes are identical to those currently used by the Ontario Syndromic Surveillance Pilot Project (also known as QUESST). This will be done in conjunction with QUESST, using their recent expertise in the mapping of health algorithms and chief complaint to these syndromes.

Following this step, analyses will be carried out to determine normal thresholds for the different syndromes. There are many different methods documented in the literature, including, but not limited to, cumulative sums[36, 37], control charts[38], recursive least squares[39, 40], and upper confidence limits, the latter which are the preferred method for NHS Direct research[18]. Using knowledge of past outbreak activity such as SARS and Norwalk-type outbreaks, the validity and reliability of the data, as well as the sensitivity, specificity and positive predictive values of these different methods will be evaluated in order to ascertain which statistical method best applies to these data.

Once thresholds have been established and evaluated, the prospective monitoring of syndromic activity will take place. This will be done both temporally and spatially. The decision to pursue both types of analyses is due to Ontario's large geographic size, combined with the uneven distribution of population. Temporal trends, usually measured through one-dimensional scan statistics[36, 41, 42] are of interest to monitor general patterns of symptoms. This is of particular interest for unusual events where a few cases would result in a likely alert (e.g. anthrax). Spatial clustering analysis, using spatial scan statistics, have been adapted for infectious disease surveillance[36, 43, 44]. This statistical method will be used to ascertain unusual activity in specific geographic areas. For example, this will allow for the monitoring of underserviced areas such as northern Ontario where infectious disease surveillance is limited and where, coincidentally, use of Telehealth is proportionally high. This statistical method relies on a geographic region's expected counts rather than on its population distribution.

It is critical that new and emerging surveillance systems implement process evaluation targets within its logic model to monitor its effectiveness and progress. In order to meet this need, we plan on implementing the Centers for Disease Control and Prevention (CDC) "Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks," [45]. As part of the routine evaluation of this surveillance system, it is our intention to compare syndromic surveillance activity monitored by the Telehealth Project (both retrospectively and prospectively) with emergency department syndromic surveillance activity. At present, the Ontario Emergency Department Syndromic Surveillance System only monitors hospitals located in Kingston, Ontario. Consequently, this portion of our evaluation is only planned for Telehealth calls made in the Kingston, Frontenac, Lennox and Addington catchment area. As other hospitals are added to the ED Syndromic Surveillance Project, they will be included in the comparative evaluation of

Ontario Telehealth and Emergency Department Syndromic Surveillance (EDSS). The last step of the evaluation of Telehealth as an early warning system will be an economic analysis that will attempt to ascertain whether Telehealth provides medical and non-medical cost savings, both in terms of monitoring, and public health surge capacity planning.

Discussion

The use of Telehealth as an early-warning syndromic surveillance system will promote communication between the acute care sector and the public health sector, by relying on the acute care system as a front-line source of information for the more effective planning and management of public health resources. This system has the potential of identifying outbreaks (such as pandemic influenza and gastrointestinal illness) and other adverse health events (such as bioterrorist attacks) before the acute care and public health sectors would be made aware of them through established avenues. Furthermore, this would improve the commonly accepted lag between identification of an event and reporting of the event to the proper authorities. This system, because of its automated and real-time nature would immediately identify aberrations in call types and would alert the proper authorities (including acute care facilities and public health) immediately.

Secondly, with its province-wide focus, it will potentially remedy some of the systemic failures identified by Justice Archie Campbell in his assessment of the Ontario SARS outbreak[46]. Particularly, this province-wide system would address issues surrounding a lack of public health surge capacity. As an early warning system, Telehealth has the potential to identify aberrations long before traditional reporting systems. In the case of the Walkerton, Ontario outbreak[47], if Telehealth had been up and operational as an early warning system, we can speculate that the number of calls for gastrointestinal complaints would have gone up, which would have created an alert for public health to investigate these calls before an increase in cases would have been identified through routine reporting systems (especially RDIS). By acting early, the levels of morbidity and mortality witnessed in Walkerton could have been curtailed by a more timely involvement of Public Health. This would have meant that control measures (such as “boil water” orders) could have implemented more quickly, which would have decreased the number of cases and would have allowed public health to work more effectively and within its available resources.

This system would also improve communication and coordination between the different levels of government (especially regional and provincial) by centralizing and streamlining the information flow, and potentially identifying important health events before they are identified by routine surveillance activities This would also allow for the implementation of emergency plans (e.g. antiviral distribution in the event of pandemic influenza) before the needs placed on public health and the acute care centers exceeds available resources, thereby enhancing the effectiveness of medical practice. This has both cost- and life-saving implications, as the Ontario SARS experience has shown us.

This surveillance system is also unique and innovative in that it does not rely on reporting of cases by physicians. In other words, it allows for the surveillance of underserviced areas such as northern Ontario, as the system relies on individuals calling a toll-free number rather than trying to get access to a physician who then has a reporting responsibility. In effect, for the purpose of surveillance, it cuts out the need for a physician as a “reporting” intermediary. This will potentially allow for a more complete picture of underserviced areas, as well as a much timelier one as it is available 24 hours a day, seven days a week, 365 days a year. The continuous availability of this service provides a front line that each and every Ontarian can access prior to or instead of seeking help from a family physician or an emergency department. When a call is placed to Telehealth, all callers are given advice based on the type and severity of symptoms they are reporting. Advice can range from staying at home to going to an emergency department immediately. Because of its province-wide coverage, it means that data on areas with limited access to emergency departments and family physicians will be collected, thereby providing new information on an underserviced subset of the population.

Furthermore, areas such as aboriginal communities have health clinics, often staffed with nurse practitioners. However, these clinics are not integrated with routine surveillance systems. Use of Telehealth for surveillance would also allow for isolated communities with few health resources to be included into a more formal surveillance system.

Finally, this project is important and of value because it has the potential to show the different levels of government that province-wide surveillance that relies on the integration of available data sources into the surveillance information flow is feasible, cost-effective, and has the potential to positively impact morbidity and mortality through better planning and the subsequent enhanced effectiveness of public health practice.

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Table 1-1. Syndrome Categories

Syndrome	Definition
Gastrointestinal	pain or cramps anywhere in the abdomen nausea, vomiting, diarrhea, and abdominal distension and swelling.
Constitutional	non-localized, systemic problems including fever, chills, body aches, flu symptoms (viral syndrome), weakness, fatigue, anorexia, malaise, lethargy, sweating (diaphoresis), light headedness, faintness and fussiness.
Respiratory	problems of the nose (coryza) and throat (pharyngitis), as well as the lungs. Examples of respiratory include congestion, sore throat, tonsillitis, sinusitis, cold symptoms, bronchitis, cough, shortness of breath, asthma, chronic obstructive pulmonary disease (COPD), and pneumonia. The presence of both cold and flu symptoms is counted in this category, not Constitutional.
Rash	any rash, such as macular, papular, vesicular, petechial, purpuric, or hives. Ulcerations are not counted as Rash unless consistent with cutaneous anthrax (an ulcer with a black eschar).
Hemorrhagic	bleeding from any site, e.g., vomiting blood (hematemesis), nose bleed (epistaxis), hematuria, gastrointestinal bleeding (site unspecified), rectal bleeding, and vaginal bleeding. Bleeding from a site for which there is a syndrome is counted as Hemorrhagic and as the relevant syndrome (e.g. hematochesia is Gastrointestinal and Hemorrhagic; hemoptysis is Respiratory and Hemorrhagic).
Botulinic	ocular abnormalities (diplopia, blurred vision, photophobia), difficulty speaking (dysphonia, dysarthria, slurred speech), and difficulty swallowing (dysphagia).
Neurological	non-psychiatric complaints that relate to brain function. Included are headache, head pain, migraine, facial pain or numbness, seizure, tremor, convulsion, loss of consciousness, syncope, fainting, ataxia, confusion, disorientation, altered mental status, vertigo, concussion, meningitis, stiff neck, tingling and numbness. (Dizziness is both Constitutional and Neurological).
Other	anything which does not fall into any of the above categories, particularly injuries.

CHAPTER 2: Ontario's Telehealth system: A novel syndromic surveillance system

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Background

The US Centers for Disease Control and Prevention define syndromic surveillance as "an investigational approach where health department staff, assisted by automated data acquisition and generation of statistical alerts, monitor disease indicators in real-time or near real-time to detect outbreaks of disease earlier than would otherwise be possible with traditional public health methods."[1]

Syndromic surveillance initially came into prominence as a bioterrorist surveillance methodology primarily following the events of September 11th, where a rapidly evolving emergency situation required regular and timely access to epidemiologic information to foresee and plan for the allocation and use of limited and stressed resources. It has subsequently evolved into a sub-discipline of epidemiologic surveillance beyond the exclusive scope of bioterrorism preparedness[2-4] to include, among others, pandemic preparedness[5,6], West Nile surveillance[7,8], and as a potential tool to enhance routine surveillance systems commonly used within the field of public health[9].

A significant benefit of syndromic surveillance systems is that they characteristically rely on the use of pre-existing datasets, thereby foregoing the challenges associated with the development and implementation of a data-collection infrastructure (including buy-in, funding, and adoption), as well as increasing communication within the public health system and between acute care and public health.

Canada, and many other countries, have access to data streams that are electronically captured in a timely manner that could theoretically be used for the purpose of syndromic surveillance. These include, but are not limited to emergency/A&E data[10,11], absenteeism data[12], emergency calls[13], ambulance dispatches[14], patient transfers[15], over the counter drug sales[16], billing data[17] and telephone medical helplines[18,19].

In Ontario, Canada, it is evident from the post-SARS literature that the Ontario public health system was, and arguably remains, burdened by many of the shortcomings consistently seen with routine public health surveillance systems. Part of the failure of the public health system during SARS was attributed to a lack of timely communication between implicated stakeholders[20]. The problems encompassed within the definition of "lack of timely communication" cannot be attributed exclusively to the lack of an infrastructure to share data in a timely fashion; however, this was one of the main problems confronting the individuals and institutions involved in the control of the SARS epidemic.

The Initial Report of the Ontario Expert Panel on SARS and Infectious Disease Control, published as a response to the SARS outbreak in Ontario, Canada, stated that the aforementioned failures in public health surge capacity could be potentially addressed by "hav[ing] a well-developed system for real-time data sharing and reporting, and for the rapid dissemination of surveillance information[21]." In particular, it mentioned the potential to "broaden the information collection capacity of Telehealth as a syndromic surveillance tool[22]."

Following the lead established by the UK's NHS Direct Syndromic Surveillance system, we are retrospectively evaluating the value of Ontario's Telehealth's health helpline as a syndromic surveillance system. To date, there have been no published descriptions of Telehealth. This article endeavours to address this lacuna by providing an overview of Telehealth, Ontario's nursing telephone helpline, including how data are collected, stored, and how the data may be evaluated to determine this data source's usefulness as a in an enhanced awareness surveillance system.

Description of Telehealth

The Ontario Telehealth Telephone Helpline (henceforth referred to as "Telehealth") was implemented in Ontario in 2001. It was initiated as a pilot study, which included the Greater Toronto area (416 and 905 calling areas), as well as the Northern area of Ontario (705 calling area). The Northern Pilot was subsequently evaluated, "suggest[ing] that teletriage may have decreased visits to emergency departments relative to patient intent[23]," one of the goals of Telehealth being to "lead to more appropriate use of emergency departments[24]."

The program was expanded province-wide at the end of 2001, and has been administered by Clinidata, a private contractor hired by the Ontario Ministry of Health and Long-Term Care. The helpline is available 24 hours a day, 7 days a week, including holidays, at no cost to the caller[25]. The calls are answered by registered nurses who are required to have multiple years of clinical experience prior to their involvement with Telehealth. Although calls are primarily answered in both official languages (English and French), the system has the capability of responding to calls in 110 different languages within 60 seconds (with the help of translators in a three-way calling setup)[26].

Calls are handled by four calling centres that use identical decision rules (algorithms) and store all call information into one centralized data repository (unlike the UK system that relies on local call centres with proprietary databases). The calls are usually approximately 10-minutes, patient based, and are directed by trained nurses who use an electronic clinical support system that can be used to provide either clinical guidelines (approved by a panel of clinicians), health information, care information, and a health care referral system.

This Telehealth evaluation project was approved by a REB, as well as meeting Ontario Personal Health Information Protection Act (PHIPA) and Ontario Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) requirements. The anonymised data were provided by the Ontario Ministry of Health and Long-Term Care as well as with Clinidata, the private company contracted out to administer Telehealth. The agreement resulted in a record of all calls spanning June 2004-June 2006 (25 months).

Who Calls Telehealth, When and Why?

Between June 2004 and June 2006, a total of over 2 million calls were made, averaging approximately 2700 calls daily, slightly lower than the numbers published elsewhere. Of calls where the caller's sex was recorded, 64.1% of calls were made by females, which can be explained in large part by the fact that mothers tend to be the primary caregiver for children and frequently call on their behalf. Calls were categorized into one of three categories: Health information (11.3% of all calls); Service referral (4.9% of all calls); Symptom (83.8% of all calls).

The volume of calls was not the same across all months. The highest call volume was recorded in January 2005 (97,896 calls), followed by March 2005 (95,097 calls). The highest call volume in the 2005-2006 year was in March 2006, with 92,527 calls. As a general rule, call volumes increased during influenza season (December-March), and were lower in the non-influenza months (Figure 1), which is similar to Telehealth call patterns reported elsewhere[27], as well as call patterns for other systems[28].

The largest proportion of calls was made during weekends – 15.2% of calls were made on Sundays, and 15.9% of calls were made on Saturdays, when doctors' offices are routinely closed. The smallest proportion of calls were made on Thursdays (13.7%) (Table 1). Of the calls where time of day was recorded (97.8% of all calls), nearly half of calls (47.5%) were made in the late afternoon and evening (16:00-23:59), when physicians' offices are closed, followed by the daytime (08:00-15:59) (37.8%). The remaining calls were made between 24:00 and 07:59.

The dataset provided to the project did not include information about whether the caller called for him/herself or for someone else. However, the age recorded in each record is the age of the person the call was made for. For example, if a mother called for her son, the age of the son, not the age of the mother, was recorded. The majority of calls were made for/by individuals aged 18-64 years of age (52.3%). Nearly 18 percent of calls were made for children aged 0-4 years, followed by calls for/by children aged 5-17 years (10. 5%). The smallest percentage of calls were made by/for individuals aged 65 years and above. Approximately 13 percent of calls did not have an age specified.

Syndromic Surveillance-Specific Data

For the purpose of the evaluation of Telehealth's usefulness as a syndromic surveillance system, the main interest is in symptom calls, which are triaged to a clinical guideline-driven nurse helpline. These calls represent a call volume of approximately 1.7 million calls, or approximately 84% of all calls made to Telehealth during the time period under study. These calls are of most interest to us as the other call types (health information and service referral) do not provide symptom information, the basic variable required for a syndromic surveillance system.

Description of Algorithms

When a symptom call is made, the call nurse follows through a decision tree, based on the algorithm that the nurses assesses as best describing the caller's initial complaint[29]. At the end of a symptom call, once the decision tree has been followed to its conclusion, a call is assigned one of 11 dispositions. These dispositions include:

- Information call (calls initially coded as symptom calls, but where no care is recommended).
- Community service
- 911 Ambulance/Dispatch
- ED (Guideline directed)
- ED (No alternative)
- Pharma
- Physician reference

- Poison control
- Self-care
- Other health care provider
- Other.

The frequency of disposition type is available in Table 2. The most commonly recorded disposition was “physician referral,” (41.9%). However, this category includes two types of physician referral – referral within 24 hours and referral within 72 hours if no improvement. The data as provided do not differentiate between the two. The next most commonly recorded disposition was “self care” (31.1%), whereby the caller/patient is to remain at home without seeking further medical condition, unless an important change in his/her condition occurs.

While there are 480 algorithms that a Telehealth nurse can chose from, there are some algorithms selected more frequently than others. Table 3 provides an overview of the ten most frequently assigned algorithms. Although the most common age group of callers was the 18-64 year age group, the top three most commonly assigned algorithms were pediatric after hours algorithms and, overall, 5 of the top 10 were pediatric. Therefore, although the majority of calls were not pediatric ones, the most commonly reported symptoms were pediatric vomiting, cough and fever – common childhood symptoms. This cannot be explained by a greater diversity of algorithms across adult age groups, relative to pediatric ones, as approximately 47% of all 440 algorithms were pediatric ones, with the remaining 53% being adult-specific or all age group algorithms.

For the purpose of using Telehealth as a syndromic surveillance tool, the different algorithms were categorized against prodrome categories by an emergency medicine physician with experience in this area. The prodromal categories include respiratory upper, respiratory lower, influenza-like illness, dermatological infectious – vesicular, dermatological infectious – not vesicular, neurological infectious, asthma, gastroenteristies. These categories were developed by the RODS-based Ontario Syndromic Surveillance Pilot Project and were used and validated within an emergency-department (A&E) setting, with a primary focus on outbreak detection of public health significance.

Next Steps

The project's next steps will include classifying all algorithms to one of the aforementioned prodromal categories, quantitatively comparing Telehealth data with laboratory data and emergency department (A&E) visits, and, using the CDC Framework for evaluating public health surveillance systems for early detection of outbreaks, retrospectively determining whether the Telehealth system could be successful as an early-warning system. More details on these steps are described elsewhere[30].

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Table 2-1. Day of Week Calls Made (All Call Types)

Day	*Health Information*	*Service Referral*	*Symptom*	*Total (%)*
Sunday	27,091	11,218	271,343	309,652 (15.2)
Monday	35,266	16,271	245,730	297,267 (14.6)
Tuesday	36,089	16,039	233,574	285,702 (14.0)
Wednesday	36,420	15,730	238,503	290,653 (14.2)
Thursday	35,074	15,101	229,657	279,832 (13.7)
Friday	33,995	14,102	234,451	282,548 (13.8)
Saturday	27,518	11,192	285,086	323,796 (15.9)
Total	**231,453**	**99,653**	**1,711,344**	**2,042,450**

Table 2-2. Disposition of Symptom Calls

Disposition	*Frequency (%)*
Information Call	31,423 (1.8)
Community Service	457 (0.0)
911 Ambulance/Dispatch	49,023 (2.9)
Emergency Department (Guideline directed)	323,336 (18.9)
Emergency Department (No alternative)	17,492 (1.0)
Pharma	991 (0.1)
Physician Reference	717,016 (41.9)
Poison Control	12,713 (0.7)
Self-care	532,729 (31.1)
Other Health Care Provider	19,750 (1.2)
Other	64,14 (0.4)
Total	**1,711,344 (100)**

Table 2-3. Most Frequently Assigned Algorithms

Symptom	***Frequency (%)***
1. Vomiting (Pediatric after hours)	74,423 (4.3)
2. Cough (Pediatric after hours)	47,050 (2.7)
3. Fever (Pediatric after hours)	45,937 (2.7)
4. Chest pain (Adult after hours)	42,691 (2.5)
5. Diarrhea (Pediatric after hours)	39,604 (2.3)
6. Colds (Pediatric after hours)	38,975 (2.3)
7. Headaches (Adult after hours)	33,775 (2.0)
8. Diarrhea (Adult after hours)	33,490 (2.0)
9. Abdominal pain – female (Adult after hours)	31,324 (1.8)
10. Vomiting (Adult after hours)	30,240 (1.8)
Total	**417,514 (24.4)**

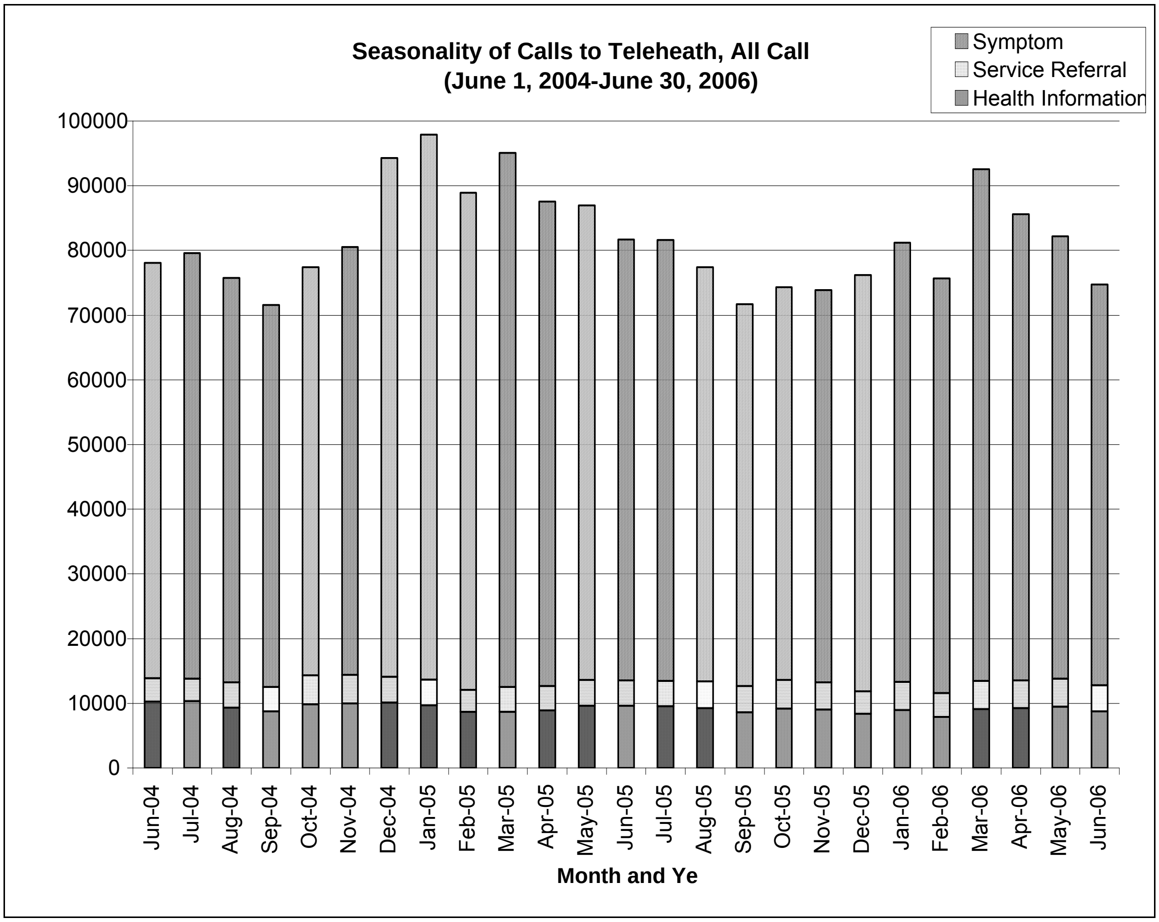

Figure 2-1. Seasonality of Telehealth Calls

CHAPTER 3: Can Telehealth Ontario respiratory call volume be used as a proxy for emergency department respiratory visit surveillance by public health?

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Introduction

The prompt detection of disease outbreaks is a major concern to public health as it has the potential to reduce morbidity and mortality[1]. Real-time syndromic surveillance uses existing non-traditional data for prompt analysis and feedback to those responsible for investigations and follow-up of potential outbreaks[2]. As this area of research progresses, decreasing false-alarm rates and time to detection is of great importance to increase sensitivity and specificity while keeping costs to a minimum. Improving the quality of existing signals and adding new signals are strategies that may improve the timeliness of detection[1]. Recent studies have suggested that integrating multiple data sources can significantly improve detection accuracy of syndromic surveillance systems, but more work is needed to explore the most effective means of said integration and what types of data streams give the greatest benefit[3,4]. Current data streams that have the potential for integration include: over-the-counter drug sales, emergency department (ED) visits, 911 calls, ambulatory dispatch, school/work absenteeism records, insurance/billing claims and telephone medical help lines[5]. In Ontario, Canada the earliest points of access to healthcare for the population are the Telehealth Ontario hotline, emergency departments, and primary care physicians[6]. These access points can be complementary or be dependant on their accessibility to the population.

Primary care in Ontario is at an early stage of adoption of the electronic health record (EHR) and hence is not amendable to syndromic surveillance systems at present due to the multitude of EHR vendors[7]. Telehealth Ontario services are contracted to a private company (Clinidata). Clinidata's highly skilled nurses use an electronic clinical support system that provides approved clinical guidelines, health information, care advice, and a service referral database to assess symptoms over the telephone and assist callers in making the most appropriate healthcare decision. Classification of each call, is based on 486 guidelines, which have been grouped into syndromes by the authors. All Ontario hospitals are required to provide information on patient visits to the National Ambulatory Care Reporting System (NACRS). These data are submitted on a regular basis and currently use the Canadian Enhancement to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10-CA) coding system for diagnoses[8]. The NACRS data is collected by the Canadian Institute for Health Information (CIHI) and includes "information to assist with the evaluation of the management of ambulatory care services in Canadian health care facilities"[8]. The concern with the NACRS is one of timeliness, as data are not available in real-time, but are rather months delayed. Therefore, a provincial syndromic surveillance system incorporating all ED's, albeit ideal, is not an option at present. This issue is also compounded by the fact that some hospitals have yet to complete a migration to electronic records management, making the integration of all EDs additionally difficult. Due to limitations inherent to the delayed transmission of data collected by NACRS, it is essential to evaluate the potential benefit of using real-time Telehealth Ontario data for public health and emergency medicine purposes.

To our knowledge, no studies have evaluated the use of Telehealth Ontario data as a surveillance tool. However, other countries have both prospectively and retrospectively evaluated the use of their teletriage systems as early warning systems. Most notably, the UK have been forerunners in the field of teletriage syndromic surveillance, having used the National Health Service (NHS) Direct system for this purpose since 1999[9-17]. In the absence of available evidence on Telehealth Ontario's usefulness as a syndromic surveillance system, key decision makers may entertain doubts about telephone health hotline effectiveness which hinders further investments and integration of such data into the health mainstream[18]. It should be noted that Telehealth Ontario is a component of the Ontario Ministry of Health and Long-term Care's (MOHLTC) influenza pandemic plan to aid in surveillance during the pandemic period of influenza outbreaks with its main role to triage callers and provide health information[19]. This further indicates the importance of assessing the value of Telehealth Ontario data. Many studies have used data on ED chief-complaints, ICD-coded respiratory illnesses, and/or laboratory-confirmed influenza and respiratory viruses to retrospectively show the validity of syndromic surveillance systems[20-23], as well as showing the impact of such illnesses on the health-care system[24-29].

The objective of this study was to examine the temporal relationship between Ontario's ED visits and Telehealth calls for respiratory illnesses. It is hypothesized that calls to the Telehealth Ontario hotline will be a proxy measure for respiratory visit data from ED's in Ontario, which could warrant the inclusion of Telehealth Ontario data into a real-time syndromic surveillance system.

Methods

Study design

We conducted a retrospective study on respiratory illness data for a 22-month period between June 1st, 2004, and March 31st, 2006. Anonymized data were obtained from two sources: The MOHLTC's Telehealth Ontario program and CIHI's National Ambulatory Care Reporting

System. Our data set was limited to this time frame as NACRS data was only available up to March 2006, and because we did not want to include any data during the SARS outbreak which may have introduced variability in our respiratory data.

Setting

Telehealth Ontario is a toll-free helpline provided by the MOHLTC and is available to all residents of the province. Users are encouraged to call with any general health questions with confidential advice being given regarding any health concerns. The system is available 24 hours a day, 7 days a week and 365 days a year with advice coming from trained and experienced registered nurses. Telehealth is available in English and French, with translational support available in 110 languages[30]. Outside of English and French; Mandarin, Cantonese, Farsi, Italian and Portuguese are the most requested languages[30]. Each nurse-led call lasts an average of 10 minutes with nurses directing patients to the most appropriate form of care. This is achieved using decision based software which are evidence-based, expert driven, and use dichotomous questioning[31]. NACRS was developed in 1997 by the CIHI to capture clinical, administrative and demographic information from all hospital-based and community-based ambulatory care[32]. Ontario is the only province in Canada that is mandated by the provincial MOHLTC to submit all abstracts on patient visits in a fiscal year. As of July 31st, 2006 the number of institutions submitting to NACRS in Ontario was 186[8].

Study population

This research is centered on the entire province of Ontario as its population base with all citizens being included in the catchment area. The study was part of a broader investigative project which was approved by the Queen's University Research Ethics Board.

Data collection and outcome measure

Telehealth services are provided by a private contractor that was hired by the MOHLTC which has collected data since December 2001. Each call is classified with one of 486 guidelines which have been reviewed and approved by a team of university-affiliated medical experts[31]. Upon studying various syndromic surveillance systems including: Real-time Outbreak and Disease Surveillance (RODS), the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) and (NHS) Direct and their respective syndrome classifications, all of the Telehealth guidelines were categorized into one of 32 syndrome names (e.g. respiratory upper, respiratory lower, asthma, trauma, gastroenteritis, and neurological-noninfectious amongst others). These 32 syndromes were created by the authors based on the formative work of the aforementioned systems, and for the purposes of this study only calls coded as an upper or lower respiratory syndrome were analyzed (Table 1).

As for the data from NACRS, once a patient's visit ends, the coding and abstracting is done at the institution. CIHI conducts edit checks on all data submitted to identify duplicate records, missing data or inconsistencies in data transmission. If errors are found, the submitting facility is asked to correct these abstracts[32]. This database has very little missing information and the reliability of the coding of data collected by CIHI ranges from 74-96%, with influenza and pneumonia reliably coded at 81%[27]. Since the fiscal year of 2002-2003, NACRS collects diagnosis and intervention related information based solely on the ICD-10-CA coding system[8]. Each ICD code was assigned by an experienced health coder from the respective health care facilities, which were then reviewed by the authors, and only those that dealt with a communicable respiratory illness were included in our data set (Table 2).

Statistical analyses

The Telehealth Ontario and NACRS data sources were compared by fitting time-series models and estimating a cross-correlogram at different lags (semi-monthly). Both data sets were transformed and detrended by differencing. Autoregressive moving average models were fitted to the differenced series to ensure the residuals were white noise. The autocorrelation and partial autocorrelation functions of the models were examined to determine autoregressive and moving average parts of the models. Residuals were checked for normality against the fitted values, and checked for white noise by the Portmanteau test. Spearman rank tests were performed and then cross-correlations were estimated for residuals (to account for seasonality and trends) at different lags with the limit of statistically significant correlation being $2/\sqrt{(N-1)}$. This method of analysis has been previously demonstrated in National Health Service Direct research[33]. All statistical procedures were generated with SAS software, version 9.1 (SAS Institute, Cary, NC, USA).

Results

Of the 1.8 million calls to the Telehealth Ontario hotline during this study time period, 216,105 (~12%) calls were for an upper/lower respiratory complaint. In contrast, 819,832 (~5%) ICD-10-CA coded complaints of the approximately 17.5 million abstracts submitted to NACRS corresponded to infectious respiratory illnesses (Table 2). Age breakdowns from each data set are shown in Table 3 with Telehealth Ontario having more calls regarding 0-4 year-olds (49%) while ED visits are comprised of mainly 18-64 year olds (44%).

There were two corresponding peaks for respiratory calls/respiratory visits in the two data sets, both of which occurred during week 7 of 2004 and 2005. The 2004 winter peak was prolonged and produced higher proportions of calls to Telehealth Ontario and more visits to ED's for respiratory illness compared to the 2005 season (Figure 1).

The Spearman rank correlation coefficient was calculated to be 0.97. This coefficient is a non-parametric statistic that measures the strength of association between two variables. Values can range between -1 and +1 with +1 representing a strong, positively correlated result. The Portmanteau test for cross correlations of residuals found that 3 sets of residuals were white noise (p=0.023). White noise is a discrete time stochastic process whose terms are independent and identically distributed. This is important in time-series analysis were trends can affect statistical comparisons. Two statistically significant correlations were found between the Telehealth Ontario and NACRS data series. One was highly significant at lag (semi-monthly) 0 indicating increases in both series can occur simultaneously, while another was weakly correlated at lag 1 indicating increases in Telehealth Ontario calls can precede increases in ED visits by as much as 15 days.

Discussion

This study is the first to examine data from Ontario's Telehealth program in an effort to provide evidence of Telehealth's possible effectiveness as a surveillance tool. Our results suggest that the integration of Telehealth Ontario data into a real-time syndromic surveillance system may be a complimentary tool for the detection of respiratory illnesses on a provincial basis. This is in line with other studies which have proposed that multiple, non-traditional data sources may be of significant use to augment current syndromic surveillance systems[4,20,34,35].

Our comparison of Telehealth Ontario to the NACRS data on respiratory illnesses show that both curves are highly correlated. The time-series cross-correlogram showed that the Telehealth Ontario data can document increases in respiratory calls simultaneously with NACRS and indicated that if threshold levels are set for the start of outbreaks, may provide warnings up to 15 days in advance of ED visits. This gives a positive indication that Telehealth

Ontario can be used as a proxy measure for discharge diagnoses from ED's for respiratory illness.

The more intense and prolonged 2004-2005 winter peak was likely due to the fact that 2004-2005 was predominantly an Influenza A year (81%[36] of all cases in Canada were Influenza A, compared to 61.1%[37] in 2005-2006), with a larger number of cases relative to other years (10,006 confirmed cases in 2004-2005 versus 6,590 confirmed cases in 2005-2006). In the 2004-2005 influenza season, the Public Health Agency of Canada (PHAC) reported a peak during week nine of 2005 for Ontario, 2 weeks after the Telehealth Ontario and NACRS; in 2005-2006, the PHAC reported a peak for Ontario was during week 8 of 2006, 1 week later than the Telehealth Ontario and NACRS data[36,37]. These lag periods reiterate Telehealth Ontario's potential as a viable early warning system for respiratory illness. Evaluation of aberration detection methods on both curves is the next step to ascertain if sufficient specificity values are being obtained from the warnings to show that action by surveillance teams and doctors is warranted.

The strength of the NACRS data is that it is based on physicians' diagnoses and then converted to ICD-codes. Studies on the accuracy of ICD-9 codes for respiratory illness have shown excellent specificity and moderate sensitivity supporting their use in public health surveillance[38]. While our study used the newer classifications (ICD-10-CA), we revised our inclusion of specific codes as a result of recent work that found the most sensitive ICD-9 codes for influenza-like illness surveillance[39]. Furthermore, evidence suggests that this is a valid assumption as syndromic surveillance systems are stable (i.e. resilient enough to change, such as a shift from coding in ICD-9 to ICD-10)[40]. While the NACRS is a concise, clinical based data set, its flaw is its timeliness. The MOHLTC mandates all Ontario hospitals to submit data, but its only requirement is that abstracts be submitted before the fiscal year-end deadline. This reporting lag makes using these data for a real-time surveillance system unfeasible, whereas the Telehealth Ontaro data are inputted in real-time as an electronic form which theoretically could be integrated into an existing provincial surveillance system.

Telehealth Ontario receives a large volume of calls for 0-4 year olds and a marked deficiency in those over the age of 65 compared to ED visits. This inadequate representation of the elderly population may be explained by their hesitation to use or lack of awareness of the Telehealth Ontario program, or their preference to see a family physician or visit the ED. The over-representation of calls associated with 0-4 year olds may in fact be essential to monitor, as children are the primary propagators of respiratory-type illnesses such as influenza, as well as having longer durations of viral shedding and generally higher titres of recovered viruses[41-43]. By early identification of respiratory illness in children, we may be able to identify circulating viruses and implement appropriate public health measures (such as public messaging, calls for vaccination and school closures) to further mitigate the spread of disease to other children, adults and the elderly. Further, if Telehealth Ontario is able to identify those patients who do not require emergency medical treatment and instead divert them to self-care or their family physician, this may help decrease the burden on ED's. However, if this is to be an effective method, further work will have to be done to ensure that patients follow the action suggested by the Telehealth Ontario nurse. Another positive aspect of the Telehealth Ontario program is its accessibility to those living in remote, geographic areas where hospitals or primary care may be difficult to access.

Limitations

Administrative data has its inherent weaknesses as there is always the possibility for coding and entry errors as well as misdiagnoses. Although experienced physicians, nurses and health coders provide this data, human error can be a factor. The retrospective aspect can also be of consequence as there is no possibility to follow-up on missing or incomplete data. Although NACRS has very good filters for this, Telehealth Ontario does not. The age and sex categories of the Telehealth Ontario data set showed minimal missing values (data not shown). These missing values, along with possible minor misclassifications are not be expected to influence results due to the large amount of data in both series. Selection bias may also have been introduced by people that do not seek any form of medical attention. This issue is also thought to be of small consequence to our study due to the toll-free nature of Telehealth Ontario and the free access to healthcare for all Canadians. Another limitation is we only had 22-months of data to look at and therefore conclusions based on this can only reflect the seasonality and circulation of respiratory viruses for this time period.

Conclusions

The analysis of routinely collected Telehealth Ontario data provides evidence that it can be a proxy measure for ED visit data for respiratory illnesses on a provincial basis. This is potentially the only source of province-wide real-time surveillance data in Ontario. The only other method currently used is influenza-like illness surveillance which is reported by sentinel physicians (1 sentinel physician per 165,000 people)[19]. The integration of Telehealth Ontario data into existing real-time syndromic surveillance systems may improve the ability of such systems to detect outbreaks of respiratory illness and assess the impact on emergency departments quicker than current methods. This would allow public health and emergency management officials a novel means of timely surveillance which could enable prompt preparation and action towards influenza-like illness outbreaks. Further research is needed on Telehealth Ontario and other non-traditional data sources in an on-going effort to improve disease detection and to provide evidence for their effectiveness as tools for surveillance, especially during pandemic influenza periods.

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Table 3-1. Syndrome grouping of upper and lower respiratory illnesses with corresponding Telehealth Ontario guidelines

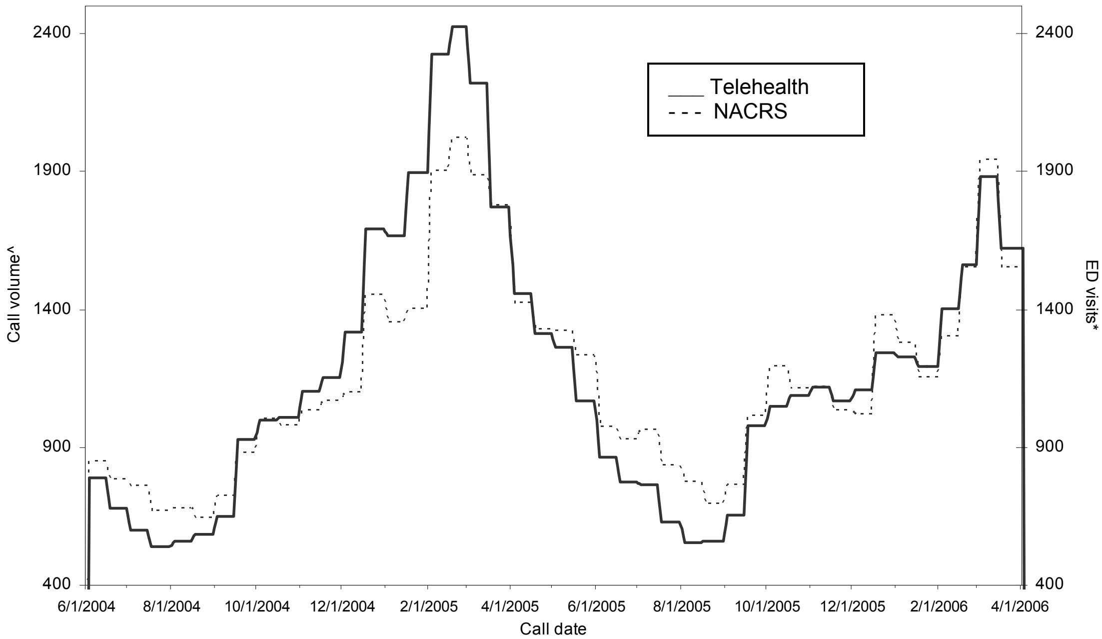
SYNDROME	***TELEHEALTH ONTARIO GUIDELINE***
Upper Respiratory	Colds (Adult After Hours)
	Colds (Pediatric After Hours)
	Congestion - Guideline Selection (Pediatric After Hours)
	Croup (Pediatric After Hours)
	Ear - Congestion (Adult After Hours)
	Ear - Congestion (Pediatric After Hours)
	Ear - Discharge (Adult After Hours)
	Ear - Discharge (Pediatric After Hours)
	Earache (Adult After Hours)
	Earache (Pediatric After Hours)
	Hoarseness (Adult After Hours)
	Hoarseness (Pediatric After Hours)
	Respiratory Multiple Symptoms - Guideline Selection (Adult After Hours)
	Respiratory Multiple Symptoms - Guideline Selection (Pediatric After Hours)
	Sinus Pain and Congestion (Adult After Hours)
	Sinus Pain Or Congestion (Pediatric After Hours)
	Sore Throat (Adult After Hours)
	Sore Throat (Pediatric After Hours)
Lower Respiratory	Cough - Acute Non-productive (Adult After Hours)
	Cough - Acute Productive (Adult After Hours)
	Cough - Chronic (Adult After Hours)
	Cough (Pediatric After Hours)
	Coughing Up Blood (Adult After Hours)
	Wheezing – Other Than Asthma (Pediatric After Hours)

Table 3-2. Communicable respiratory syndromes coded by hospital health coder post-discharge from ICD-10-CA classifications

ICD-10-CA CODE	*CODE DESCRIPTION*
J00	Acute nasopharyngitis (common cold)
J01	Acute sinusitis
J02	Acute pharyngitis
J03	Acute tonsillitis
J04	Acute laryngitis and tracheitis
J05	Acute obstructive laryngitis (croup) and epiglottitis
J06	Acute upper respiratory infections of multiple and unspecified sites
J10	Influenza, due to identified influenza virus
J11	Influenza, virus not identified
J12	Viral pneumonia, not elsewhere classified
J16	Pneumonia due to other infectious organisms, not elsewhere classified
J17	Pneumonia in diseases classified elsewhere
J18	Pneumonia, organism unspecified
J20	Acute bronchitis
J21	Acute bronchiolitis
J22	Unspecified acute lower respiratory infection
J40	Bronchitis, not specified as acute or chronic
J41	Simple and mucopurulent chronic bronchitis
J42	Unspecified chronic bronchitis

Table 3-3. Age distribution of the National Ambulatory Care Reporting System's emergency department visits and Telehealth Ontario calls for respiratory illnesses in Ontario, Canada from June 2004 to March 2006

Age group (years)	*NACRS (n=819,832)*		*Telehealth (n=216,105)*	
	n	*%*	*n*	*%*
0-4	198,585	24.2	104,805	48.5
5-17	165,707	20.2	29,760	13.8
18-64	362,825	44.3	75,095	34.7
65+	92,715	11.3	6,445	3.0



^Call volume refers to Telehealth Ontario hotline (data series 4x original counts)

*ED visits refers to NACRS

Figure 3-1. Telehealth Ontario and the National Ambulatory Care Reporting System (NACRS) time series for respiratory illnesses, semi-monthly – Ontario, Canada, June 2004 – March 2006

CHAPTER 4. The Utility of Emergency Department Triage Chief Complaints for Real-Time Respiratory Illness Monitoring and Outbreak Detection in Ontario

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Introduction

Minimizing the impacts of health events is a primary goal of public health. Critical to this effort is detecting health events as early as possible so that control and mitigation interventions can be initiated before impacts are widespread. Syndromic surveillance has the potential to detect infectious disease outbreaks before they are identified through conventional diagnostic/laboratory-based surveillance methods by making use of alternative more timely data sources [1]. Many of these alternative data, such as over-the-counter drug sales, absenteeism records, telephone health hotlines, and emergency department triage data, are already routinely collected. The goal of syndromic surveillance is to compile, analyze, and monitored such data in real-time (or near real-time). This paper describes an investigation to assess the utility of a triage chief complaints (CC) based Emergency Department Surveillance System (EDSS) in Kingston, Ontario as a monitoring tool for respiratory illness by comparing it retrospectively to National Ambulatory Care Reporting System (NACRS) and Telehealth Ontario data.

Typically, emergency department (ED) syndromic surveillance makes use of a patients' presenting chief complaint, as recorded by a triage nurse. These data have been shown to be good indicators of patient illness, especially in the case of respiratory and gastrointestinal illnesses[2]. Chief complaint data from ED's were successfully integrated into several surveillance systems, notably at the 2000 Sydney Olympic games[3], the 2002 Salt Lake City Olympic games[4], and the 2003 Rugby World Cup in Australia[5]. Chief complaint data have shown to be effective in the early identification of influenza outbreaks[6], and are particularly effective in tracking common symptoms such as injury and respiratory disease[5]. ED syndromic surveillance systems make use of routine data collected during the triage process, thereby minimizing additional workload on hospital staff.

In September 2004, Kingston, Frontenac and Lennox and Addington (KFL&A) Public Health launched a program to develop and evaluate an Emergency Department Surveillance System (EDSS) in collaboration with the Ontario Ministry of Health and Long Term Care (MOHLTC) – Public Health Branch, Queen's University, Kingston General Hospital (KGH) and Hotel Dieu Hospital (HDH). The goal of the program is to monitor changes in the incidence of endemic disease and also to detect new or emerging disease threats. ED visits are collected electronically in near real-time from seven area hospitals. Non-nominal patient data collected include date and time of visit, demographics, five-digit postal code of residence, Canadian

Triage Acuity Score (CTAS), and chief complaint or reason for visit. Data is fed into an automated information management/technology (IM/IT) platform where they are classified into syndromes, aggregated, displayed using graphs and maps, and to which statistical aberration detection algorithms are applied. The University of Pittsburgh's Real-Time Outbreak and Disease Surveillance (RODS) system was adapted and used during the time period of this study[7].

The National Ambulatory Care Reporting System (NACRS) gathers data for hospital-based and community-based ambulatory care, day surgery, outpatient clinics, and emergency departments. Records contain patients' diagnoses using the International Classification of Diseases, Tenth Revision (ICD-10). Every hospital in Ontario submits data to the NACRS, thus the system includes demographic, clinical, and administrative data for the whole province[8]. The NACRS patient data are accurate and comprehensive, and have been used in several retrospective studies[9-11]. The accuracy of the data is assured by checks for duplicate records, missing data, and inconsistencies. Erroneous records in the database are deleted, and individual hospitals are asked to re-submit the corrected data[8]. Although an excellent source of ED data, the NACRS data are not available in real-time, and thus the usefulness of the NACRS as a timely epidemiological surveillance data source is limited.

Telehealth Ontario is the provinces' teletriage helpline available free to all Ontario residents 24 hours a day, 7 days a week. Callers are connected to skilled nurses who assess symptoms over the phone using standardized algorithms and assist callers in making the most appropriate healthcare decision[12]. For each call, caller demographics are recorded, together with the nurse-identified guideline. Each call is classified into one of 486 guidelines based on information obtained (eg. symptoms, history, etc).

Methods

Daily counts of Kingston area respiratory-related discharge diagnoses based on ICD-10-CA codes (Table 1) were obtained from the NACRS database (July 4th 2004 to March 31st 2006). Daily counts of respiratory-related chief complaints (Table 2) from patients presenting to Kingston area hospitals were collected from the KFL&A EDSS (July 4th 2004 to March 31st 2006). From June 2004 to August 2005, the EDSS gathered data from all hospitals in the KFL&A Public Health jurisdiction. Starting September 2005, hospitals in the Hastings & Prince Edward Counties Health Unit (HPECHU) jurisdiction were joined to the EDSS. For both the

EDSS and the NACRS, patients were linked to the Kingston area based on patient Health Unit status as recorded in the respective databases.

Weekly Telehealth counts of respiratory-related cases from the Kingston area based on Telehealth guidelines (Table 3) were obtained (July 4^{th} 2004 to March 31^{st} 2006). The categorization of Telehealth calls into upper or lower respiratory episodes was based on classifications schemes previously developed by researchers involved with Real-time Outbreak and Disease Surveillance (RODS) system (7), the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) system[13], and the National Health Service Direct[14,15]. Telehealth Ontario calls were geolocated to Kingston based on the home address (Forward Sortation Area) of the caller.

All of the collected data were compiled into weekly totals (Sunday to Saturday). The significance of weekly lags were considered using time series analysis and the PROC ARIMA procedure. Spearman correlation coefficients were produced using PROC CORR. All statistical procedures were carried out using SAS software, version 9.1 (SAS Institute, Cary, NC, USA).

Results

During the period of July 2004 to the end of March 2006, the EDSS contained 30,417 respiratory-related cases presenting to one of the seven area hospitals. In the same time period, Telehealth Ontario received 4,247 upper and lower respiratory-related calls, and the NACRS contained 19,315 cases diagnosed with respiratory-related illness (of which 3% were specifically diagnosed with influenza) from Kingston area FSAs.

Analysis (Figure 1, Table 4) comparing the EDSS respiratory chief complaints to the Telehealth respiratory calls resulted in a Spearman Correlation Coefficient of 0.91, indicating good correlation. The analysis comparing the EDSS respiratory chief complaints to all NACRS respiratory disease diagnoses calculated a Spearman Correlation Coefficient of 0.98 indicating very good correlation. The EDSS respiratory chief complaints and the NACRS influenza diagnoses analysis demonstrated a Spearman Correlation Coefficient of 0.52 indicating that the two series were moderately correlated. All correlations were highly significant (P-Values < 0.0001). Correlations were highest and most significant when no lags were included in the models.

Discussion

This study demonstrated that Emergency Department (ED) triage chief complaints accurately reflect respiratory illness both among ED patients and in the community, and ED chief complaint data can be used as a timely data source for respiratory illness surveillance. ED triage chief complaints in the Kingston areas were strongly correlated in time with both NACRS respiratory discharge diagnoses and Telehealth respiratory related calls. Whereas NACRS data is unavailable to public health stakeholders in a timely enough fashion to be useful for the day-to-day monitoring of respiratory disease trends in the community, ED triage chief complaints can successfully contribute to real-time public health surveillance as demonstrated by the KFL&A EDSS program.

As EDSS respiratory-related chief complaints correlated very well with NACRS respiratory-related discharge diagnoses and only moderately with NACRS influenza-specific diagnoses, we believe that influenza infections represent only a small fraction of the entire respiratory burden in the community during a given year. In fact, only three percent of the total NACRS respiratory patients were specifically diagnosed with influenza during the study period. In addition to influenza, respiratory syncytial virus (RSV) has been found to significantly influence trends in respiratory illness, and when considered together, lab results for RSV and influenza have been shown to produce good correlation with respiratory syndrome frequency fluctuations[16]. Figure 1 shows that the total number of EDSS respiratory-related chief complaints peaked during the influenza season's (early-November 2004 to mid-April 2005 and early-December 2005 to early-May 2006) as expected; however, EDSS chief complaints continued to fluctuate in the influenza off-season. We believe that the latter observation is also likely due to the influence of other respiratory pathogens. The nature of the EDSS data does not allow one to separate respiratory complaints that were related to influenza from those related to other pathogens.

The results of this study demonstrated that at a local level respiratory data from Telehealth Ontario corresponded well to both the NACRS discharge diagnoses and the EDSS chief complaints. These results reflect the findings of previous work that demonstrate on a provincial level that Telehealth Ontario respiratory call data correspond very well to respiratory related ICD-10 NACRS discharge diagnoses[12]. These results thus suggest that together with EDSS data, Telehealth Ontario call data also have the potential to contribute to real-time respiratory disease surveillance systems. Ontario Telehealth data, like ED data can be easily leveraged in near real-time.

Emergency Department triage chief complaints accurately reflect the true conditions of patients as demonstrated by the strong correlation with the NACRS discharge diagnoses. The strong correlations between ED triage chief complaints and the NACRS discharge diagnoses and Telehealth calls, strongly suggest that the EDSS program is able to accurately monitor the status of respiratory illnesses in the community and contribute to the early detection of respiratory illness outbreaks.

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Table 4-1. NACRS communicable respiratory syndromes coded by hospital health staff post-discharge from ICD-10-CA classifications

ICD-10-CA CODE	*CODE DESCRIPTION*
J00	Acute nasopharyngitis (common cold)
J01	Acute sinusitis
J02	Acute pharyngitis
J03	Acute tonsillitis
J04	Acute laryngitis and tracheitis
J05	Acute obstructive laryngitis (croup) and epiglottitis
J06	Acute upper respiratory infections of multiple and unspecified sites
J10	Influenza, due to identified influenza virus
J11	Influenza, virus not identified
J12	Viral pneumonia, not elsewhere classified
J16	Pneumonia due to other infectious organisms, not elsewhere classified
J17	Pneumonia in diseases classified elsewhere
J18	Pneumonia, organism unspecified
J20	Acute bronchitis
J21	Acute bronchiolitis
J22	Unspecified acute lower respiratory infection
J40	Bronchitis, not specified as acute or chronic
J41	Simple and mucopurulent chronic bronchitis
J42	Unspecified chronic bronchitis

Table 4-2. Respiratory illness syndrome with corresponding EDSS chief complaint

SYNDROME	***EDSS CHIEF COMPLAINT***		
Respiratory	Otitis	Swollen neck	Fever and Cough
	Ear pain/ache	Sore throat/rash	Fever, Abd pain
	Sinusitis	Nasal congestion	Nausea and cough
	Laryngitis	Throat problem	Cough/Wheeze
	Croup	Ear infection	Cough/Croupy
	Pharyngitis	Difficulty breathing	Cold
	Epiglotitis	Stuffy nose	Sore throat/chills
	URI	Difficulty swallowing	Left earache
	Right earache	Sinus congestion	Sore throat, weakness
	Bronchitis	Productive cough	Croup
	Bronchiolitis	Lungs full	Head cold/Runny nose
	Pneumonia	Tonsilitis	Bilateral ear infection
	Cough	Sinus pain	Cough, fatigue
	Chest congestion	Throat swelling	Rough cough
	Tracheitis	Cold symptoms	Hoarse voice
	RSV	Strep throat	Flu symptoms/cough
	Cough/indrawing	Shortness of breath/cough	
	Barky cough	Sore throat, muscle aches	

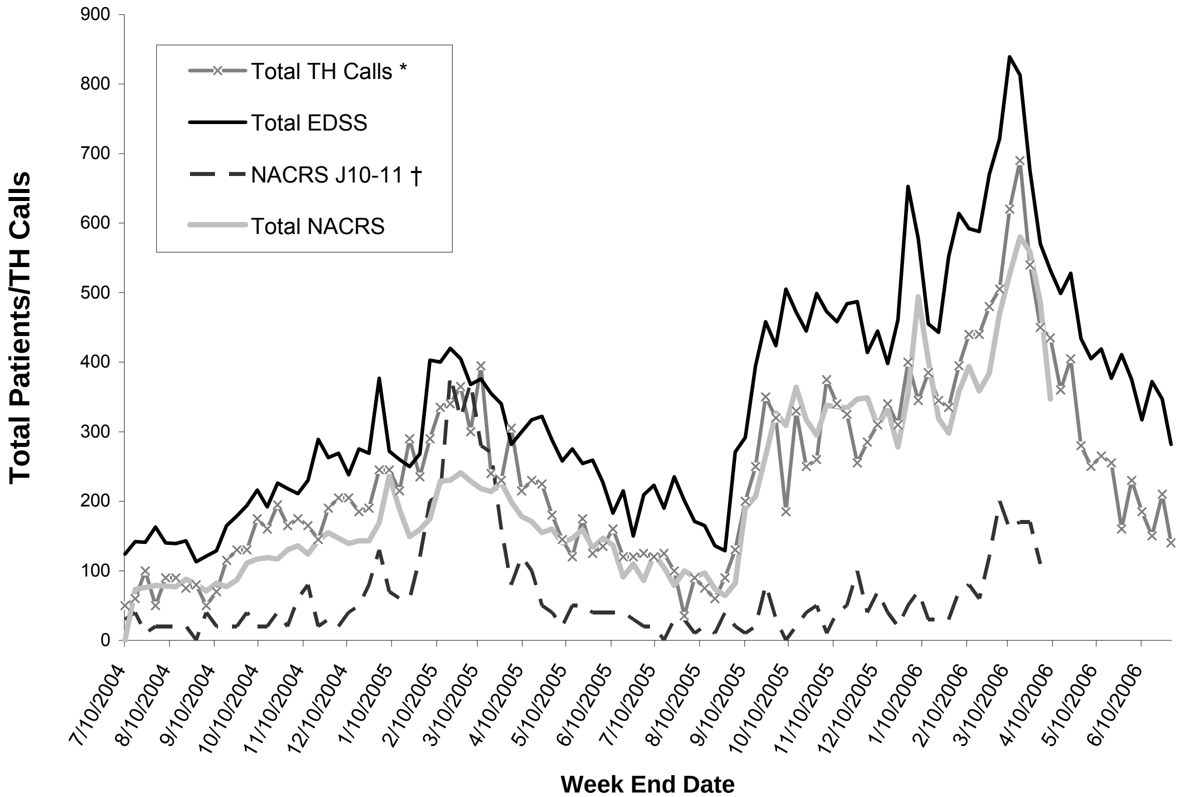
Table 4-3. Upper and lower respiratory illnesses syndromes with corresponding Telehealth Ontario guidelines

SYNDROME	***TELEHEALTH ONTARIO GUIDELINE***
Upper Respiratory	Colds (Adult After Hrs)
	Colds (Pediatric After Hrs)
	Congestion (Pediatric After Hrs)
	Croup (Pediatric After Hrs)
	Ear - Congestion (Adult After Hrs)
	Ear - Congestion (Pediatric After Hrs)
	Ear - Discharge (Adult After Hrs)
	Ear - Discharge (Pediatric After Hrs)
	Earache (Adult After Hrs)
	Earache (Pediatric After Hrs)
	Hoarseness (Adult After Hrs)
	Hoarseness (Pediatric After Hrs)
	Respiratory Multiple Symptoms (Adult After Hrs)
	Respiratory Multiple Symptoms (Pediatric After Hrs)
	Sinus Pain and Congestion (Adult After Hrs)
	Sinus Pain Or Congestion (Pediatric After Hrs)
	Sore Throat (Adult After Hrs)
	Sore Throat (Pediatric After Hrs)
Lower Respiratory	Cough - Acute Non-productive (Adult After Hrs)
	Cough - Acute Productive (Adult After Hrs)
	Cough - Chronic (Adult After Hrs)
	Cough (Pediatric After Hrs)
	Coughing Up Blood (Adult After Hrs)
	Wheezing – Other Than Asthma (Pediatric After Hrs)

Table 4-4. Spearman Correlation Coefficients between EDSS, NACRS, and Telehealth respiratory related cases (lag 0)[1].

	Telehealth	EDSS	NACRS (all)	NACRS (influenza only)
Telehealth	1	0.91	0.92	0.60
EDSS	0.91	1	0.98	0.52
NACRS (all)	0.92	0.98	1	-
NACRS (influenza only)	0.60	0.52	-	1

[1] All values were significant, P-Values < 0.0001



*Telehealth call counts were multiplied by 5 for visibility on the graph

†NACRS J10-11 counts were multiplied by 10 for visibility on the graph

Figure 4-1: Weekly totals of EDSS respiratory chief complaints, NACRS respiratory visits, NACRS influenza visits and Telehealth respiratory calls (July 2004 to June 2006)

CHAPTER 5: Mapping the influenza epidemics of 2004-5 and 2005-6 in Ontario using data from emergency department and Telehealth Ontario utilization

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Introduction

Influenza epidemics are an annual occurrence in Ontario, with known cases usually reaching a peak in the early months of the year and declining in the Spring. The specific timing and severity of the epidemic varies each year depending on a variety of factors including the particular influenza strains involved and the effectiveness of vaccination programs[1]. The standard for documenting the rise and fall of influenza in Ontario and in Canada as a whole is the data on laboratory-confirmed cases provided by the Canadian Communicable Disease Report (CCDR). Unfortunately, these data are not immediately available to public health agencies, particularly to Public Health Units, and other sources of data need to be evaluated for their ability to provide near real-time monitoring of the growth and spread of the annual epidemic. Two source offer promise in this regard: (i) the National Ambulatory Care Reporting System (NACRS) data on Emergency Department visits and hospital admisssions, which are collected daily and are coded by major symptom permitting patient visits and hospital admissions for respiratory reasons to be identified; (ii) data from use of Telehealth Ontario, where each call is also coded by major symptom. Both Emergency Department (ED) and Telehealth Ontario data are coded by 3-digit postal codes (there were 510 such postal codes, also known as Forward Sortation Areas (FSAs), in Ontario in 2004) and these form the basis for defining the spatial extent of the epidemic over time.

In this document the procedures for generating the data for mapping the influenza data on a weekly basis during the influenza seasons in 2004-5 and 2005-6 are presented. The maps themselves are available in separate documents.

Overall Comparison of Data Series

Three series are examined:

a) Telehealth Ontario calls for respiratory reasons. All Telehealth Ontario calls are characterized in terms of 486 guidelines; these guidelines were grouped into 32 syndromes by medical experts and data for the respiratory syndrome were used in this study. During the study period from July 1, 2004 to June 30, 2006, 222,787 cases were available for spatial analysis.

b) ED visits for respiratory reasons. All NACRS data on Emergency Department visits are given an ICD-10-CA code assigned by an experienced health coder based on a physician's medical diagnosis. Only ICD codes for a respiratory syndrome were used in this study. The period from July 1, 2004 to March 31, 2006 produced 791,354 respiratory cases for spatial

analysis. The shorter time period reflects the reporting procedures for the Ministry of Health which currently release these data by fiscal year which ends in March.
c) CCDR confirmed cases. The 4313 confirmed influenza`cases for the 2 year period were concentrated in 2 distinct influenza seasons: i) from Oct. 31, 2004 to April 30, 2005 and ii) from Dec. 11, 2005 to May 27, 2006.

The decision was made to present each data series aggregated by week to conform to the reporting procedures of CCDR. The total counts by week for the 3 series for Ontario are graphed in Figure 1. From visual comparisons it is clear that the timing of the peaks in these data tend to coincide. One major exception is that the ED data indicate a significant peak over the Christmas – New Year period when family physician services are often not available. It is interesting that this substitution effect is dramatically higher for the ED service than for Telehealth Ontario. A second difference is that the CCDR peak seems to be earlier than the Telehalth/ED peak in 2006. This difference may arise as the relative importance of Type A and Type B influenza varied between the two seasons. Type B occurred earlier in 2006 and generally resulted in less significant health problems than the later Type A[2].

When we examine the relationship between Telehealth Ontario and ED data more analytically, the correlation between the two weekly series is very strong (Table 1). The highest association is with zero lag, indicating that the series are coterminous. The high, but declining, correlations for the other lags reflects the fact that the overall pattern shows only one major peak in a twelve month period with relatively smooth transitions between winter highs and summer lows. Separate analyses shows that these strong temporal relations also exist over this period for individual PHU'S.

Mapping Respiratory Illness at the Sub-Provincial Level

Although the strong cyclical pattern of both respiratory illness and confirmed influenza incidence is evident in the provincial data, we need more detailed spatial data to explore the nature of the spread of respiratory illness across the province in each of the influenza seasons during our study period. Given that Public Health Units (PHUs) are an important administrative entity with respect to local management of epidemics, it would be desirable to present the spatial element of epidemics at the PHU level as well as producing more general models of the epidemics with continuous surfaces of incidence rates.   The ability to produce such maps is dependent on the way in which geographic locations are coded in the Telehealth Ontario and ED records.

Basic Coding

Telehealth Calls:

Each call is coded by the first 3-digits of the Postal Code (PC) where the call originated, also known as the Forward Sortation Area (FSA). FSAs are not the most satisfactory of units as they vary greatly in size (Figure 2A and 2B). There were 510 Forward Sortation Areas (FSAs) in Ontario in 2004. Clearly, the sizes reflect the differences in population density in urban and rural areas with the sparsely populated Northern region containing FSAs which have areas of more than 20,000 sq. km. Unfortunately, there are two additional problems with FSAs: i) the rural areas surrounding urban areas are often one single FSA (see Figure 3 for an example), and ii) the FSAs do not map simply onto Public Health Unit boundaries (Figures 4 & 5).

Emergency Department visits

Each visit to the ED is coded in the NACRS database by both the FSA and the PHU in which the patient resides. PHUs also vary in size in response to variations in population density (Figure 4) but not in as dramatic a way as FSAs (Figure 4). The more serious issue is that there are significant overlaps with single FSAs often crossing the borders of 2 or more PHUs. Figure 5 illustrates the issue in the Ottawa region. The FSA 'K0K' is a continuous area around the southern boundary of the city and it overlaps 3 different Public Health Units, so if we have a particularly record for 'K0K' we cannot tell where it is located with any degree of accuracy. If we are to produce maps of Telehealth Ontario calls related to respiratory problems at the PHU level we need an algorithm for assigning calls to PHUs based on their FSA location.

The FSA-PHU Allocation Procedure

Given that we are primarily concerned with aggregate measures (weekly counts of Telehealth Ontario cases by PHU), we do not need to allocate each record for a given FSA to a specific PHU. What we need is an estimate of the probability p_{ij} that a record in the i^{th} FSA belongs in the j^{th} PHU. Then, if N_i is the number of calls generated in the i^{th} FSA in a given time period (usually a week), then

$$F_j = \sum_I N_i \, . \, p_{ij} \qquad (1)$$

where F_j is the estimated number of calls to the j^{th} PHU in the same period.

One method of generating allocation estimates would be to calculate the proportion of the area of the i^{th} FSA which lies in the j^{th} PHU and use this proportion as a direct estimate of the probability p_{ij}. This is a reasonable approach if the population density is relatively uniform across the FSA. However, such uniformity is highly unlikely in outer suburbs and rural areas, where population tends to occur in well-spaced clusters. We adopted a different approach using all NACRS records, not just those for respiratory reasons, for the 2 year period from July 2004 to March 2006. There were over 9 million eligible records containing valid FSA and PHU codes (about 2 percent of all records had invalid FSA codes or incompatible codes for FSA and PHU). On average there were approximately 18,000 records for each FSA which were empirically assigned to a destination PHU over the 2 year period. It was assumed that these were sufficiently large samples to generate reliable estimates of the underlying probabilities. Thus if M_{ij} was the total number of visits from the i^{th} FSA to the j^{th} PHU during the 2 year period then the estimated probability p_{ij} is given by

$$p_{ij} = M_{ij} / \sum_j M_{ij} \qquad (2)$$

These estimates can then be inserted in (1) to give the estimated number of calls to the j^{th} PHU in any selected time period, which in this study is the week by week counts from July 2004 to June 2006.

$$F_j = \sum_I N_i \,.\, (M_{ij} / \sum_j M_{ij}) \qquad (3)$$

Adjustments to Raw Counts in the Mapping Process

While mapping weekly counts does give some idea of the actual loads on the two service components (Telehealth Ontario and Emergency Departments) arising from respiratory problems in each PHU, this is of limited value if the focus is on the nature of the spread of an epidemic . In the first instance, weekly counts are directly influenced by the size of the population at risk in each PHU. When such populations are highly variable across the province, maps based on raw counts will tend to reproduce the overall population distribution. The calculation of counts of calls (or visits) per 100,000 represents the first adjustment.
If P_i is the population of the i^{th} FSA , N_i is the number of calls from the i^{th} FSA in a given week, the call rate for the i^{th} FSA, R_i is

$$R_i = (N_i / P_i).100{,}000 \qquad (4)$$

If Q_j is the population of the j^{th} PHU, F_j is the estimated number of calls from the j^{th} PHU, the call rate for the j^{th} PHU, S_j is

$$S_j = (F_j / Q_j) \,.\, 100{,}000 \qquad (5)$$

A second problem in using both of these data series is that the likelihood of using each service is highly variable across the province and differs significantly between the two services. In general, individuals are 4 to 5 times as likely to use Emergency Departments than Telehealth Ontario for respiratory problems, but there are also strong differences from area to area. To provide the most detailed demonstration of these effects we calculated the total number of respiratory calls per 100,000 persons for the entire 2 year period for each FSA and for the province as a whole. Each FSA rate was then divided by the Provincial rate to give a scaled value of *Intensity of Use,* where the value of 1.0 is equivalent to the Provincial rate, 0.5 is half the Provincial rate and 2.0 is twice the Provincial rate. If N_{i+} is the total number of calls from the i^{th} FSA in the 2 year period, N_{++} is the total number of calls generated in the Province and P_+ is the population of Ontario, then the Intensity of use for Telehealth Ontario calls for the i^{th} FSA, I_i is

$$I_i = (N_{i+}/P_i).100,000 \qquad (6)$$

and the Provincial Intensity of use, I_+ is

$$I_+ = (N_{++}/P_+).100,000 \qquad (7)$$

The Scaled Intensity of Use, U_i is

$$U_i = I_i / I_+ \qquad (8)$$

Similar calculations produce scaled intensities of Telehealth Ontario calls for the j^{th} PHU and the entire process can be repeated to produce scaled intensities for Emergency Department visits for both FSAs and PHUs. Figures 6A and 6B present these scaled values for Emergency Department visits for Ontario as a whole and for the Toronto region. Figures 7A and 7B provide comparable data for Telehealth Ontario calls.

The urban-rural contrast in ED use is dramatic, particularly in the Toronto region. The ratio of utilization rates between the Grey-Bruce area to the North-West of Toronto and central Toronto is as much as 8 to 1. While understanding the causes of these differentials deserves detailed analysis, one of the main determinants is undoubtedly the availability of alternative service points. If an individual needs health care (especially non-critical care), a number of options are available: the family doctor, after-hours clinic, walk-in clinic, emergency department and Telehealth Ontario, with the family doctor being the dominant source. The availability of family doctors, and particularly walk-in clinics, is much higher in the larger urban areas. Other socio-economic and demographic factors may also be important – such as age-structure, immigrant concentration and language competence, household income and education – and should be examined.

The patterns for Telehealth Ontario are not so straightforward. The main differentials are the higher than average use in the more remote suburbs of Toronto, areas which are further from hospitals and have relatively high levels of income and education. South Western Ontario, especially along the Lake Huron shoreline has a markedly lower than average use of Telehealth

Ontario, which may reflect the strong network of small hospitals which provide alternative service points.

If we are to construct maps of the evolving severity of an epidemic across the province, we need to compensate for the differential propensity to use the two different services. Using the weekly population adjusted rates, the simplest procedure is to adjust each weekly call rate for the i^{th} FSA, R_i, by the Scaled Intensity Rate U_i to produce the Intensity adjusted rate, V_i

$$V_i = R_i/U_i \qquad (9)$$

These calculations can be replicated for PHUs and for ED visits for FSAs and PHUs. The resulting Intensity adjusted rate represents the number of calls/visits per 100,000 persons in a given week in the i^{th} area if the propensity to use the given service (Telehealth Ontario or Emergency Department) is the same as the overall provincial rate in every FSA or PSU. The resulting maps then provide an estimate of the relative severity of the influenza epidemic in different locations across the province for the given week.

Map Sequences

The primary focus of the sub-provincial analysis of the spread of influenza is at the scale of the PHU, which is the scale at which many local public health decisions are made. Further, it is desirable to make analyses compatible with the standard reporting by the Canadian Communicable Disease Report (CCDR). Therefore the time scale is the weekly CCDR schedule and the influenza seasons and also defined by CCDR data: : i) from Oct.31, 2004 to April 30, 2005 and ii) from Dec. 11, 2005 to May 27, 2006. These criteria led to the production of 4 weekly series:

1. *Weekly Emergency Department Visit Intensity Adjusted Rates by PHU* from the week ending Oct. 31, 2004 to the week ending April 30, 2005.
2. *Weekly Emergency Department Visit Intensity Adjusted Rates by PHU* from the week ending Dec.11, 2005 to the week ending April 1, 2006 (note that this is the end of the available data from the Ministry of Health not the end of the influenza season).
3. *Weekly Telehealth Ontario Call Intensity Adjusted Rates by PHU* from the week ending Oct. 31, 2004 to the week ending April 30, 2005.
4. *Weekly Telehealth Ontario Call Intensity Adjusted Rates by PHU* from the week ending Dec. 11, 2005 to the week ending May 27, 2006.

The full sequences of maps are available in Powerpoint files. Here we provide examples for selected weeks in the Emergency Department sequences for each season (Figures 8 and 9). A number of features are worthy of note:

- The epidemic was stronger and lasted for a longer period in 2004-5 than 2005-6.
- in 2004-5 the epidemic started in Eastern Ontario and then migrated westward and northward. Although it spread rapidly to the northern districts, it died out earlier in the main urban areas and lingered longer in the South-West.
- In 2005-6 the epidemic started later and had a much shorter high intensity period. There was not the same early focus in the East while the South-West (particularly the rural areas) ended with the highest levels.
- The spread in both seasons does not show a classic contagious spread from one area to contiguous areas. The spread is very rapid and moves as quickly from southern cities to the north as to other cities in the same region. The overall pattern of modern travel by air, train and automobile is a far more significant factor than mere proximity.
- With a significantly higher number of cases, the ED based maps are a more reliable representation of the spread of the epidemics than the Telehealth Ontario-based maps, although the latter do reproduce the essential features.

Modeling the Respiratory Illness Surfaces

It is also possible to consider the spread of influenza to comprise a continuous surface of infection which moves across the province. This spread is reflected in elevated respiratory illness incidence across the province. The question is then how to use the type of data available to this study to estimate the nature of these changing surfaces. The standard approach is to treat rate data for small areas as being focused on the centroids of those areas so that the value associated with a centroid can be used as a measure of the height of the surface at that point. One needs a relatively large number of points to represent a surface so it is better to use the 510 FSAs than the 36 PHUs. However, problems arise if the density of centroids varies substantially across the province as is the case for Ontario (Figure 10). Using standard mapping software to model a surface for the whole of Ontario produce highly unreliable estimates for many parts of northern Ontario where observation points are very sparse. As a compromise maps were produced for Southern Ontario only although data for the whole of Ontario were used in the estimation of the Southern Ontario rates. Even in this case there are still problems with sparseness of observations in the rural areas to the north-east of Toronto.

ESRI's ArcMap ™9.2 was used in the construction of the maps, using the method of *kriging*. Kriging is a method of interpolating values in spatial data based on spatial variation in observed data and on minimizing prediction errors[3]. For each map a first-order trend was fitted to assess whether the overall surface indicated broad regional trends in the distribution of calls. Model maps of Southern Ontario were constructed for the same 4 map sequences as for the PHU data. Selected maps for key dates for Telehealth Ontario calls in the 2004-5 season are presented in Figure 11. Similar trends are evident in these maps as for the Emergency Department data at the PHU scale (Figure 8). Respiratory calls originally rose in the eastern part of the province but rapidly spread both westward and northward. As the epidemic died down in April, it lingered longest in the South West.

Conclusion

The overall impact of the mapping exercise is positive. Not only do the respiratory data from NACRS and Telehealth Ontario closely follow the temporal sequence of confirmed influenza cases reported by CCDR for the province as a whole, but the temporal sequence of each data series are very similar at the PHU scale. When the temporal sequences are mapped at the PHU scale, a number of important aspects of the 2004-5 and 2005-6 influenza epidemics emerge:

- The two influenza seasons are not only different in intensity but also in the spatial patterns of their evolution, although some central features of the spread are common to both years.
- Although the epidemic can start in a variety of places in the province it moves to the large urban centres rapidly. It then spread to all parts of the province very quickly. The rapid linkages between the main population centres provided by the transport network are more important than mere proximity. The tail end of the epidemic occupies different spatial locales in each year.
- The implication is that once the epidemic emerges in a specific locale in the province, all areas of the province should be alert for its potential arrival in their area within 1-2 weeks (it could take a little longer but the specifics of the transmission cannot be predicted with any greater accuracy.

There are data implications that arise from this exercise:

- Both the NACRS and the Telehealth Ontario databases are valuable tools in the monitoring of the spread of influenza in the Province. Although both databases identify respiratory illness rather than influenza *per se*, the data track the temporal evolution of the CCDR confirmed cases so closely that there is much confidence in the ability to identify the upsurge in influenza cases in the community.

- The restriction of the geographic coding of released data to 3-digit postal codes (FSAs) forces the introduction of estimation techniques in generating PHU counts for Telehealth Ontario calls. While reasonably robust, any such estimates require assumptions about local distribution of calls which are not easily testable. It would be useful to explore ways of releasing more detailed geocodes (such as 6-digit postal codes or coding to Statistics Canada Dissemination Areas) while maintaining appropriate protection of individual privacy. This would be an important step if links to other resources such as local socio-economic and demographic profiles available from the Census were desired for further analysis of factors affecting the spread of epidemics.

References

1. Kwong J.C., Sambell C., Johansen H., Stukel T.A., and Manuel D.G.. 2006. The effect of universal influenza immunization on vaccination rates in Ontario. *Health Reports* 17(2): 31-40.

2. CCDR , 2006. Influenza in Canada - 2004-2005 Season, *Canadian Communicable Disease Report*, 32, 06 at http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/06vol32/dr3206ea.html.

3. Oliver, M.A. [a]; Webster.R. [b] 1990., Kriging: a method of interpolation for geographical information systems. *International Journal of Geographical Information Science* 4(4): 313 – 332.

TABLE 5-1: Lagged Correlations of Weekly Data for Emergency Department and Telehealth Ontario Records

	Tel (-2)	*Tel (-1)*	*Tel (0)*	*Tel (+1)*	*Tel (+2)*
Province	0.792	0.883	0.946	0.942	0.895

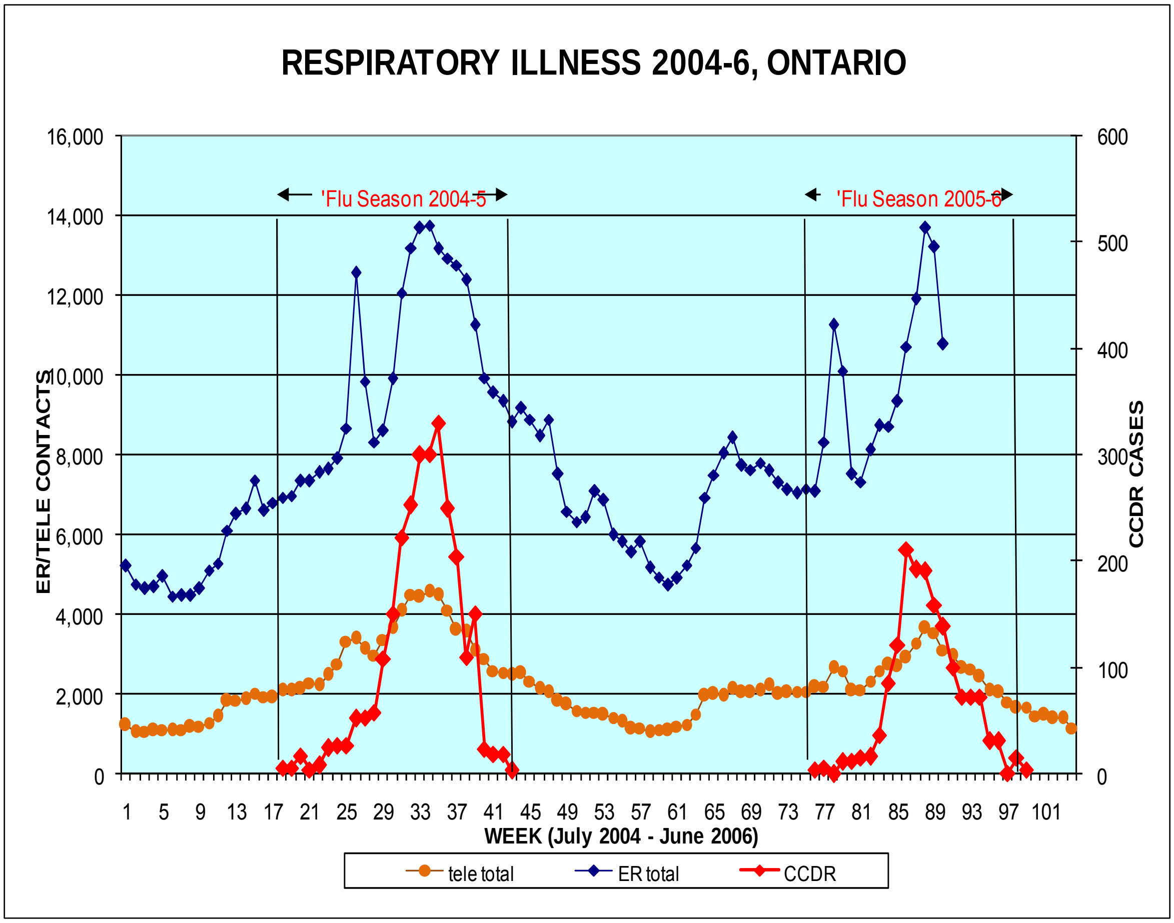


Figure 5-1: Comparative data series by week – 2004-6

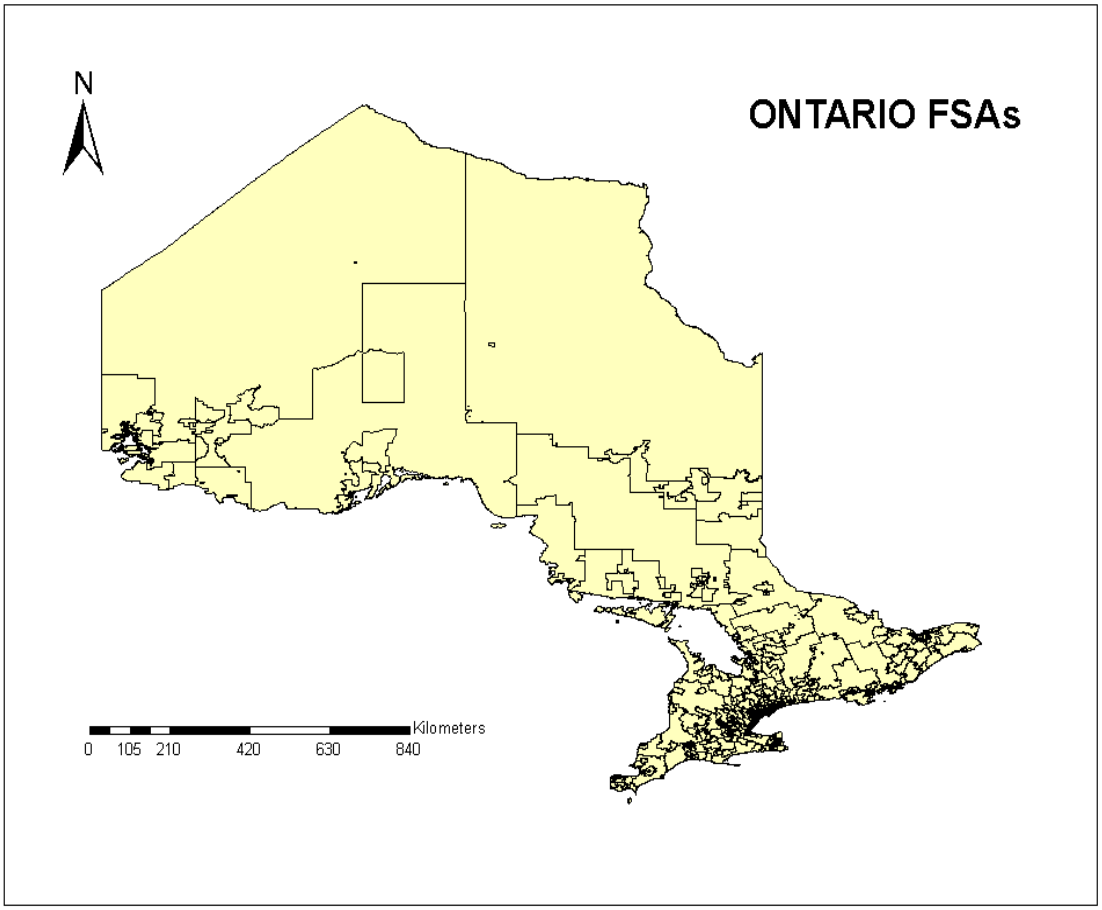


Figure 5-2A: 3-digit postal codes (FSAs) in Ontario

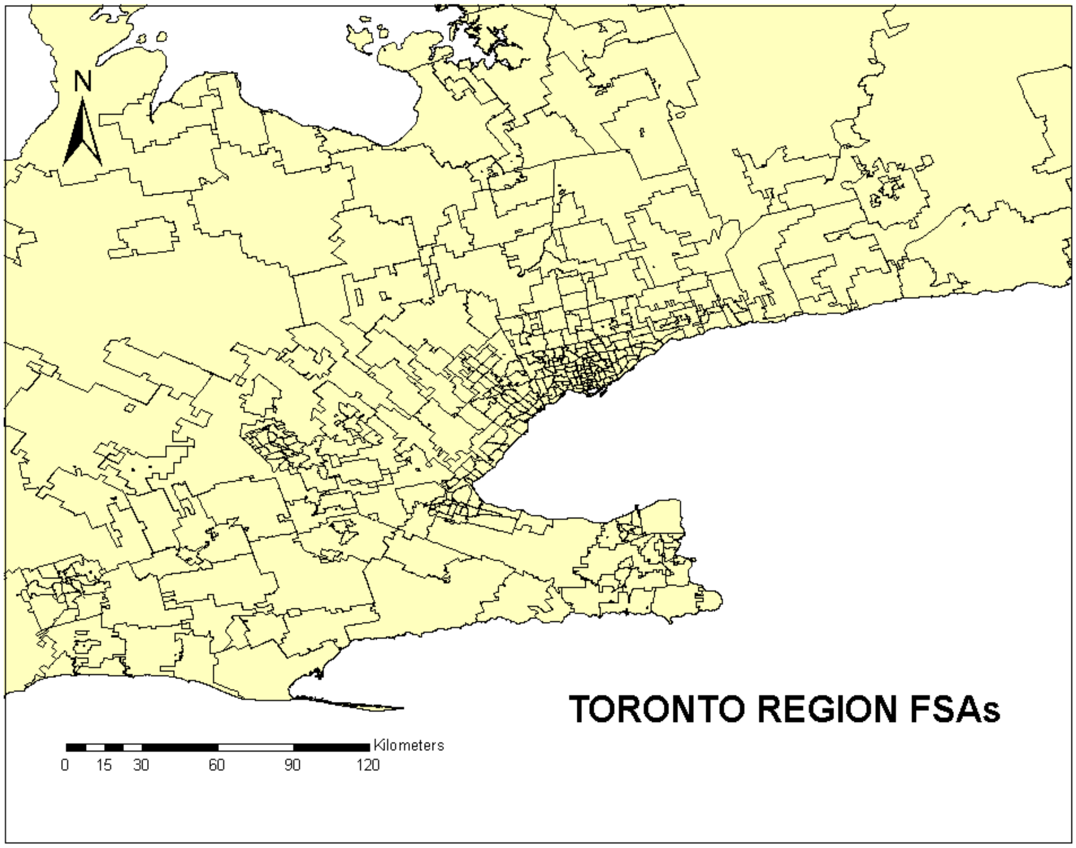


Figure 5-2B: 3-Digit postal codes (FSAs) in the Toronto region

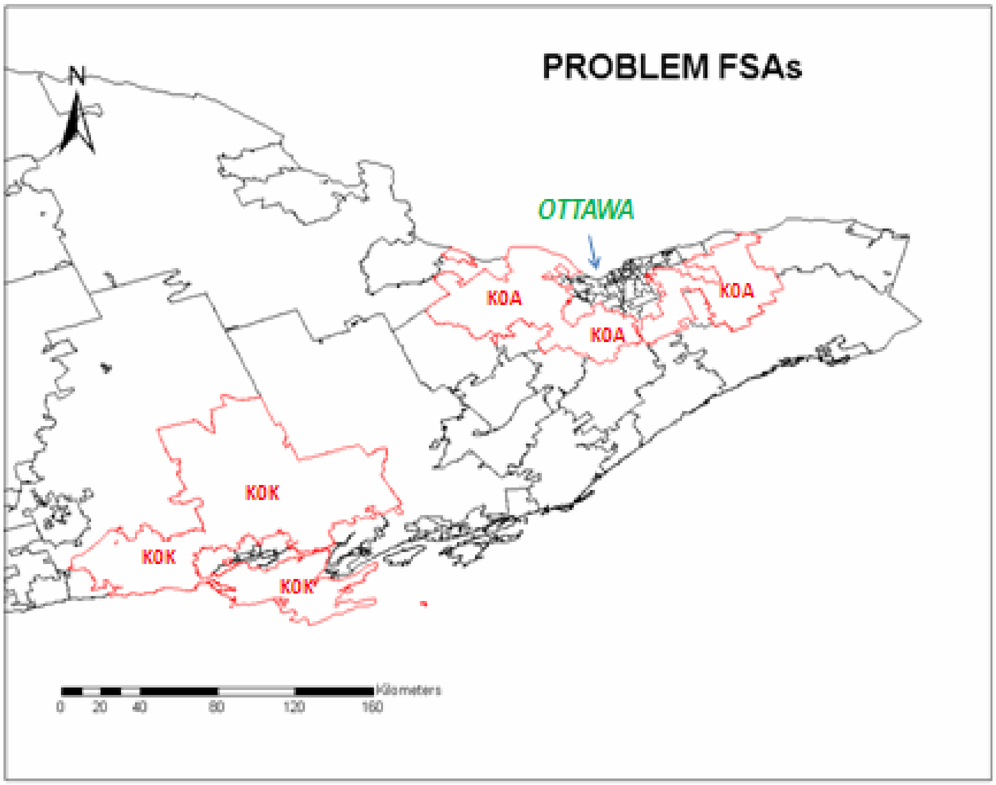


Figure 5-3: Rural FSAs surrounding Ottawa and Belleville

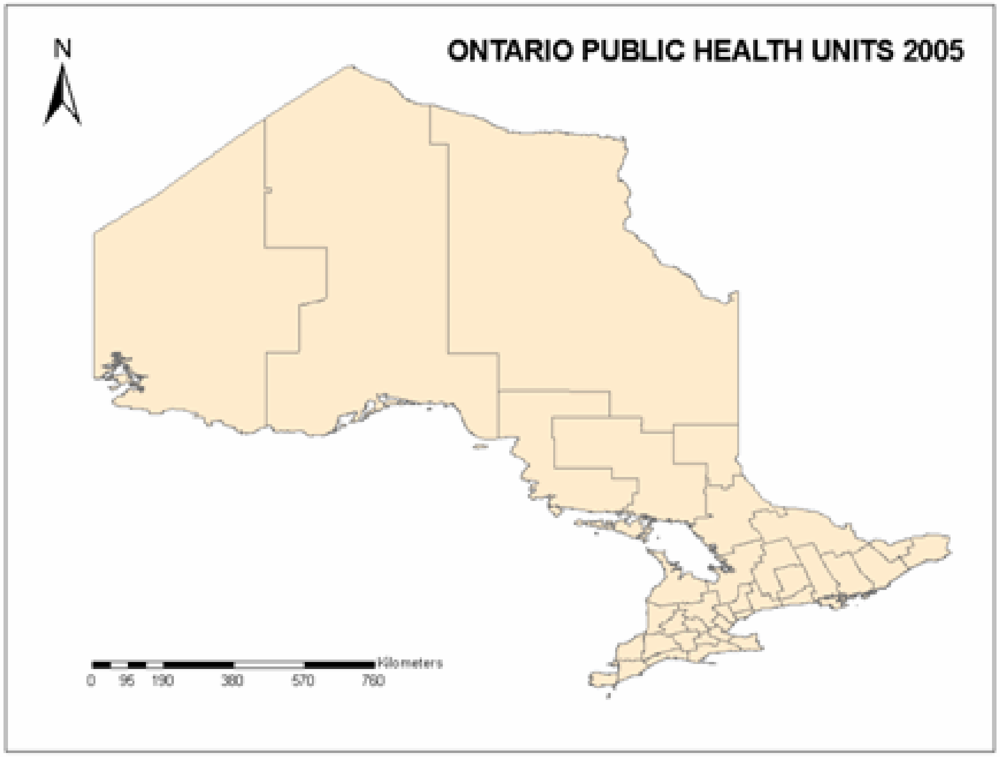


Figure 5-4: Ontario Public Health Units in 2005

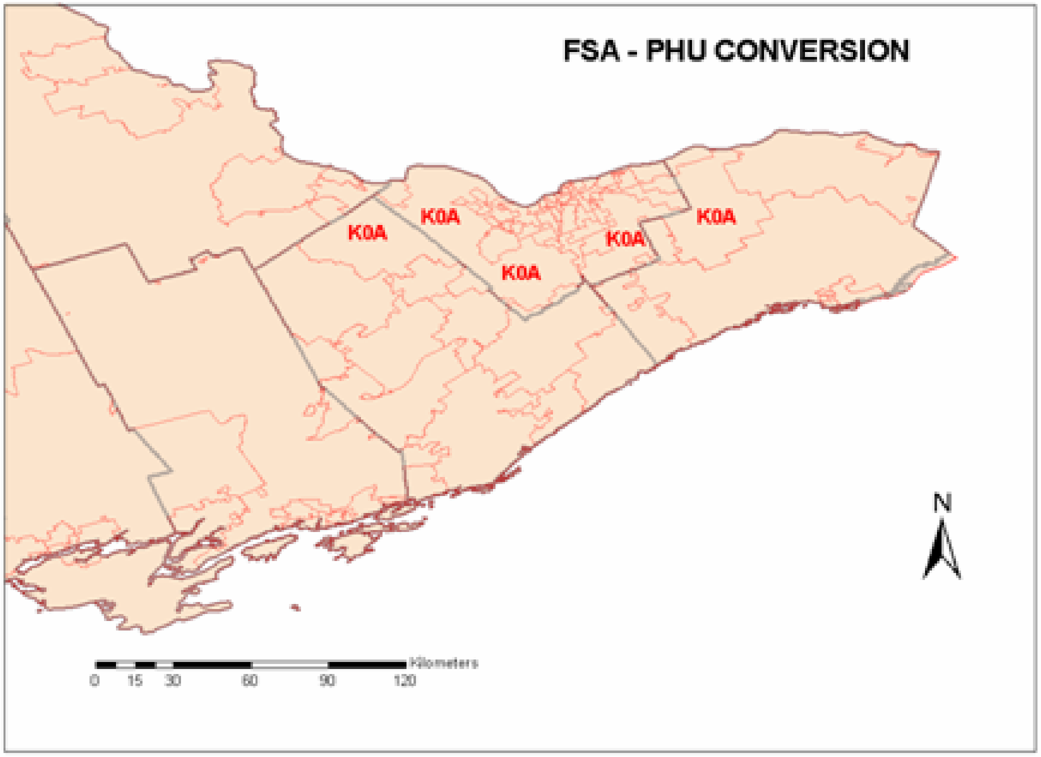


Figure 5-5: Overlaps of FSA and PHU boundaries in Ottawa

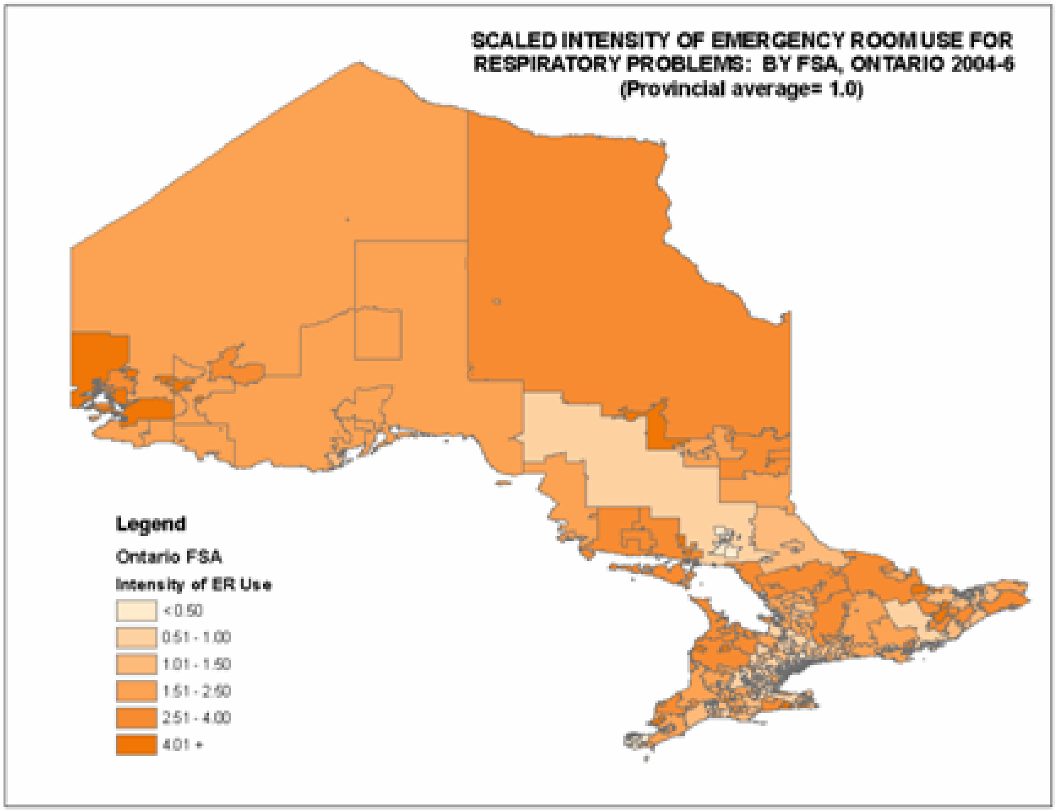


Figure 5-6A: Scaled intensity of emergency room use – Ontario 2004-6

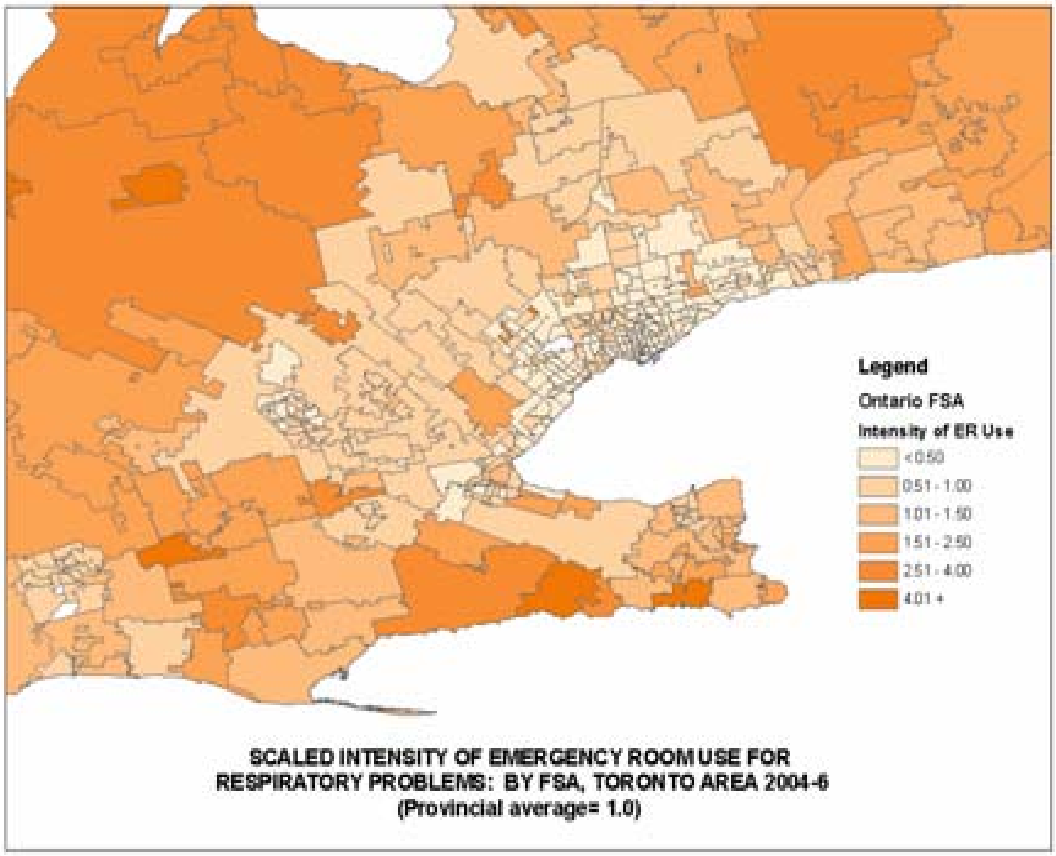


Figure 5-6B: Scaled intensity of emergency room use – Toronto region 2004-6

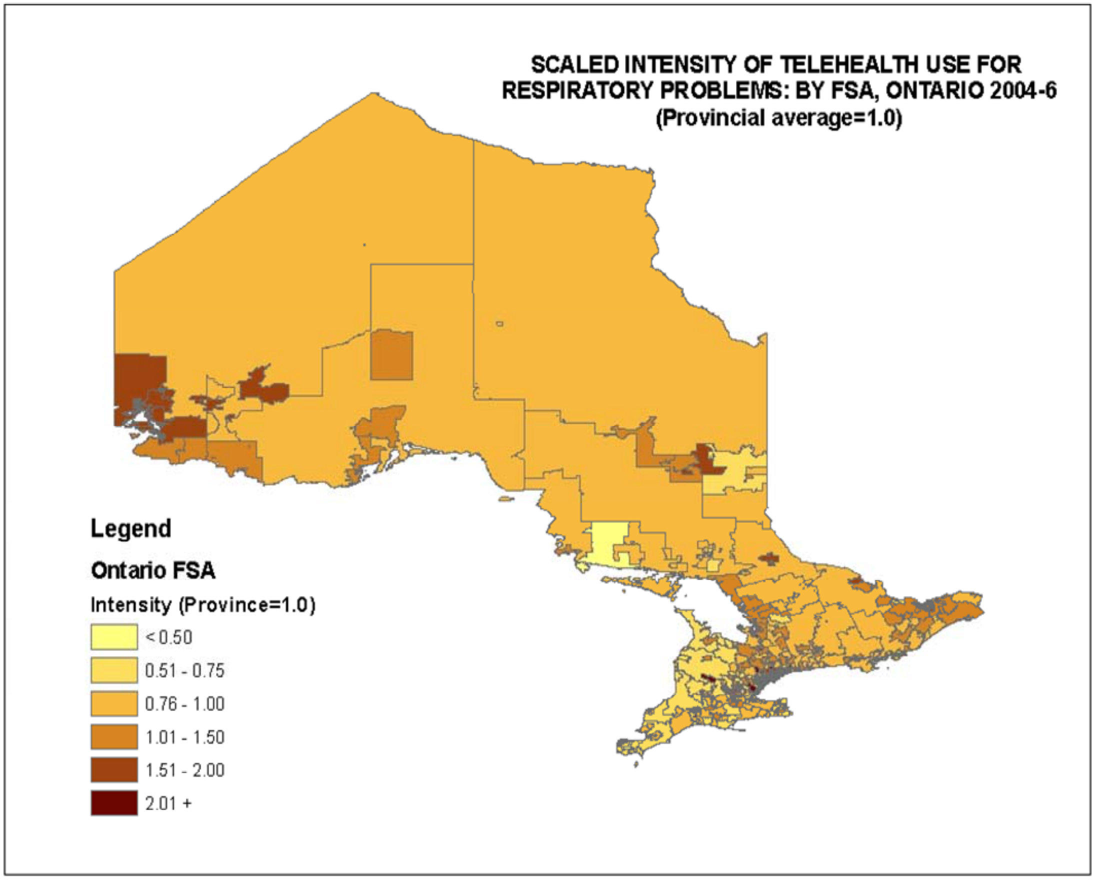


Figure 5-7A: Scaled intensity of Telehealth Ontario use – Ontario 2004-6

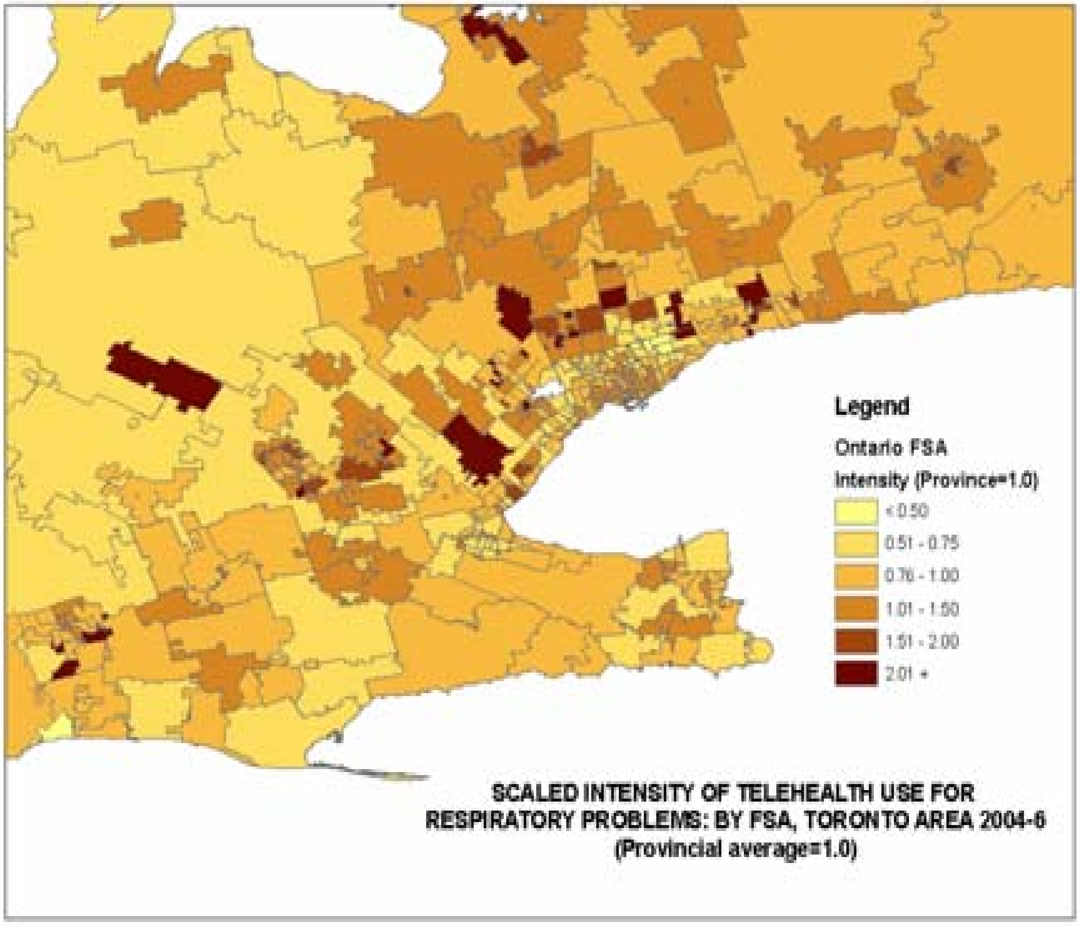


Figure 5-7B: Scaled intensity of Telehealth Ontario use – Toronto region 2004-6

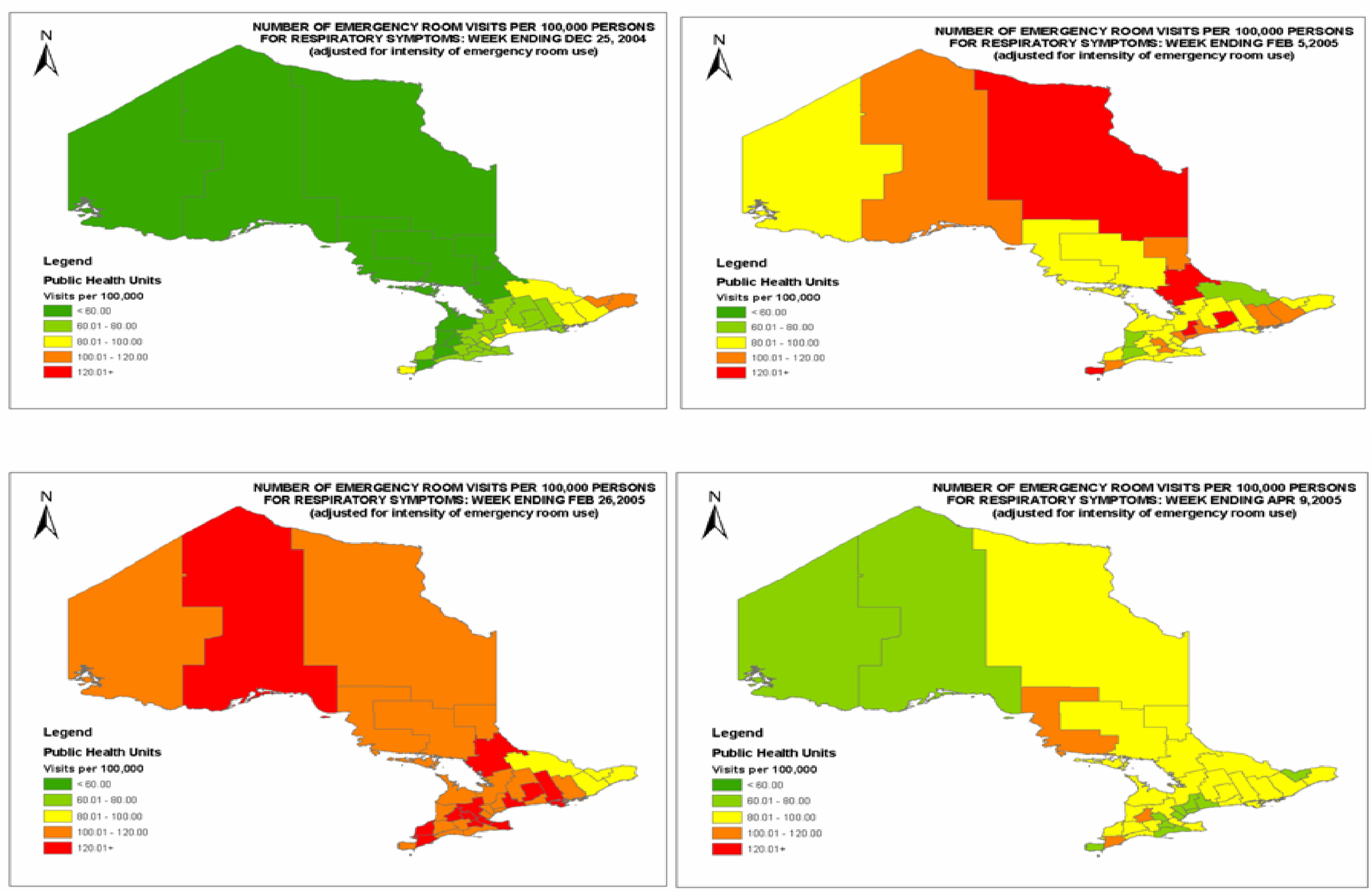


Figure 5-8: Progress of the 2004-5 influenza season at the PHU scale

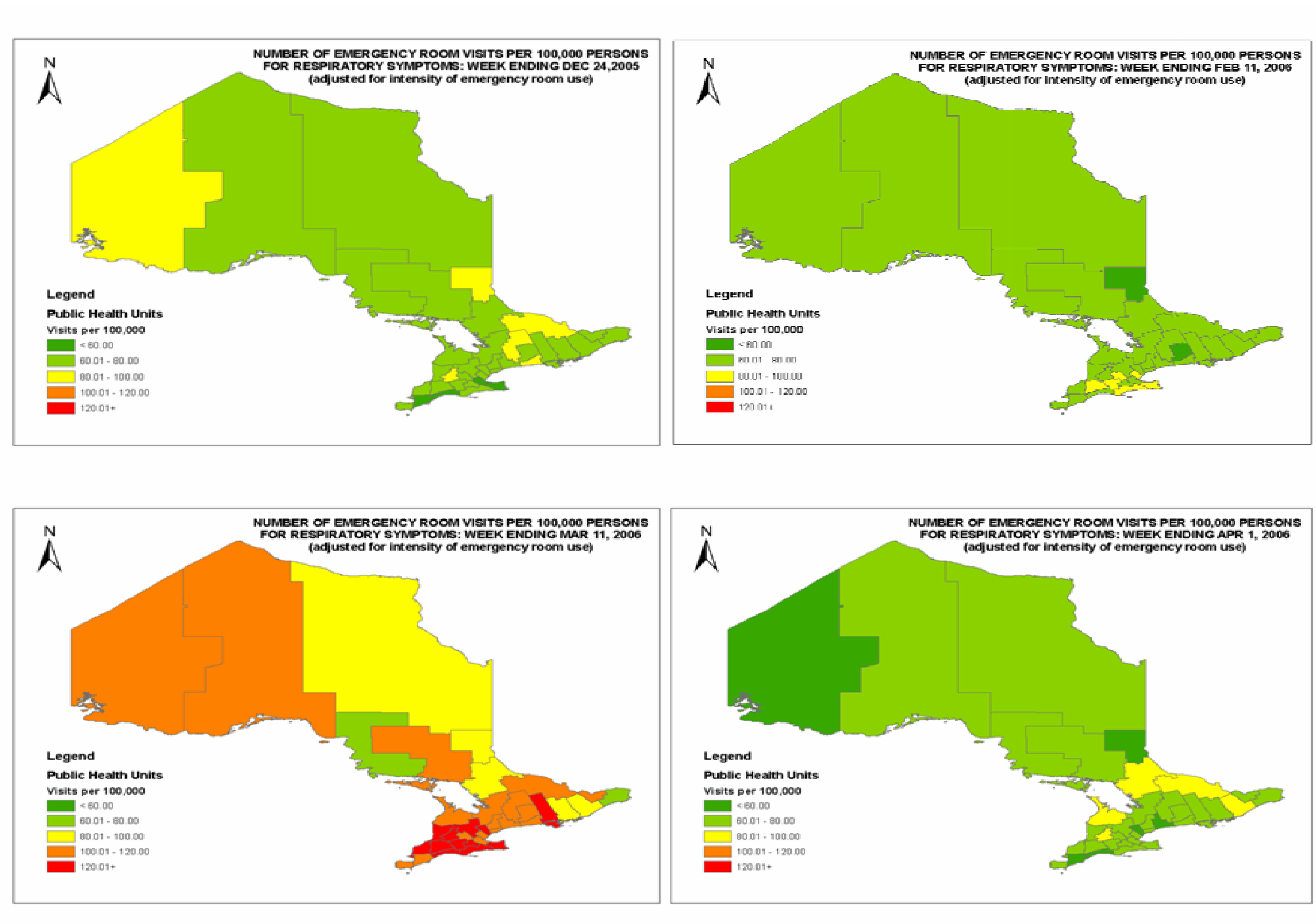


Figure 5-9: Progress of the 2005-6 influenza season at the PHU scale

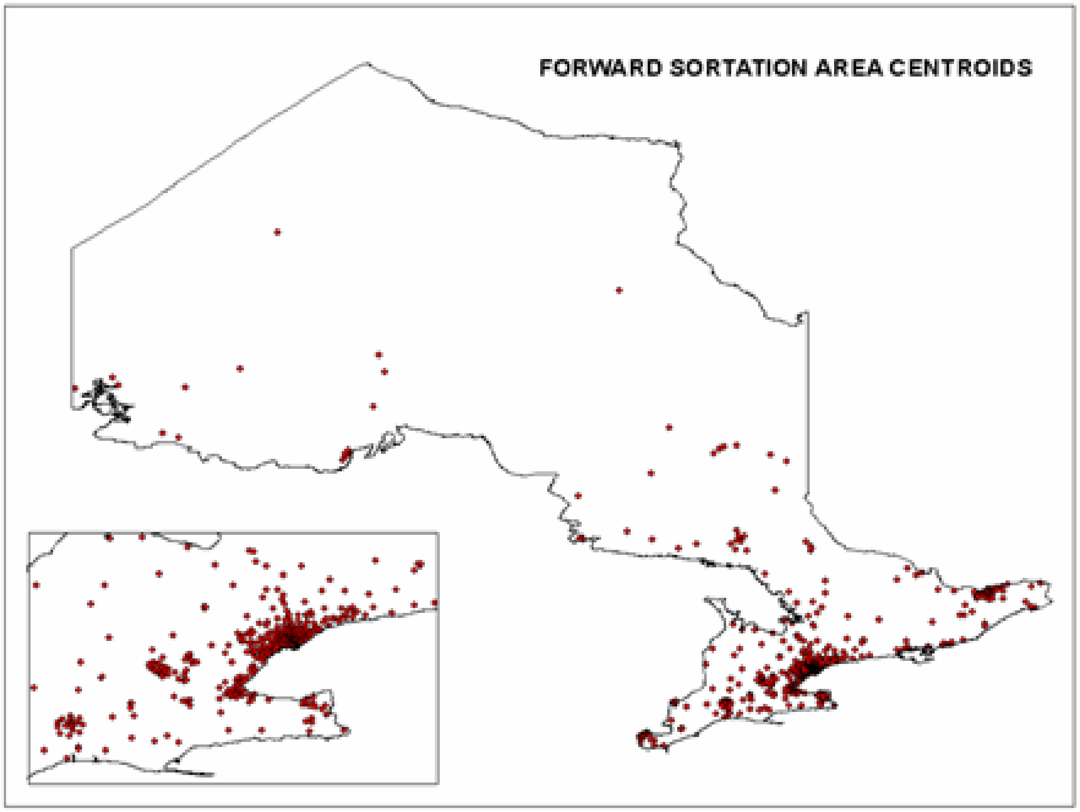


Figure 5-10: Distribution of FSA centroids in Ontario

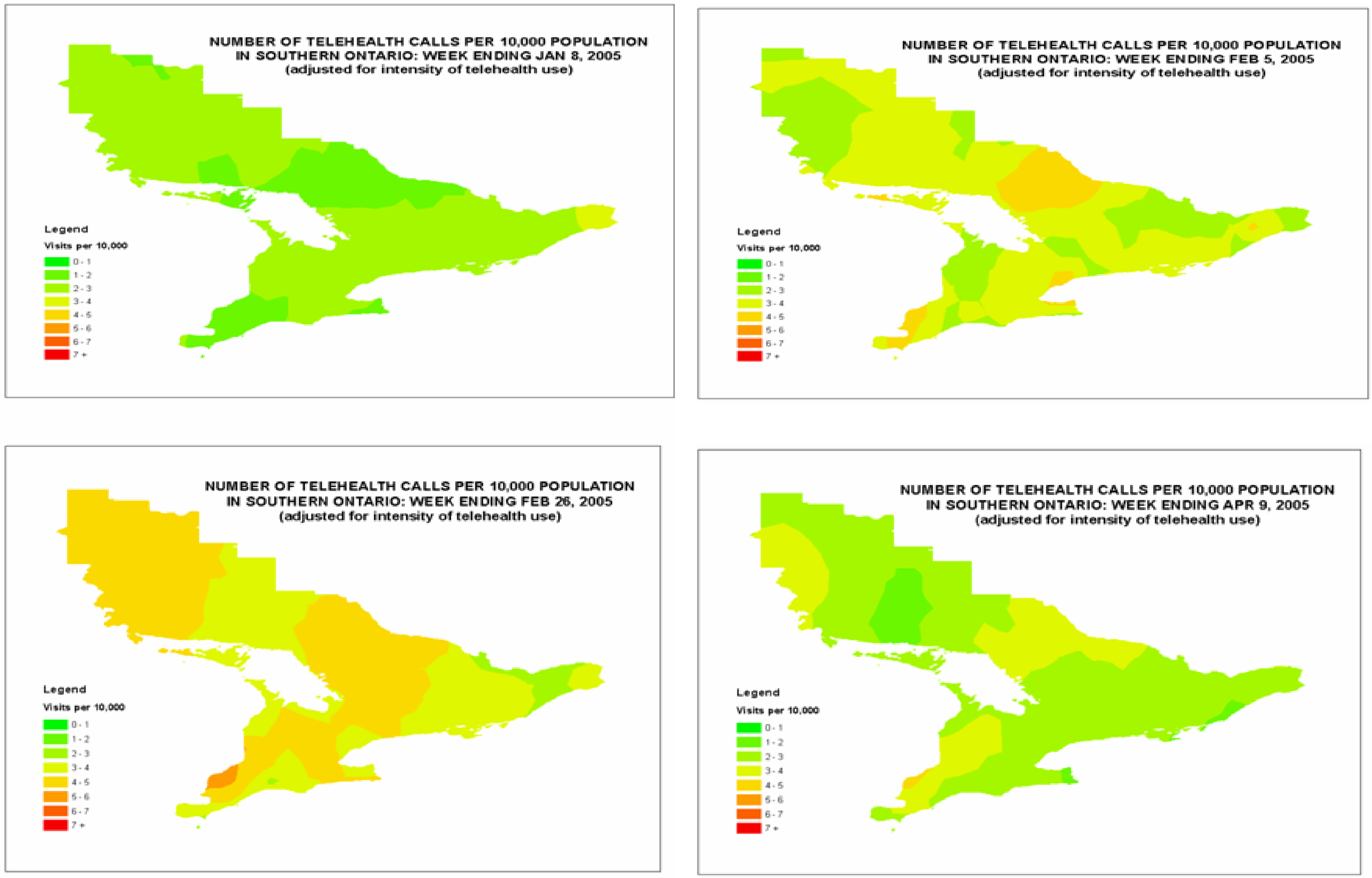
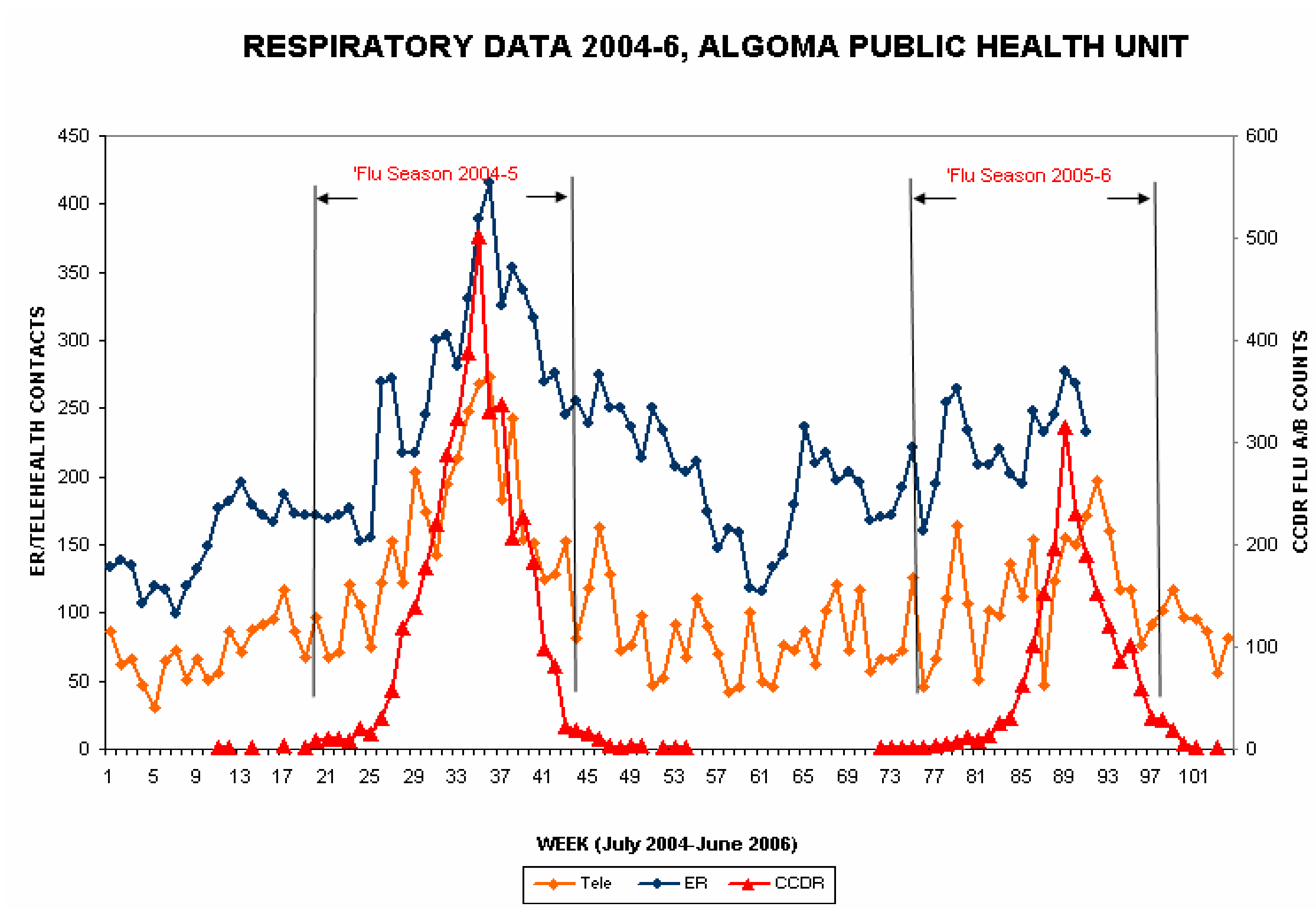
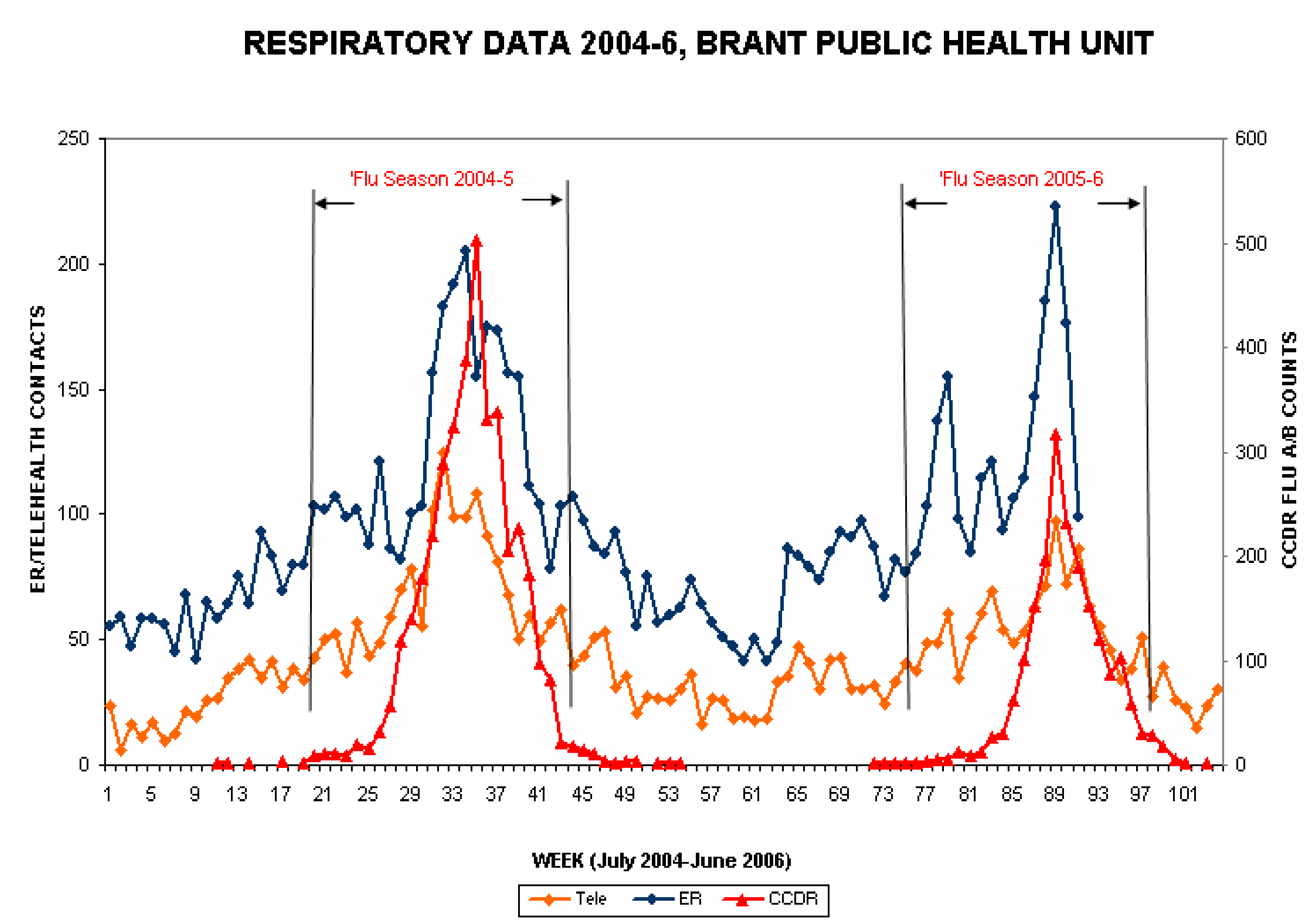


Figure 5-11: Model surfaces for the 2004-5 influenza epidemic for Southern Ontario

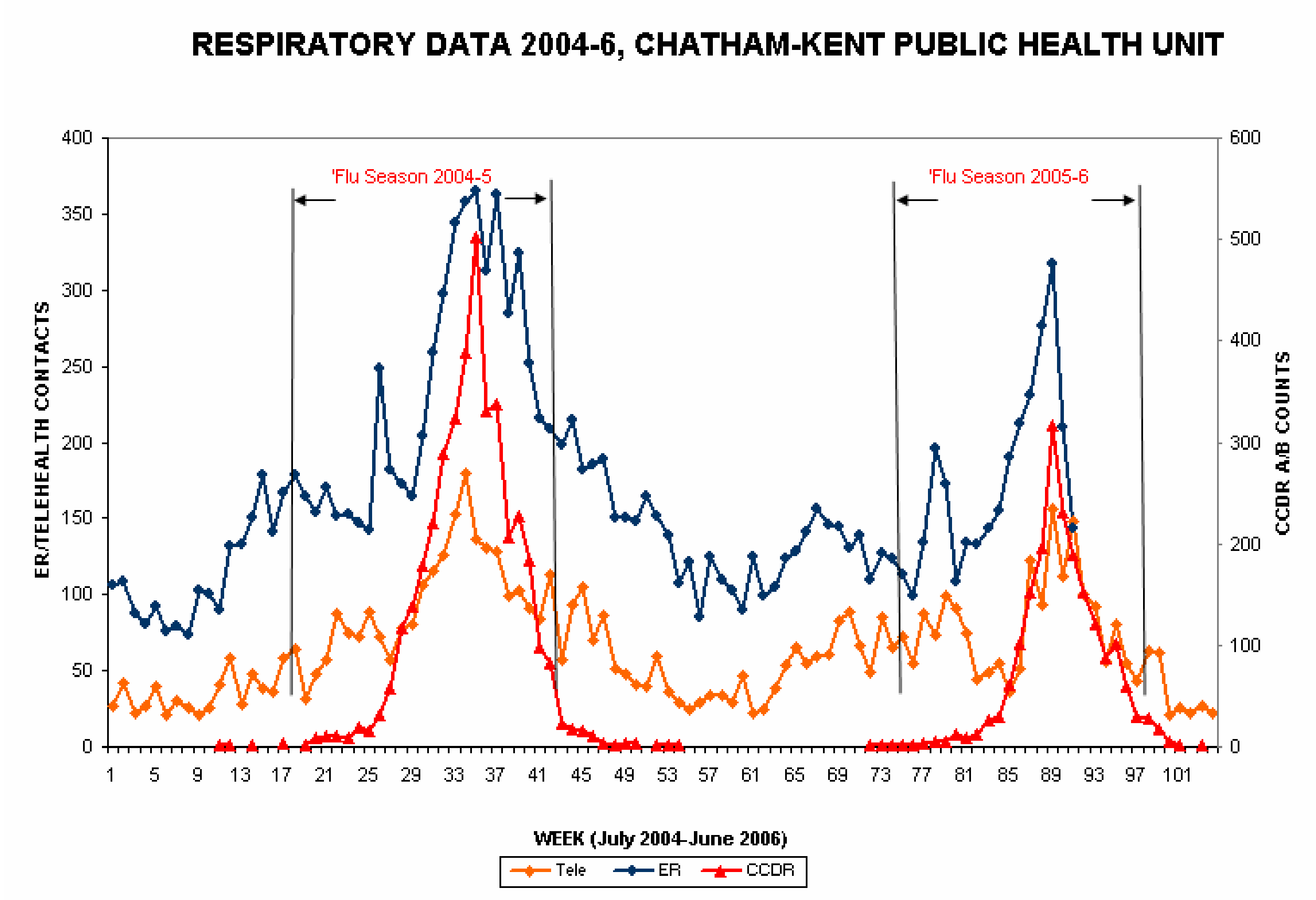
APPENDIX: Comparative data series by week and by Health Unit 2004-6



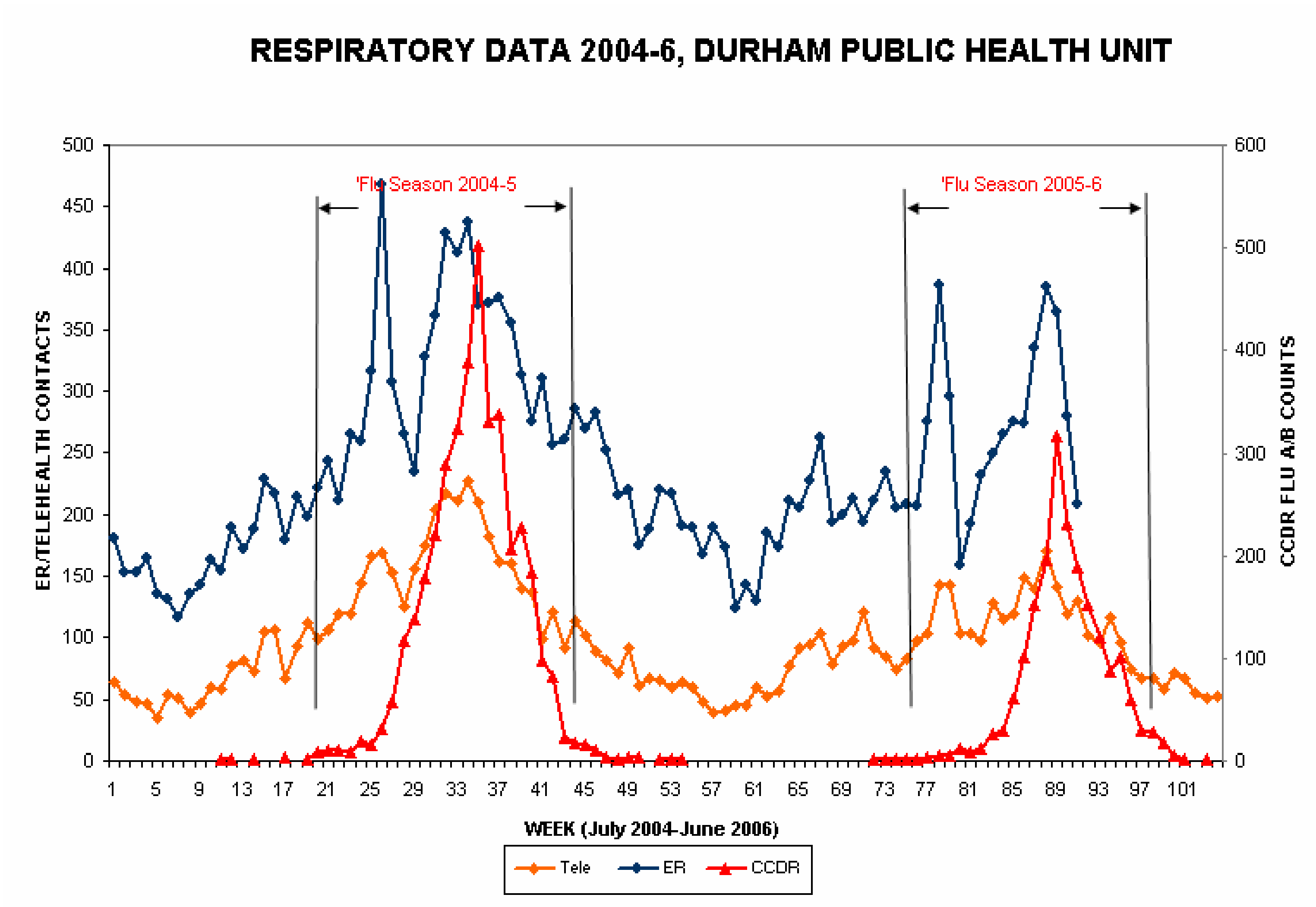
* Telehealth call data multiplied by a factor of five (5).

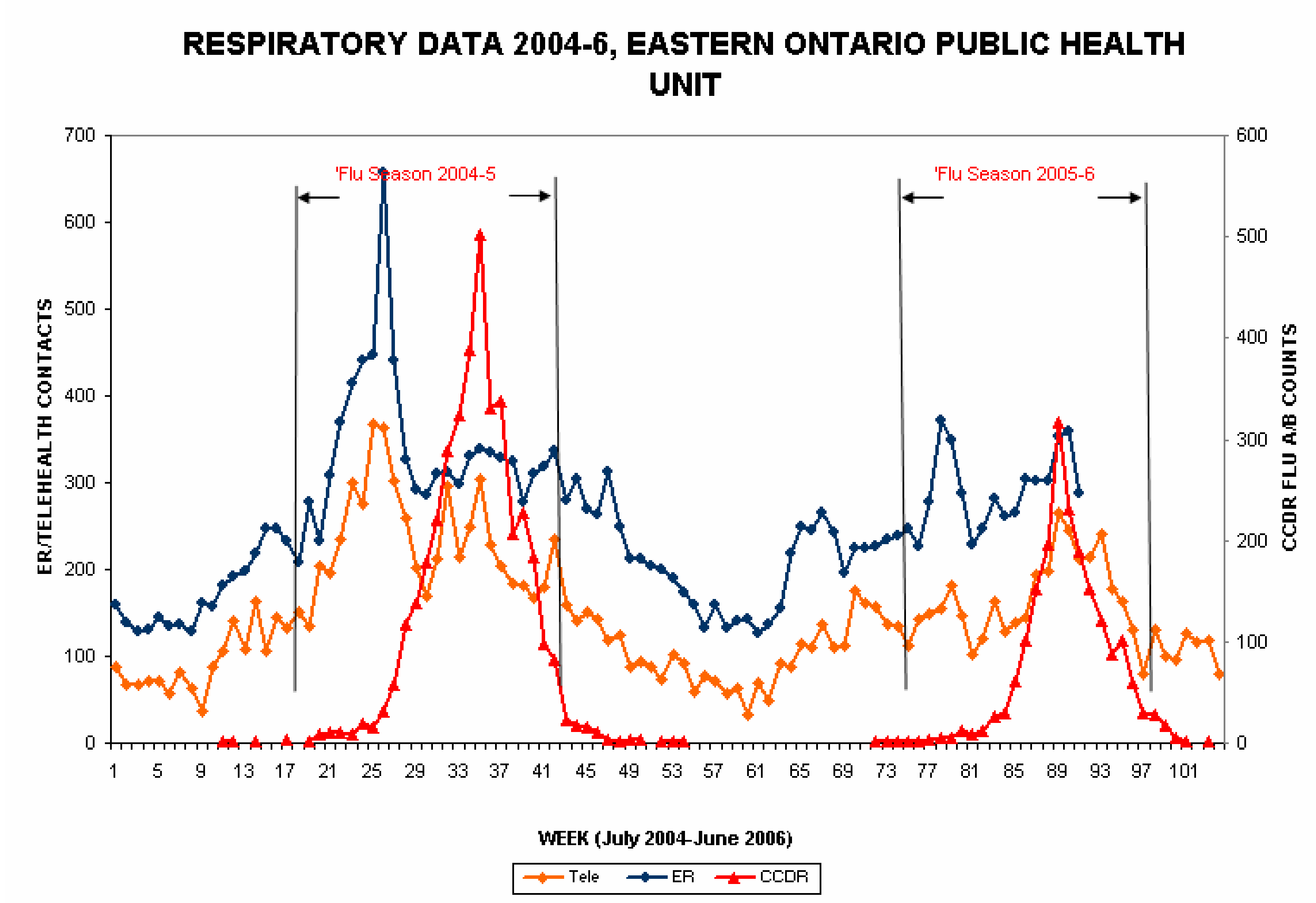


* Telehealth call data multiplied by a factor of two (2).



* Telehealth call data multiplied by a factor of three (4).


RESPIRATORY DATA 2004-6, DURHAM PUBLIC HEALTH UNIT
'Flu Season 2004-5
'Flu Season 2005-6
ER/TELEHEALTH CONTACTS
CCDR FLU A/B COUNTS
WEEK (July 2004-June 2006)
Tele
ER
CCDR



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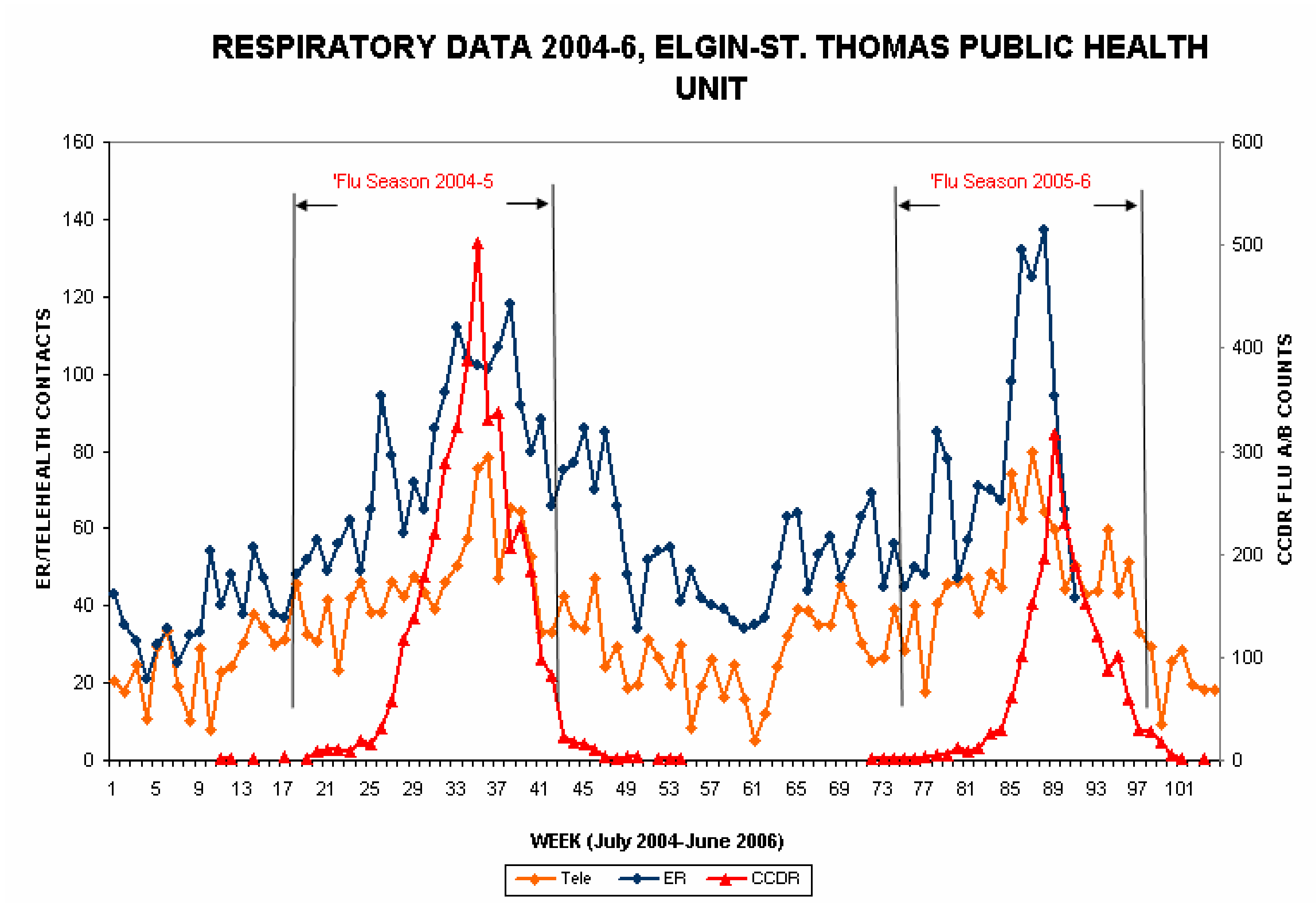
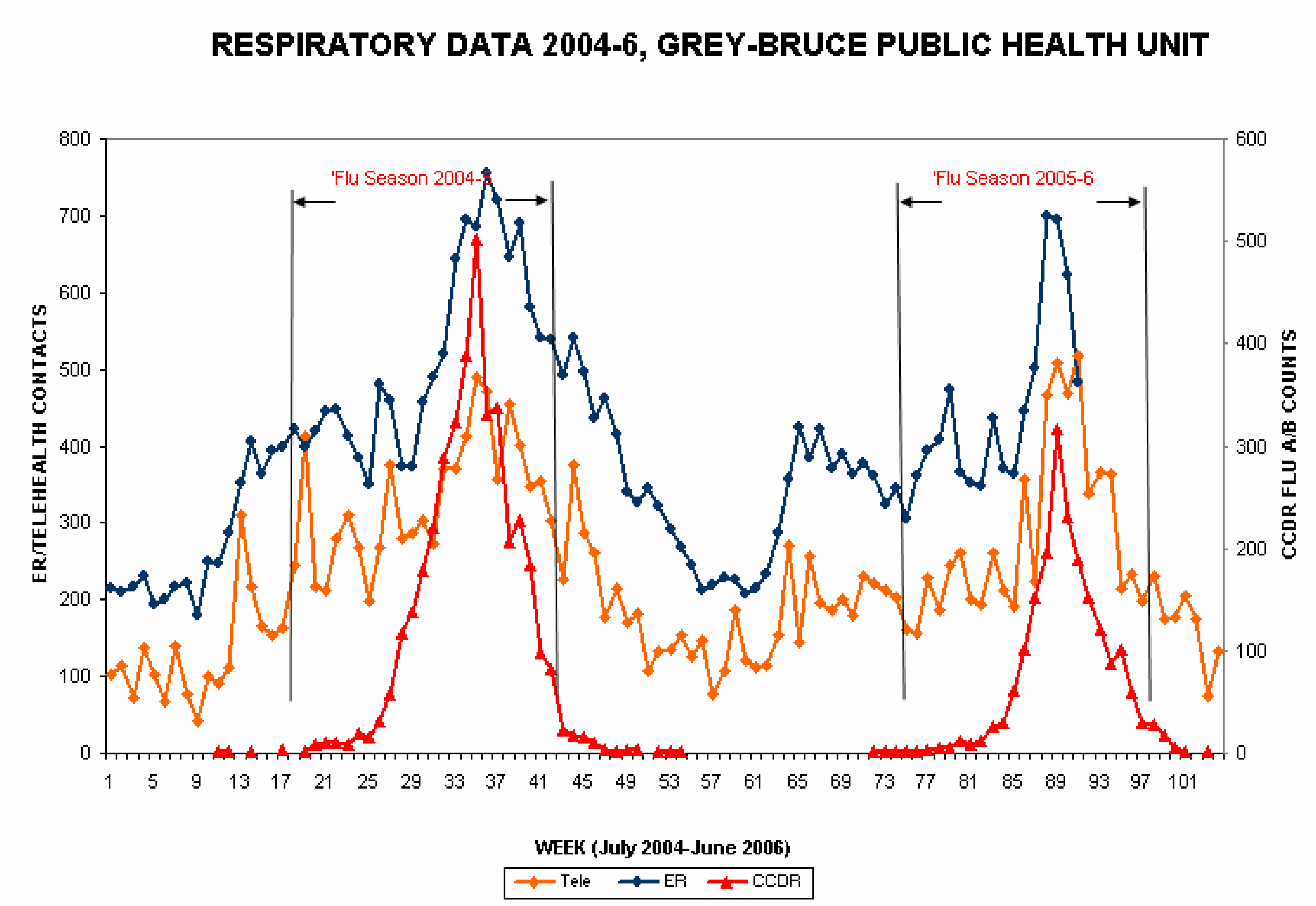
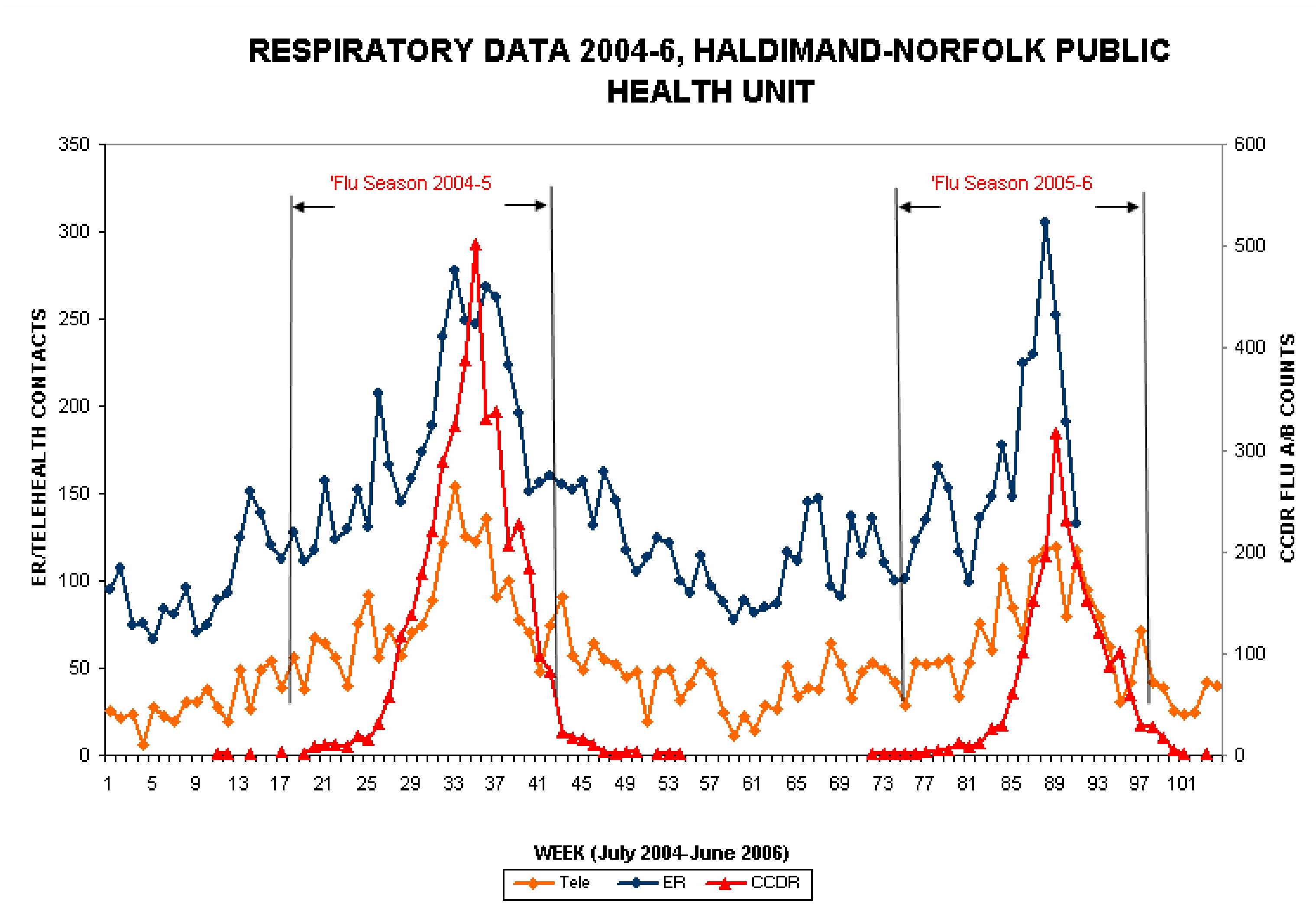


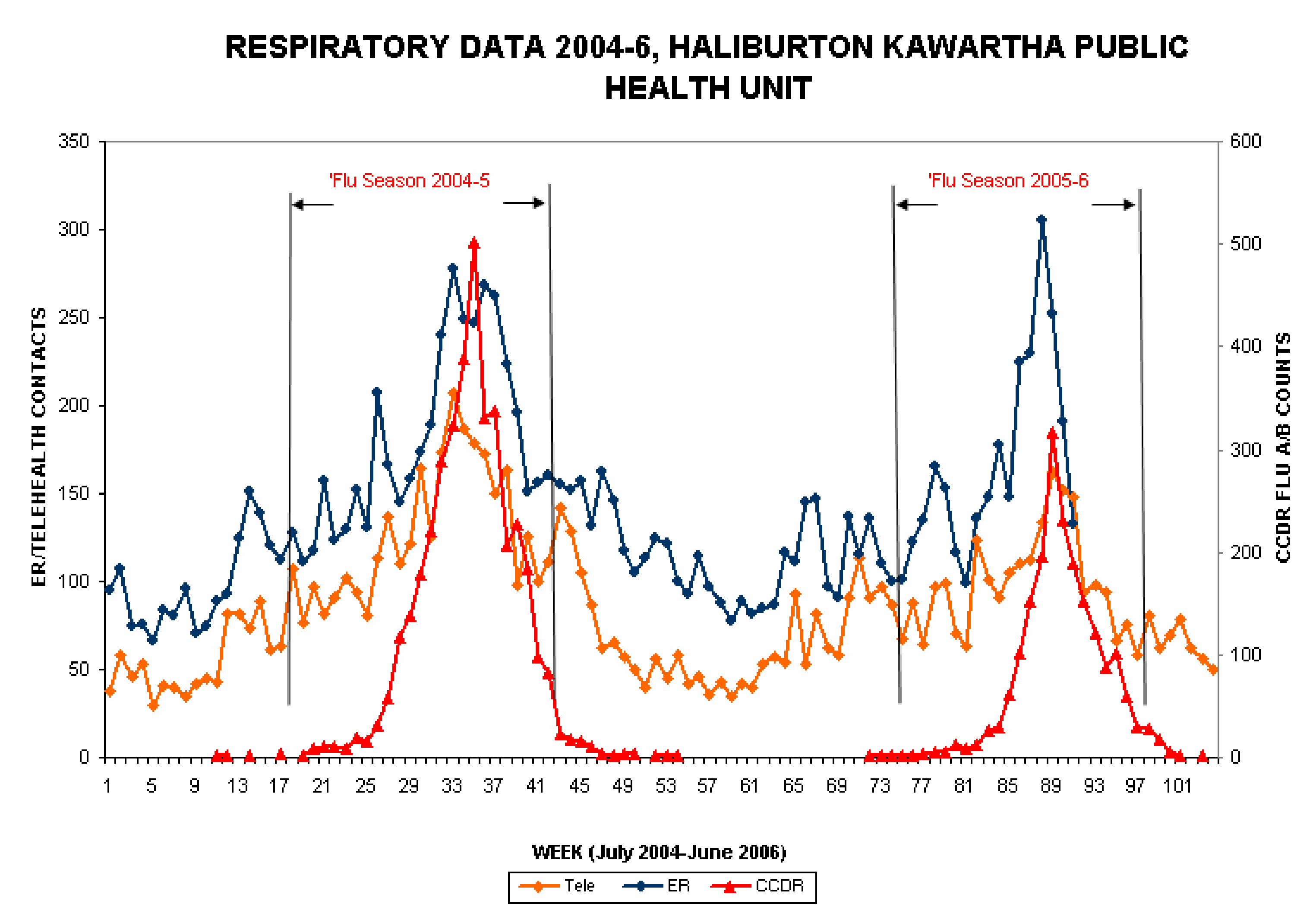
* Telehealth call data multiplied by a factor of three (3).



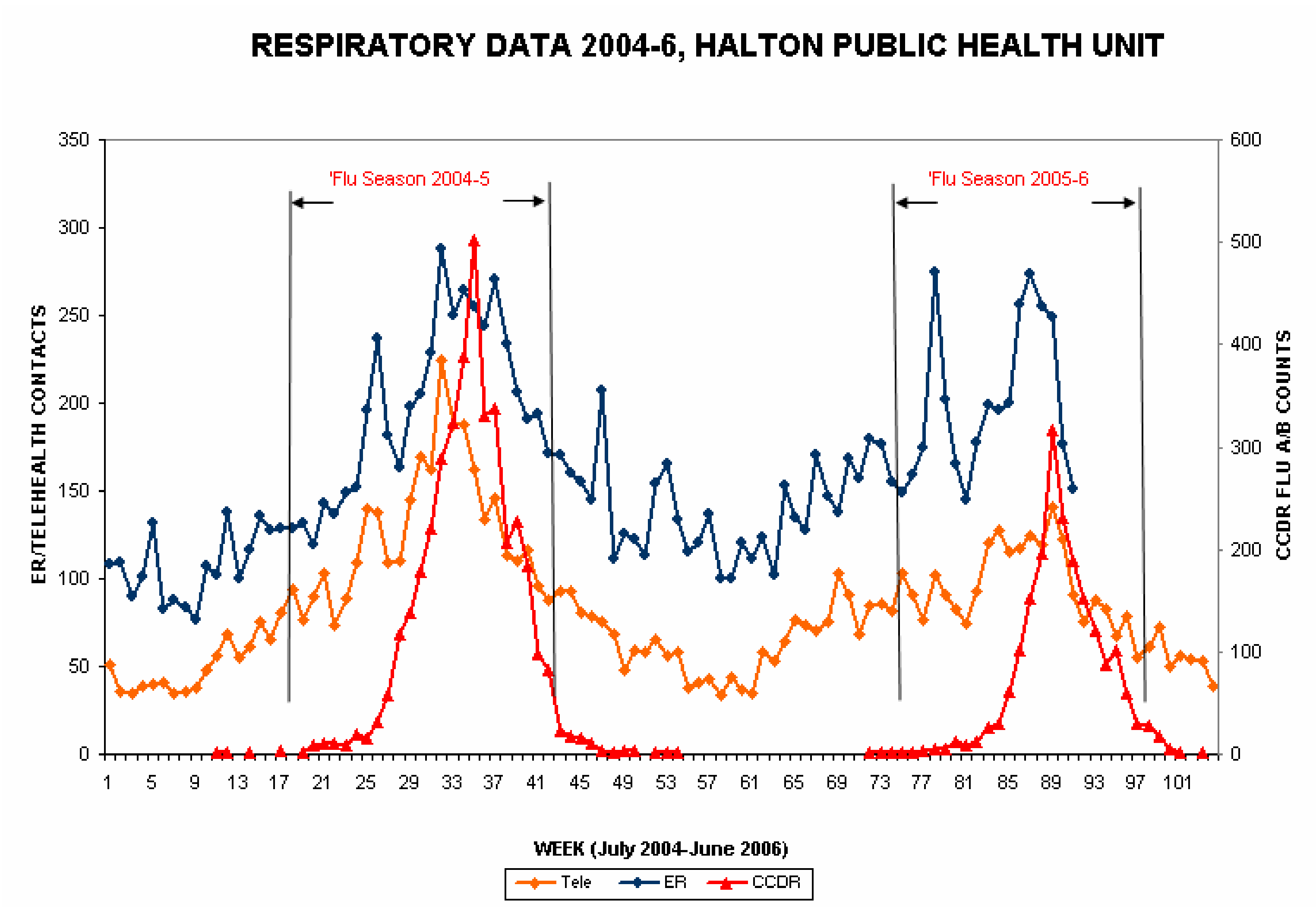
* Telehealth call data multiplied by a factor of ten (10).



* Telehealth call data multiplied by a factor of four (4).



* Telehealth call data multiplied by a factor of three (3).



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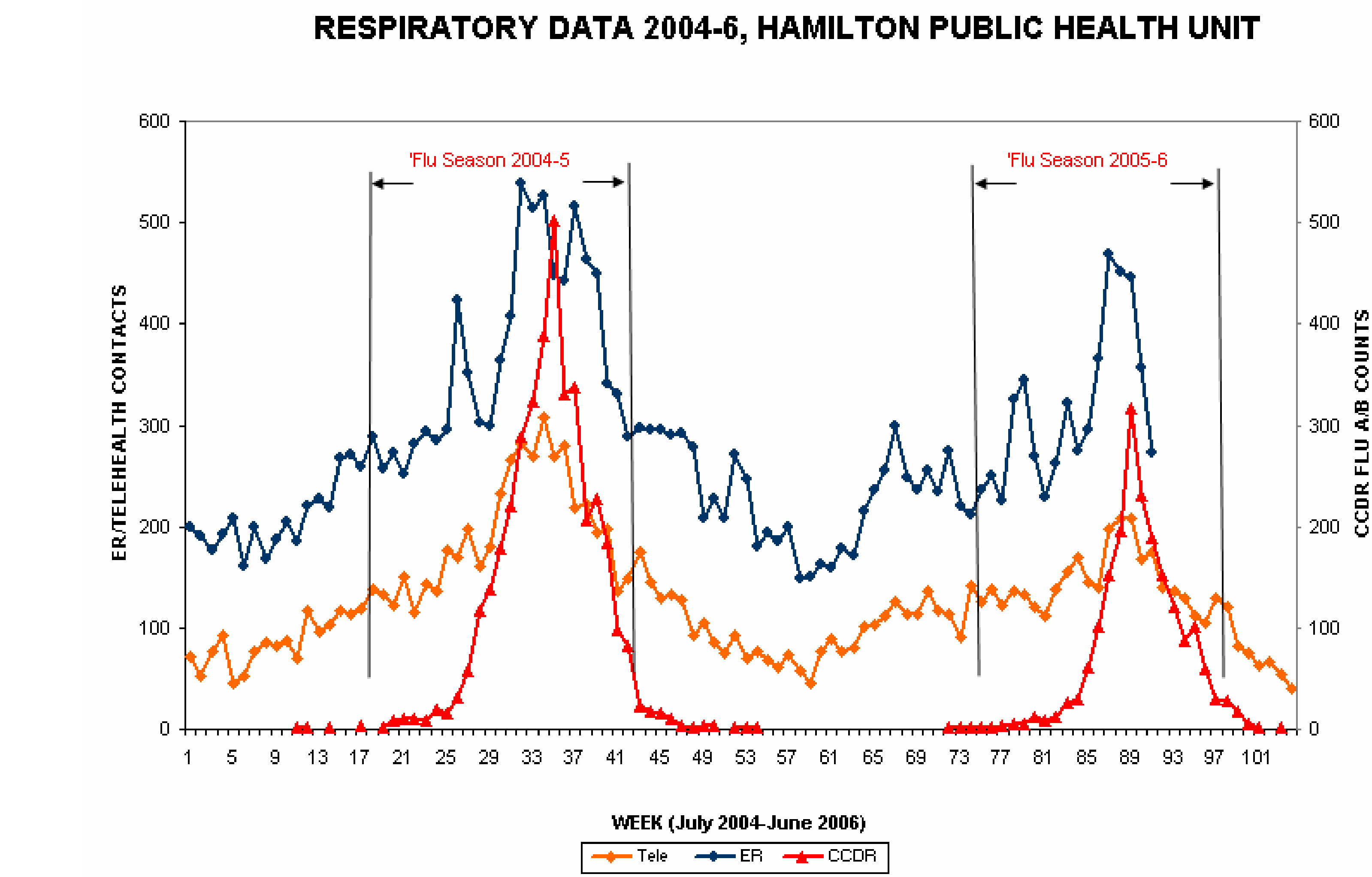
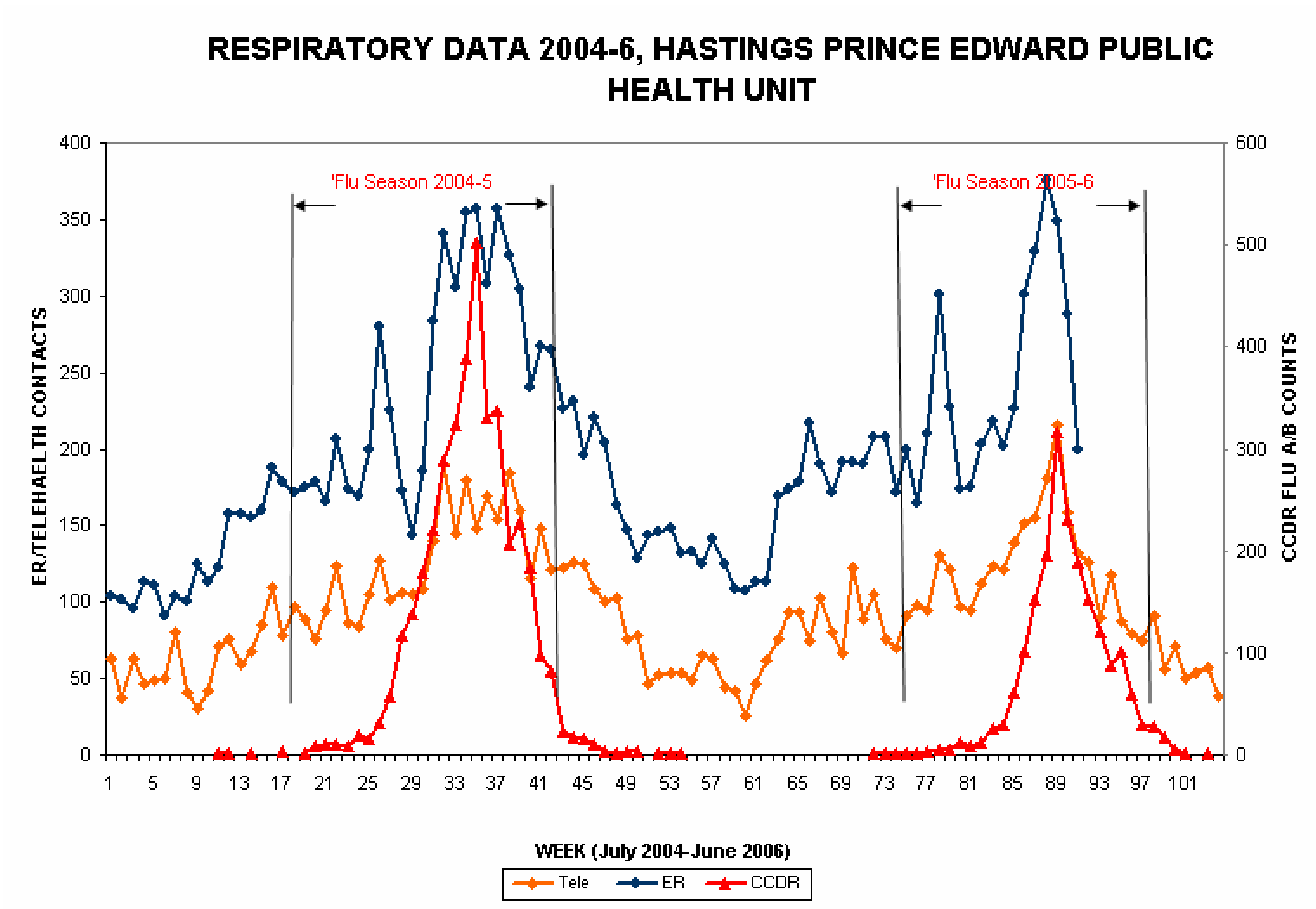
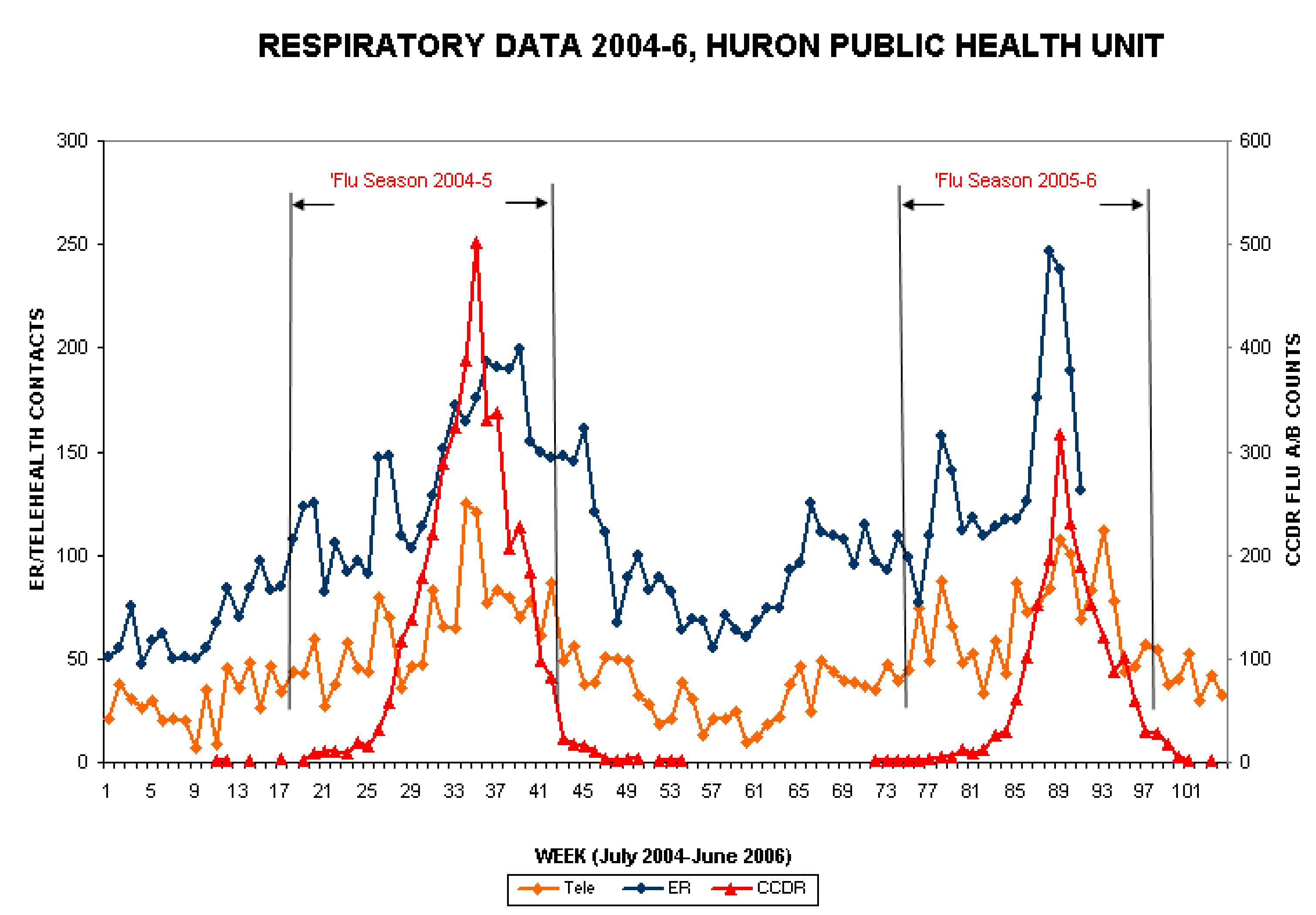


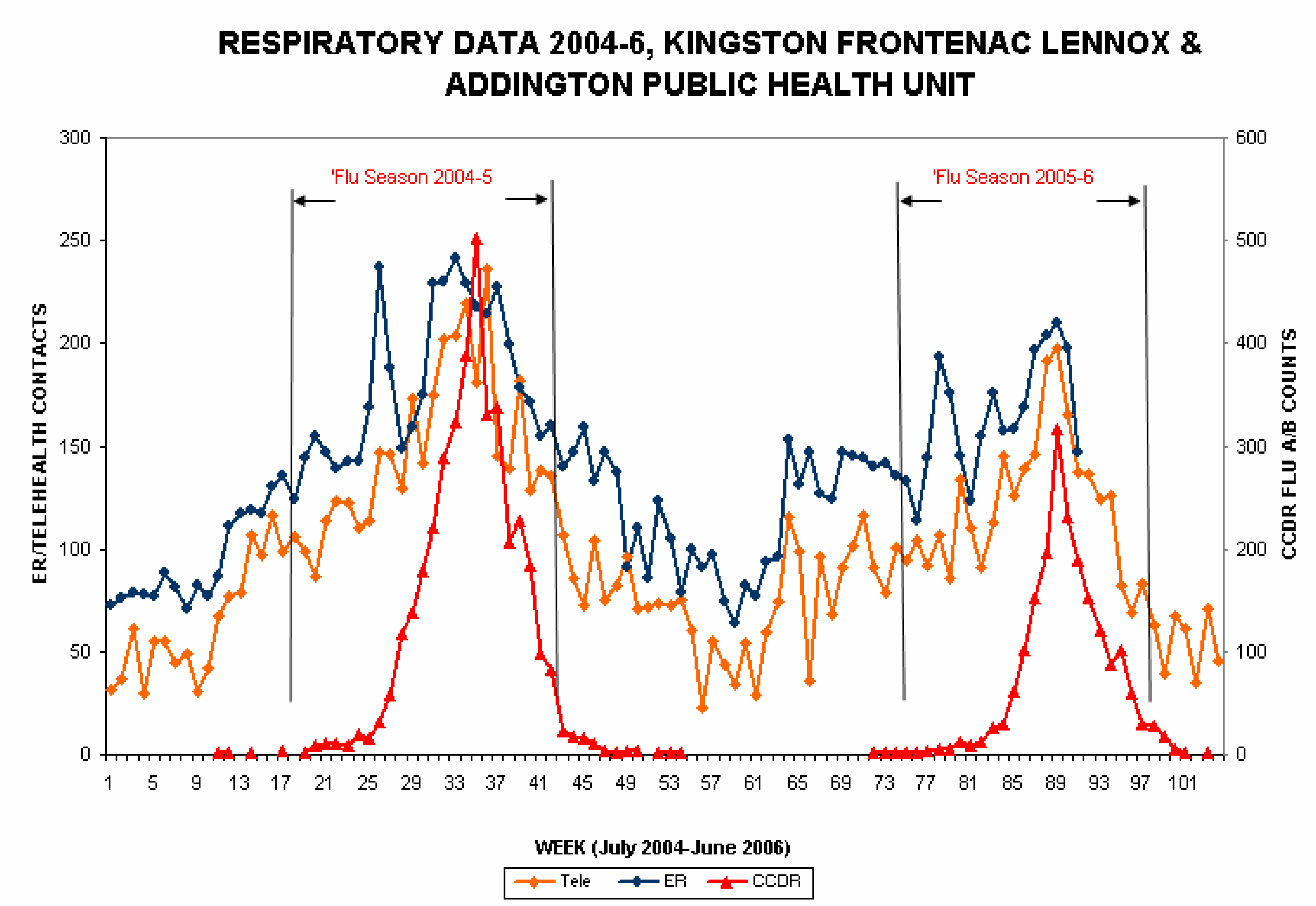
* Telehealth call data multiplied by a factor of two (2).



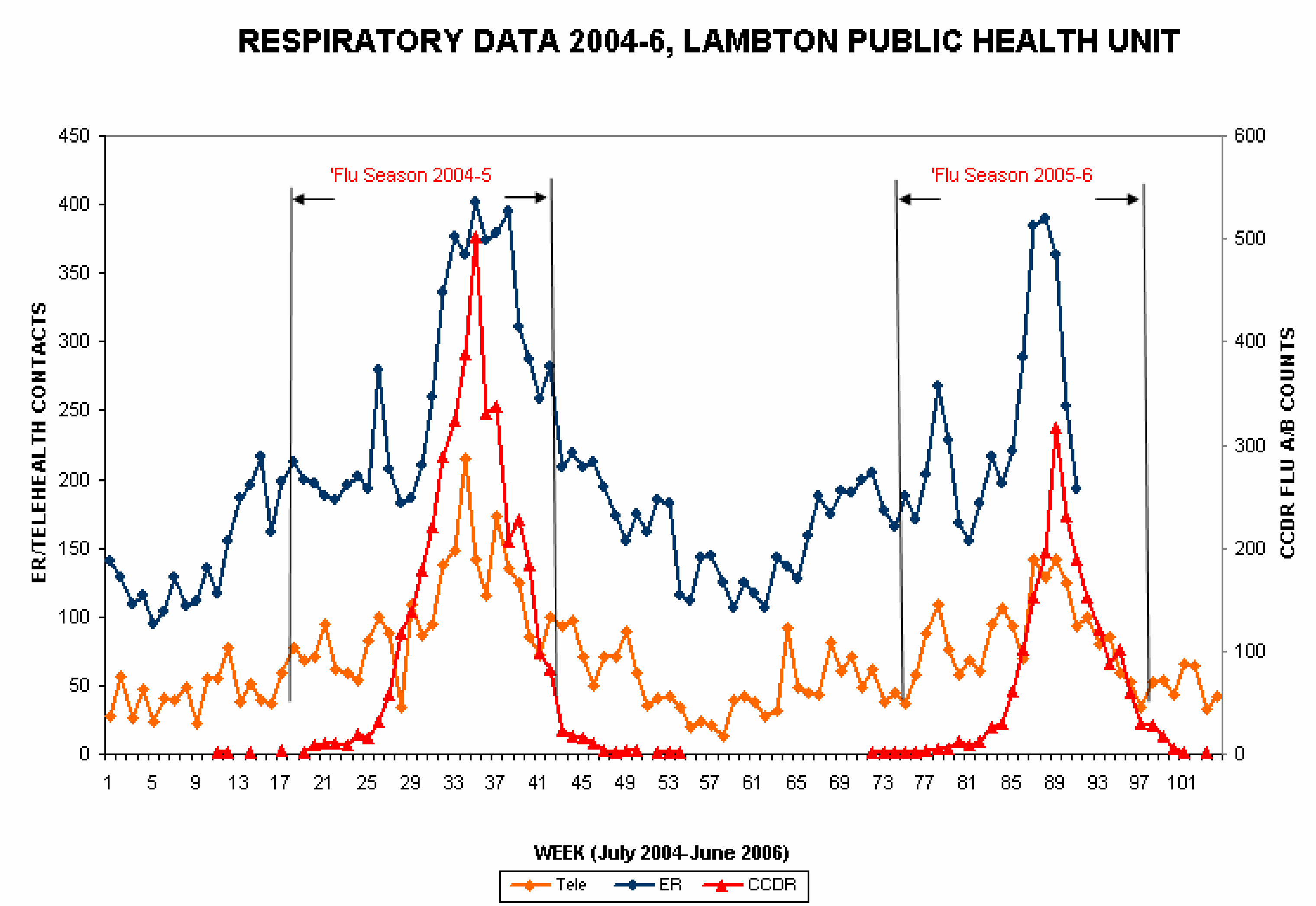
* Telehealth call data multiplied by a factor of three (3).



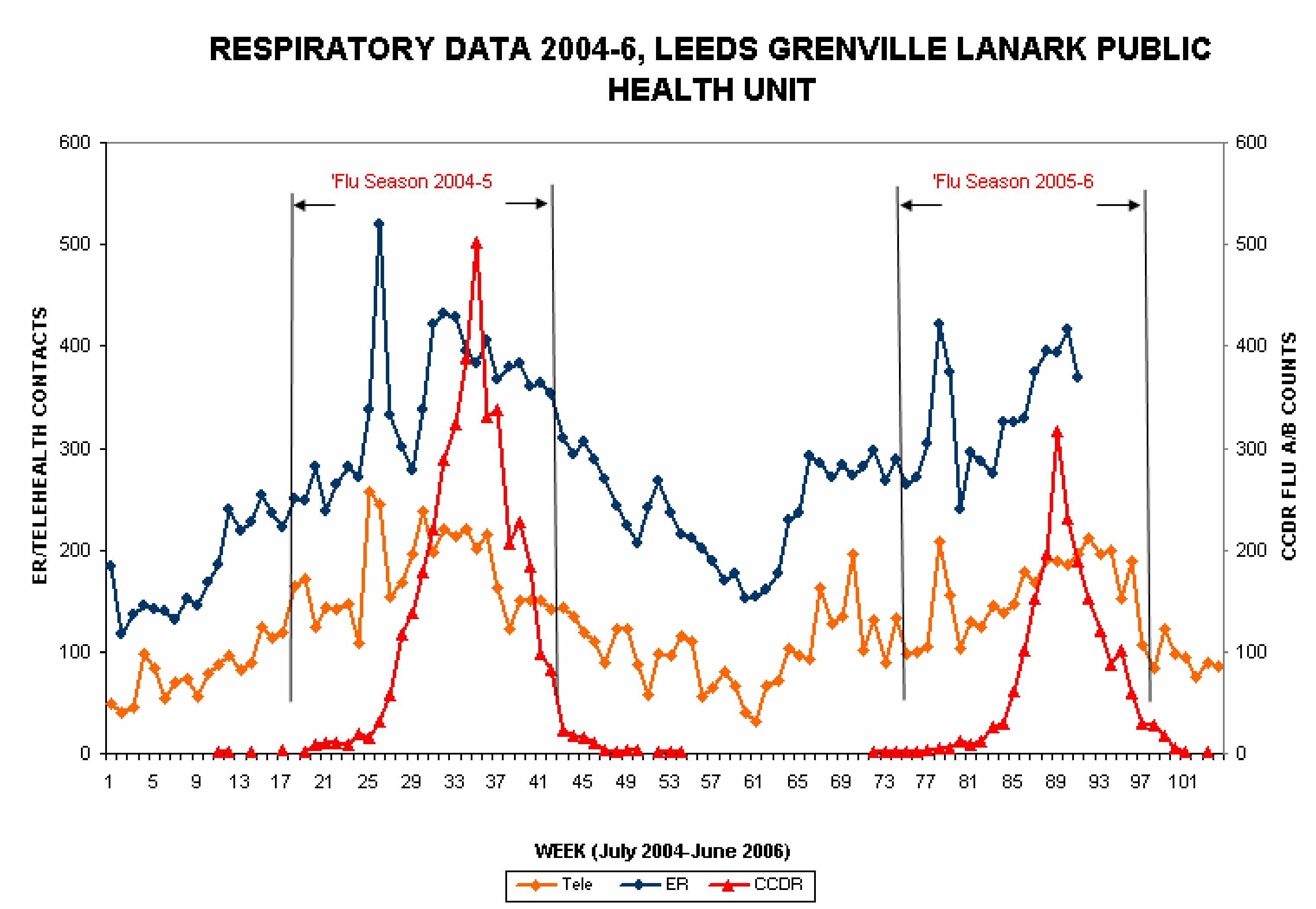
* Telehealth call data multiplied by a factor of six (6).



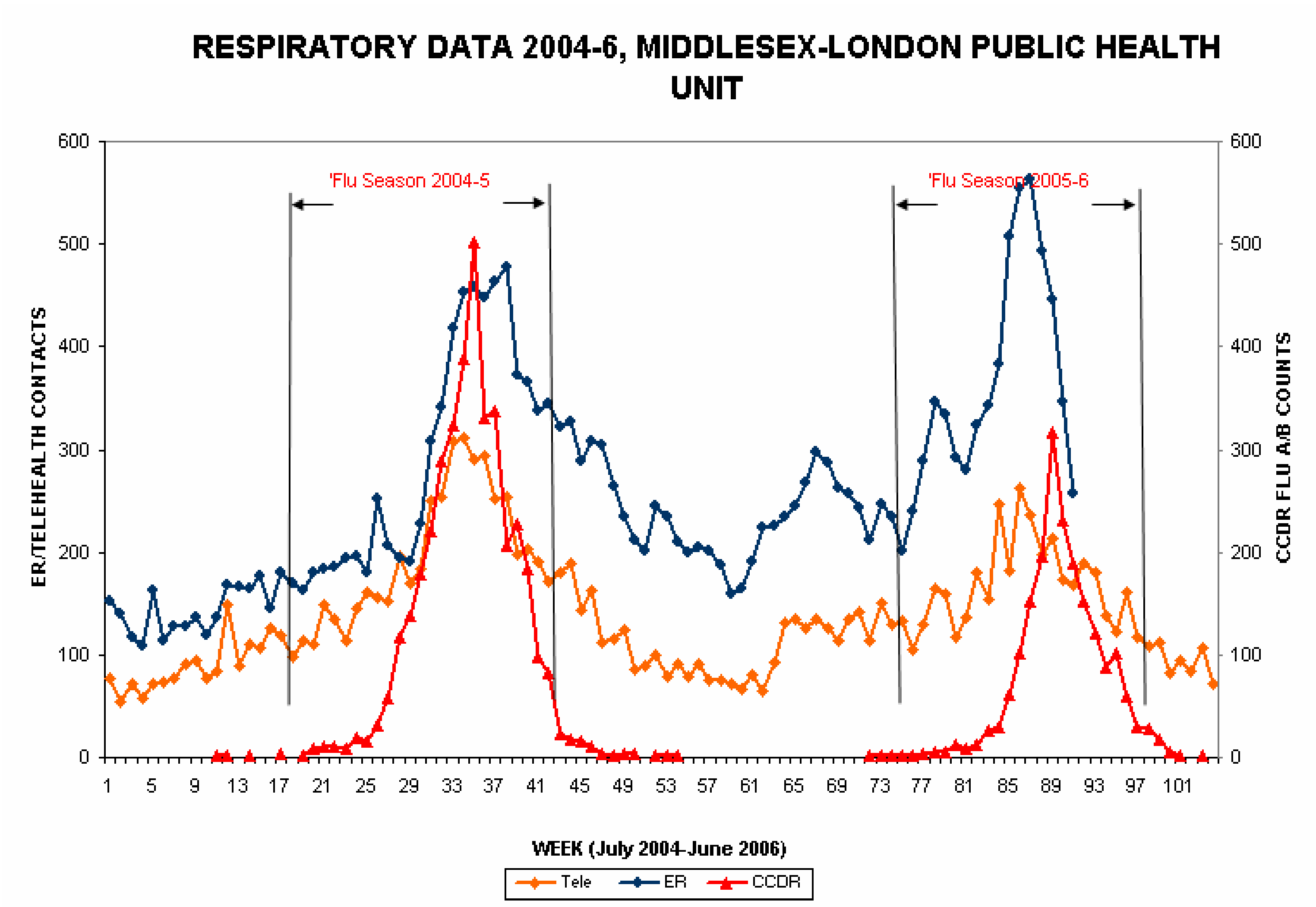
* Telehealth call data multiplied by a factor of six (3).



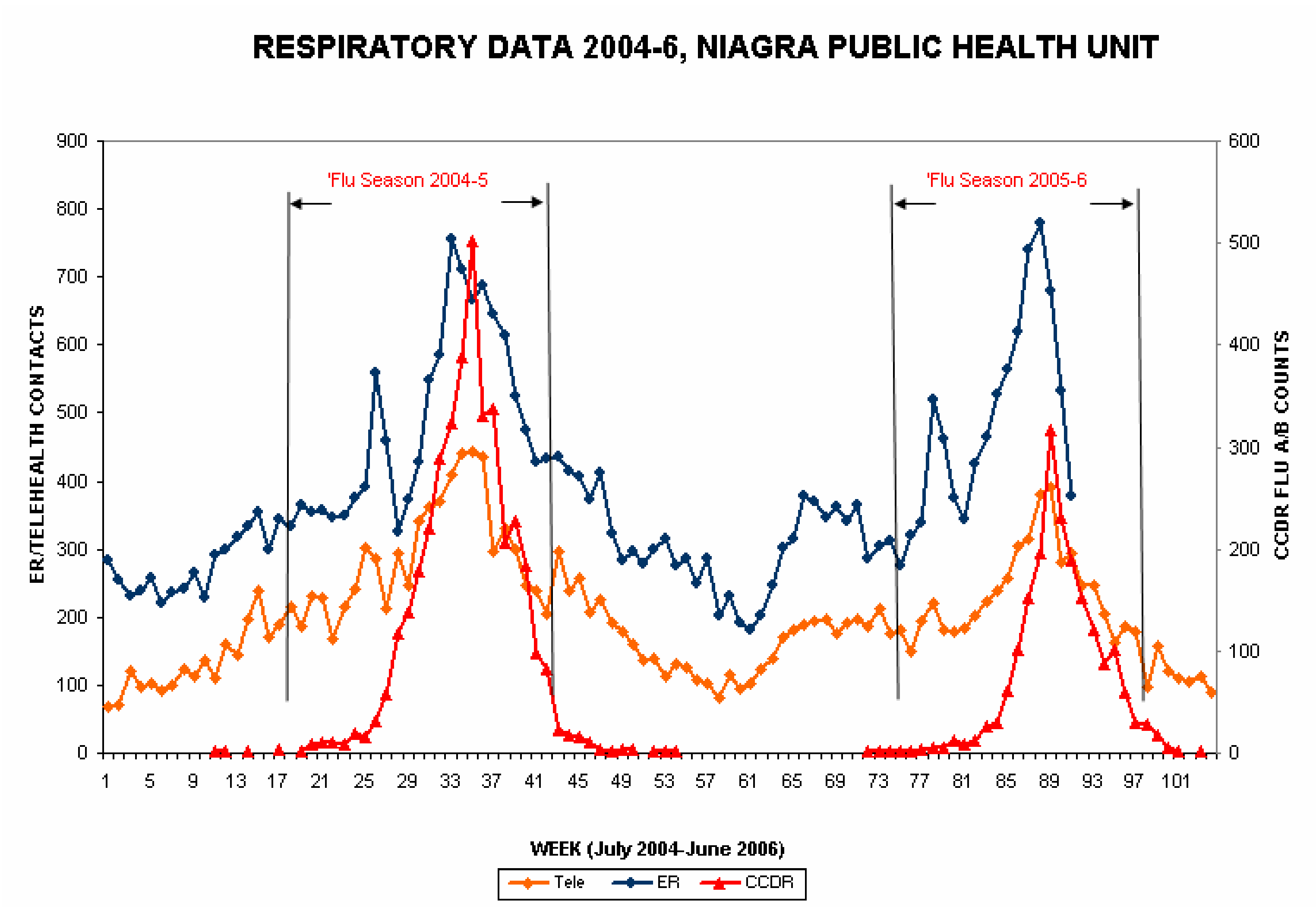
* Telehealth call data multiplied by a factor of three (4).



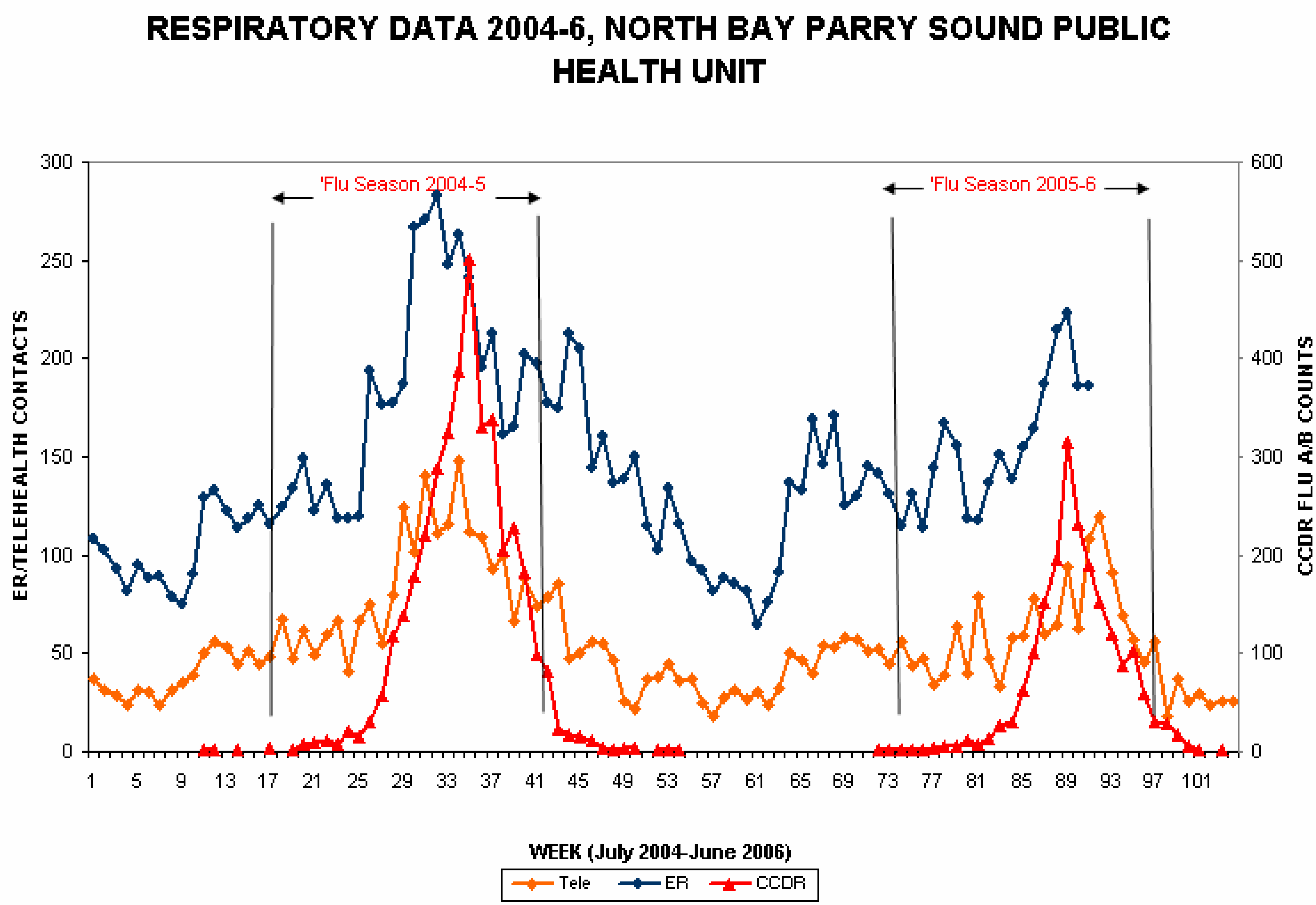
* Telehealth call data multiplied by a factor of four (4).



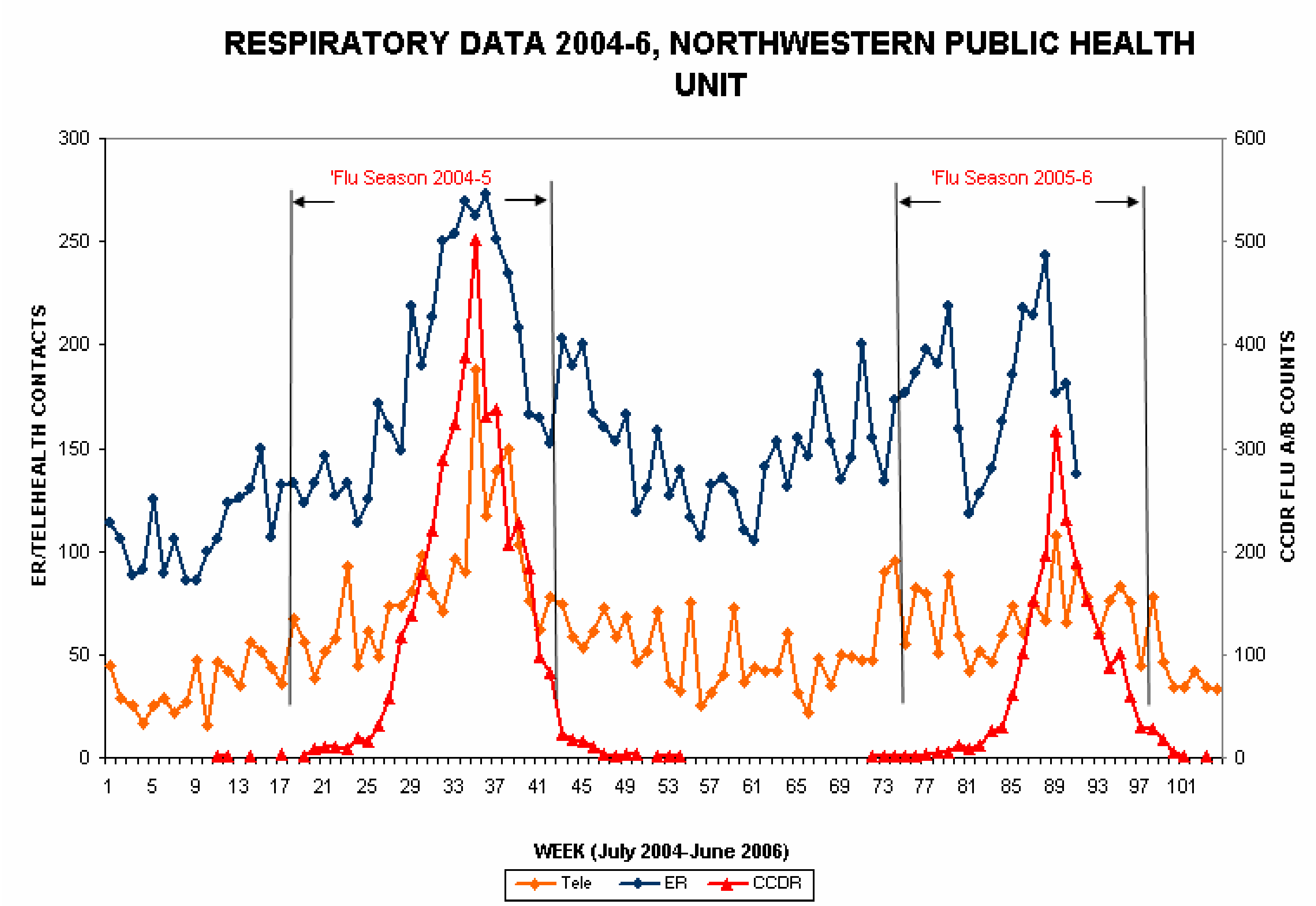
* Telehealth call data multiplied by a factor of four (2).



* Telehealth call data multiplied by a factor of two (3).

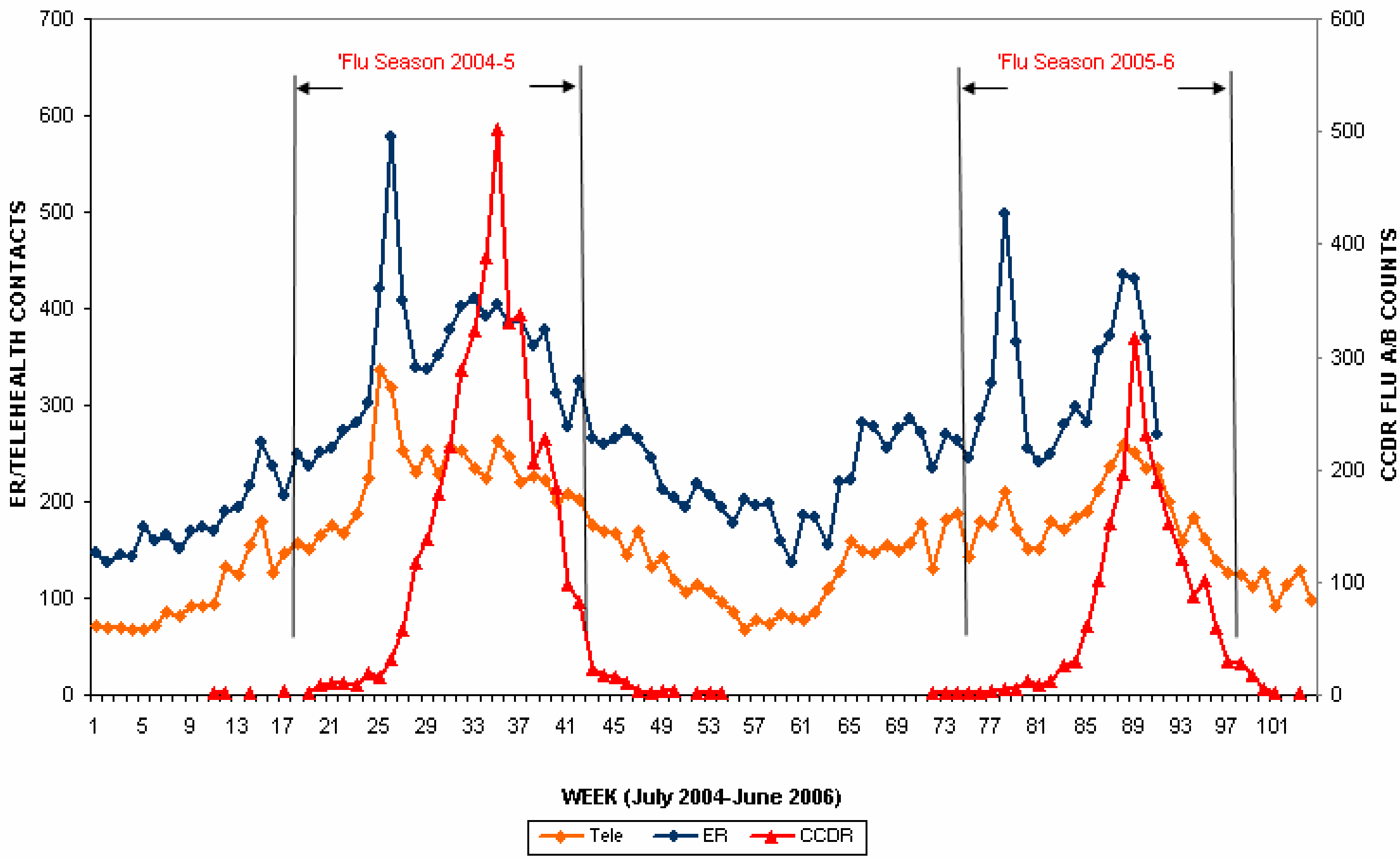


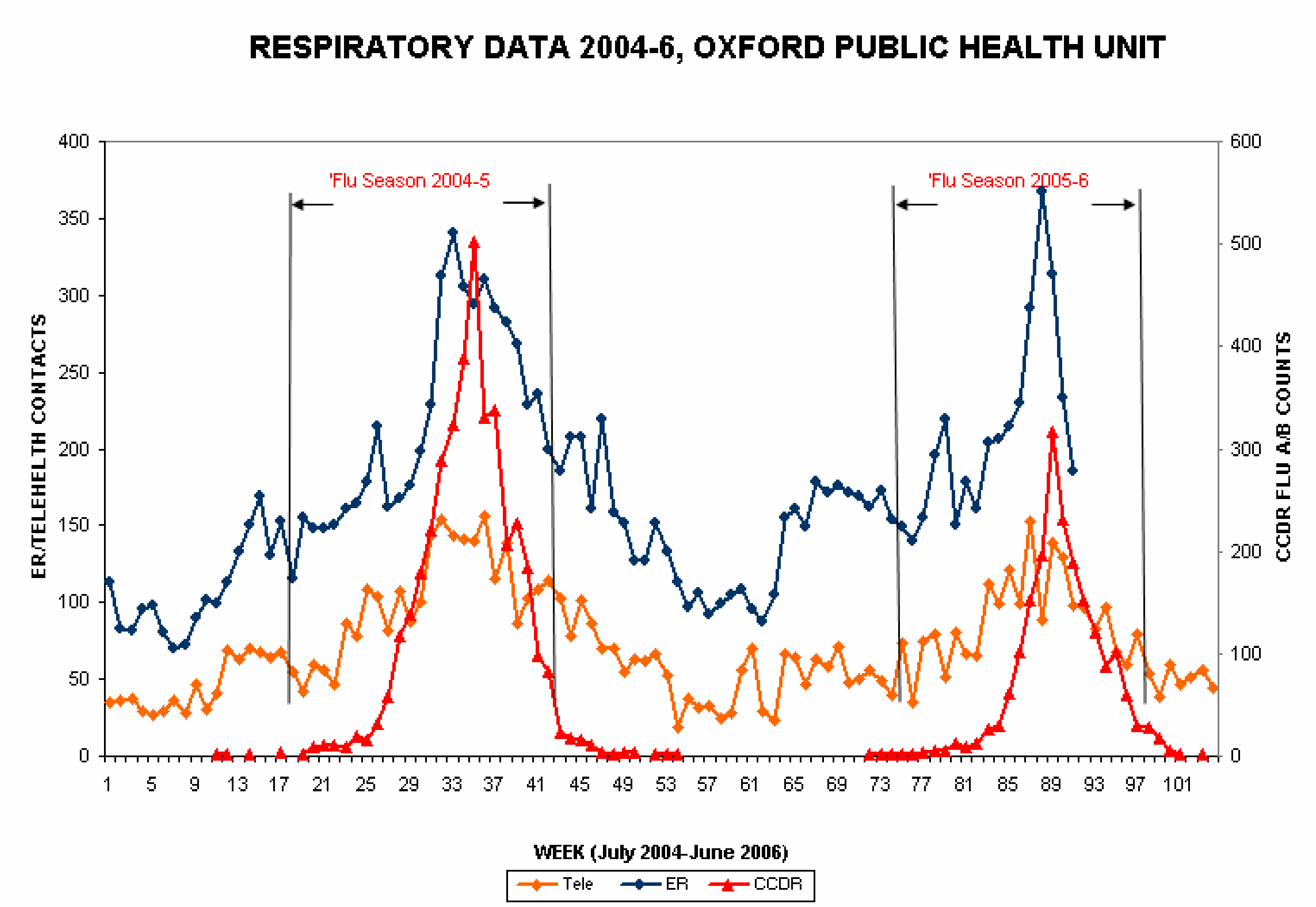
* Telehealth call data multiplied by a factor of two (2).



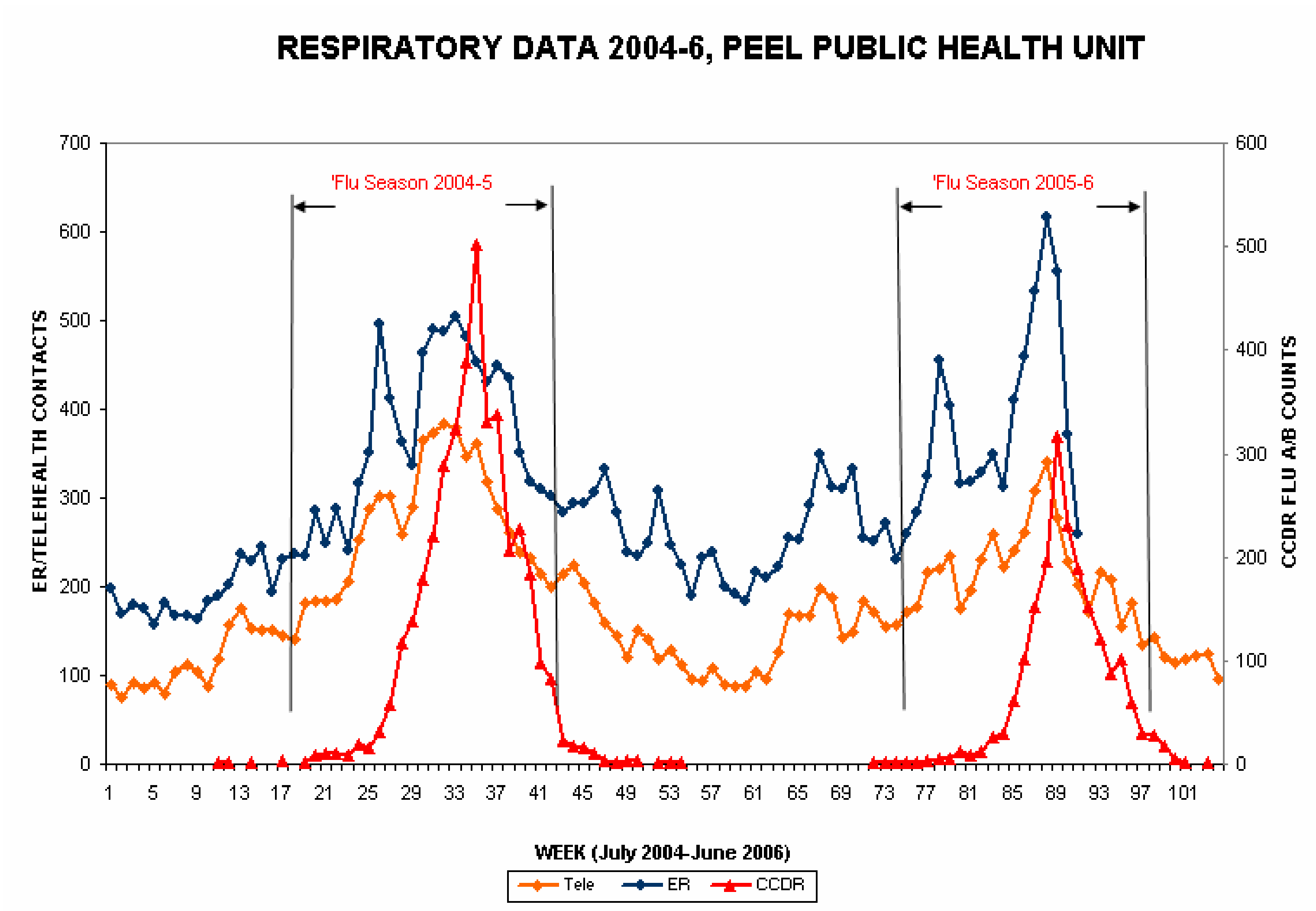
* Telehealth call data multiplied by a factor of three (3).

RESPIRATORY DATA 2004-6, OTTAWA PUBLIC HEALTH UNIT



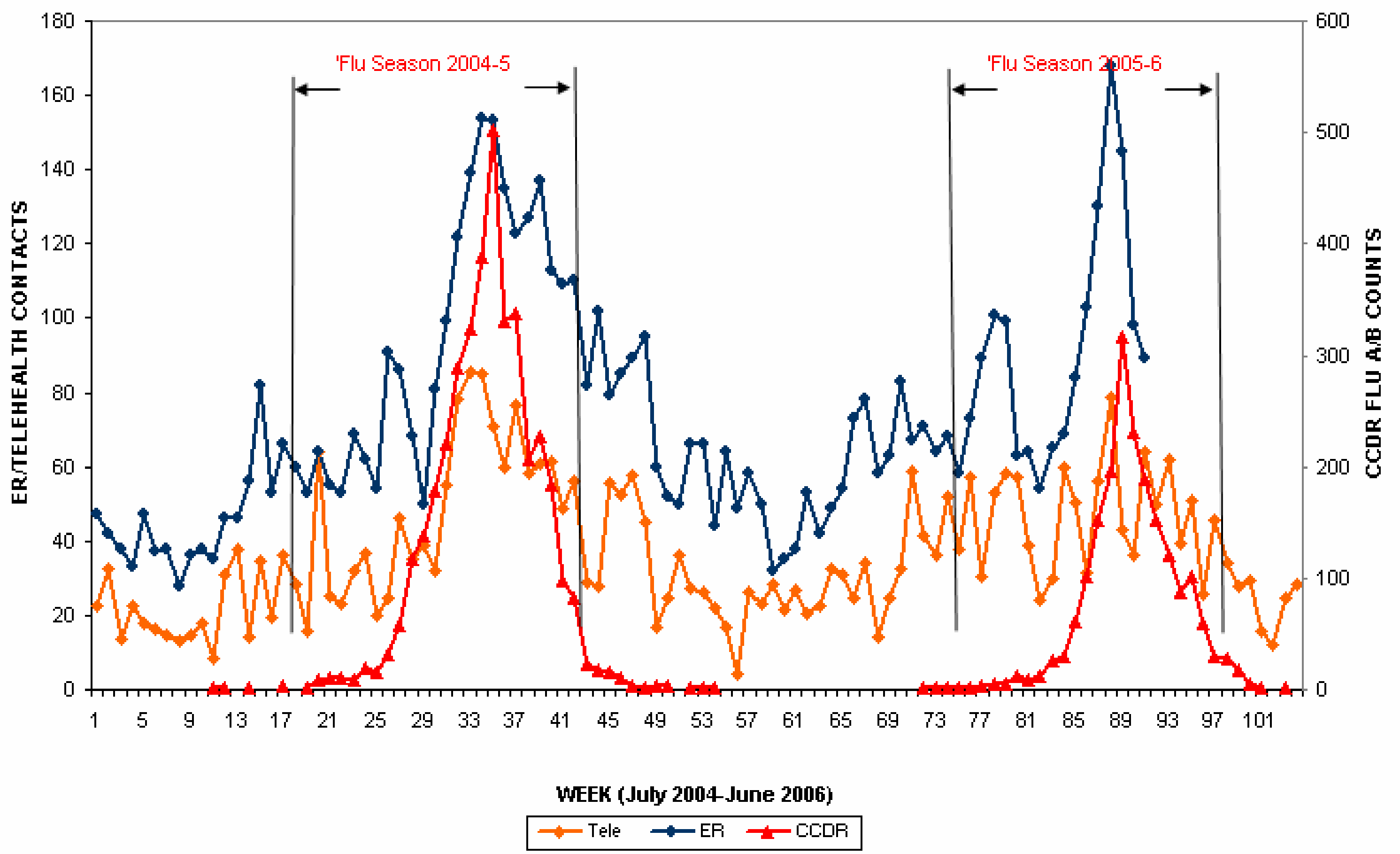


* Telehealth call data multiplied by a factor of three (4).

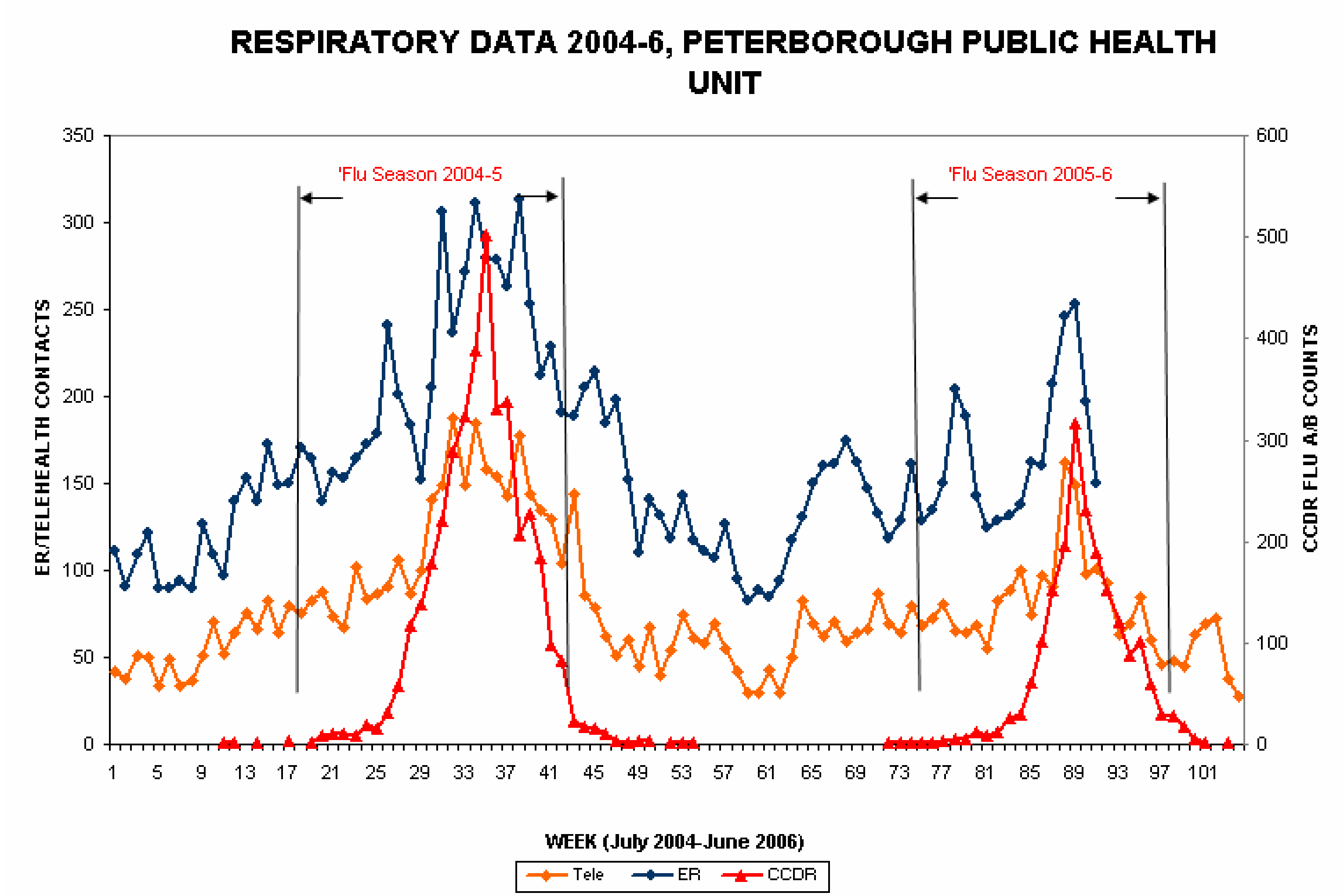


RESPIRATORY DATA 2004-6, PEEL PUBLIC HEALTH UNIT
'Flu Season 2004-5
'Flu Season 2005-6
ER/TELEHEALTH CONTACTS
CCDR FLU A/B COUNTS
0
100
200
300
400
500
600
700
0
100
200
300
400
500
600
1
5
9
13
17
21
25
29
33
37
41
45
49
53
57
61
65
69
73
77
81
85
89
93
97
101
WEEK (July 2004-June 2006)
Tele
ER
CCDR

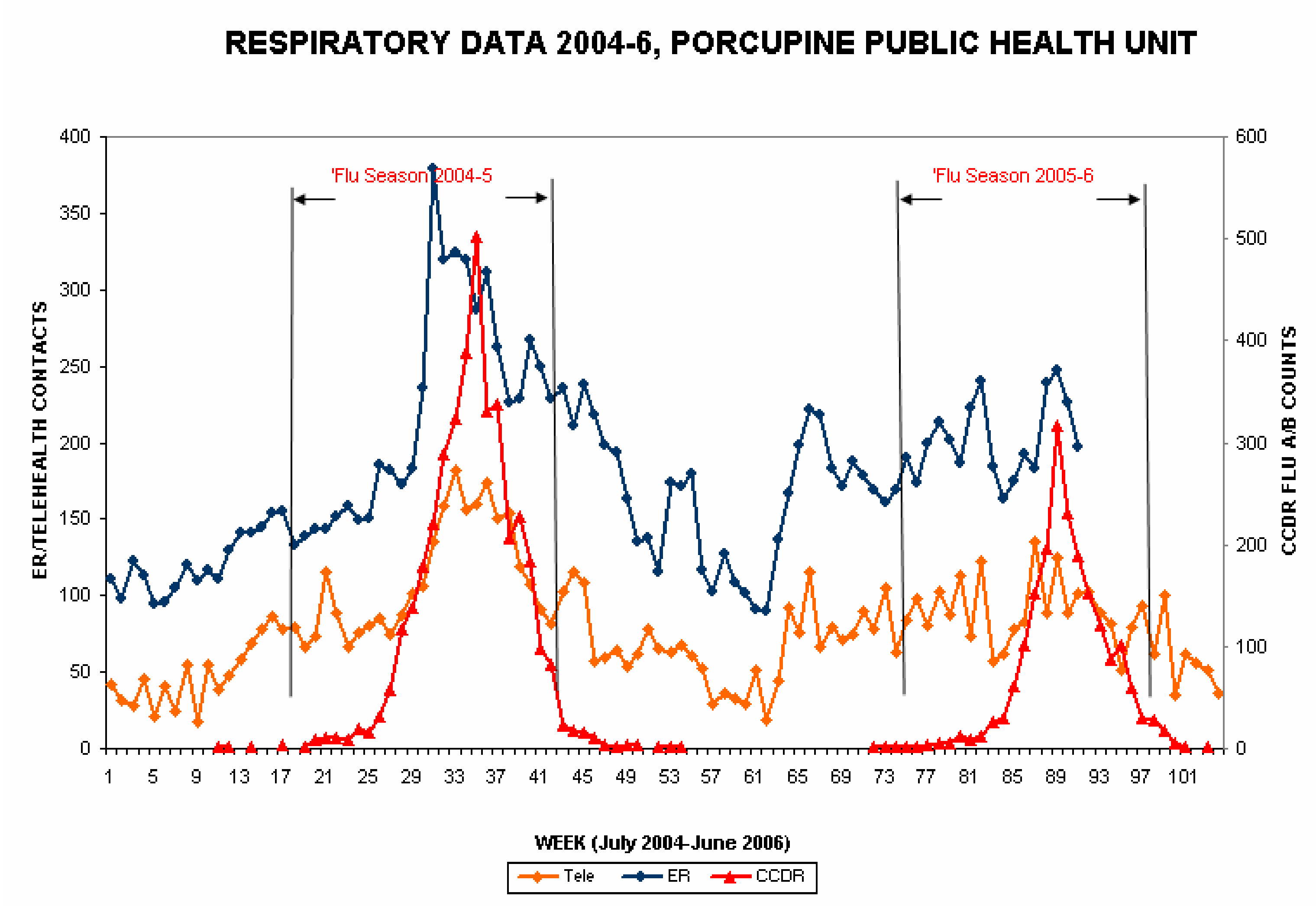
RESPIRATORY DATA 2004-6, PERTH PUBLIC HEALTH UNIT



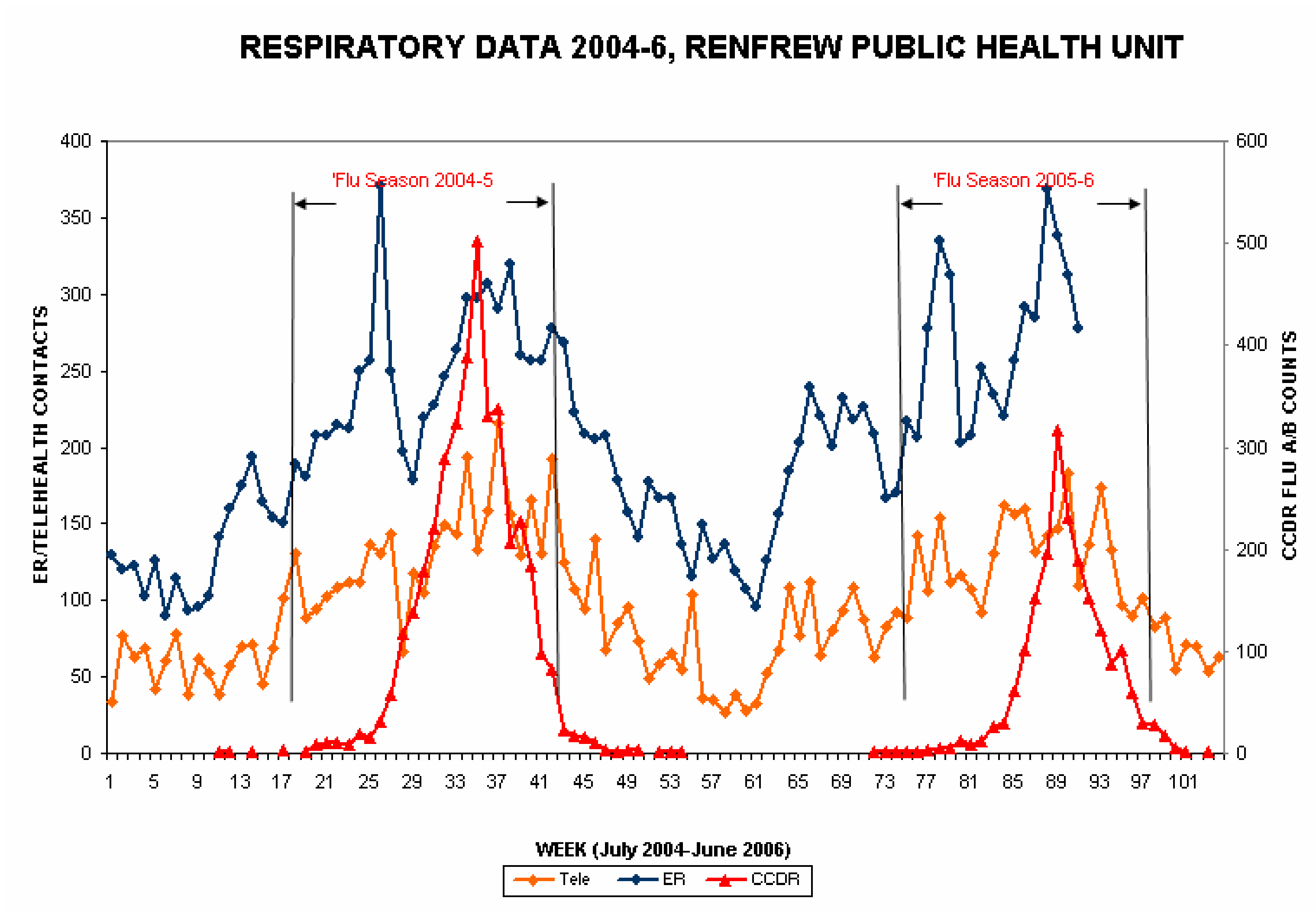
* Telehealth call data multiplied by a factor of three (3).



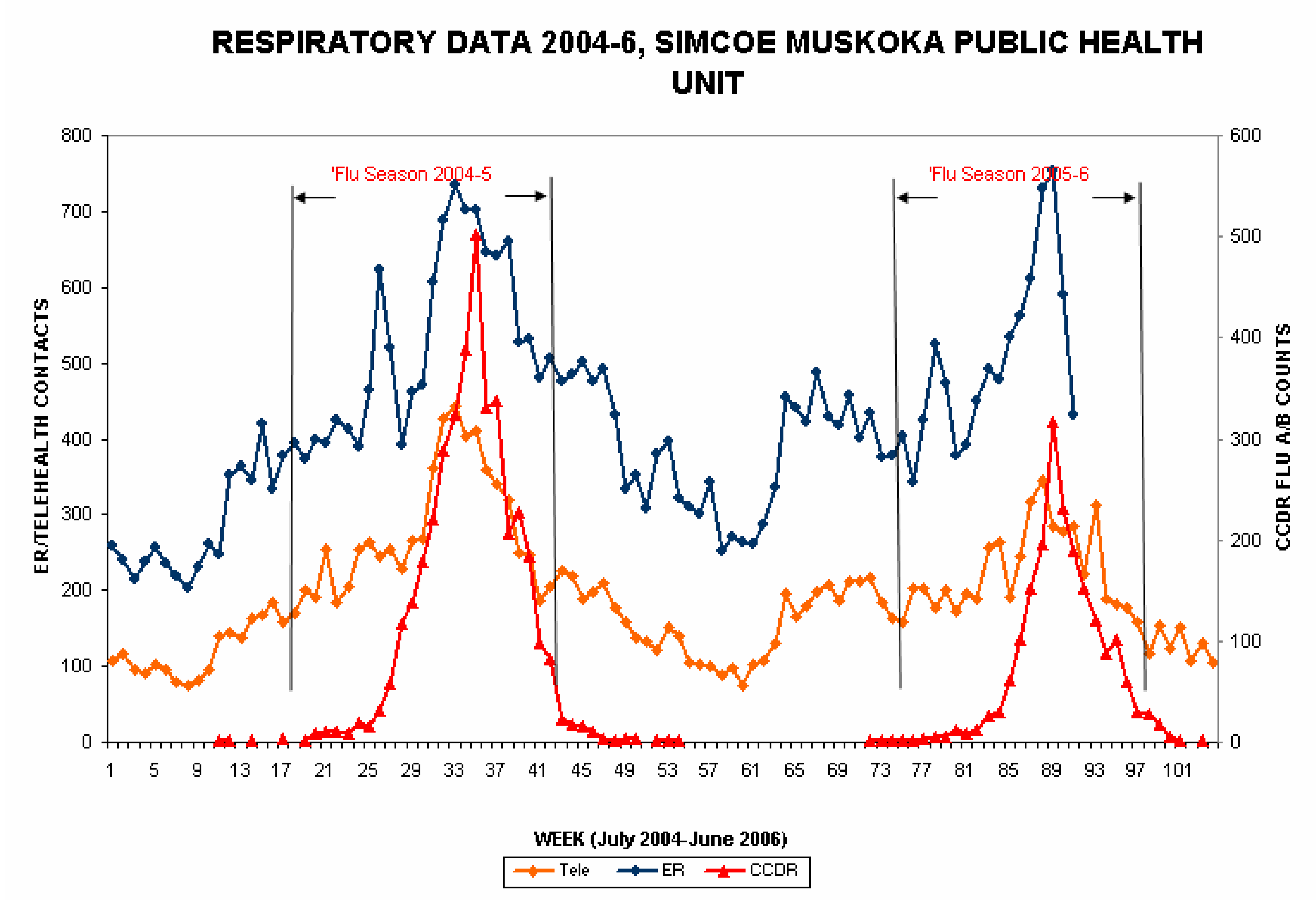
* Telehealth call data multiplied by a factor of two (3).



* Telehealth call data multiplied by a factor of four (4).

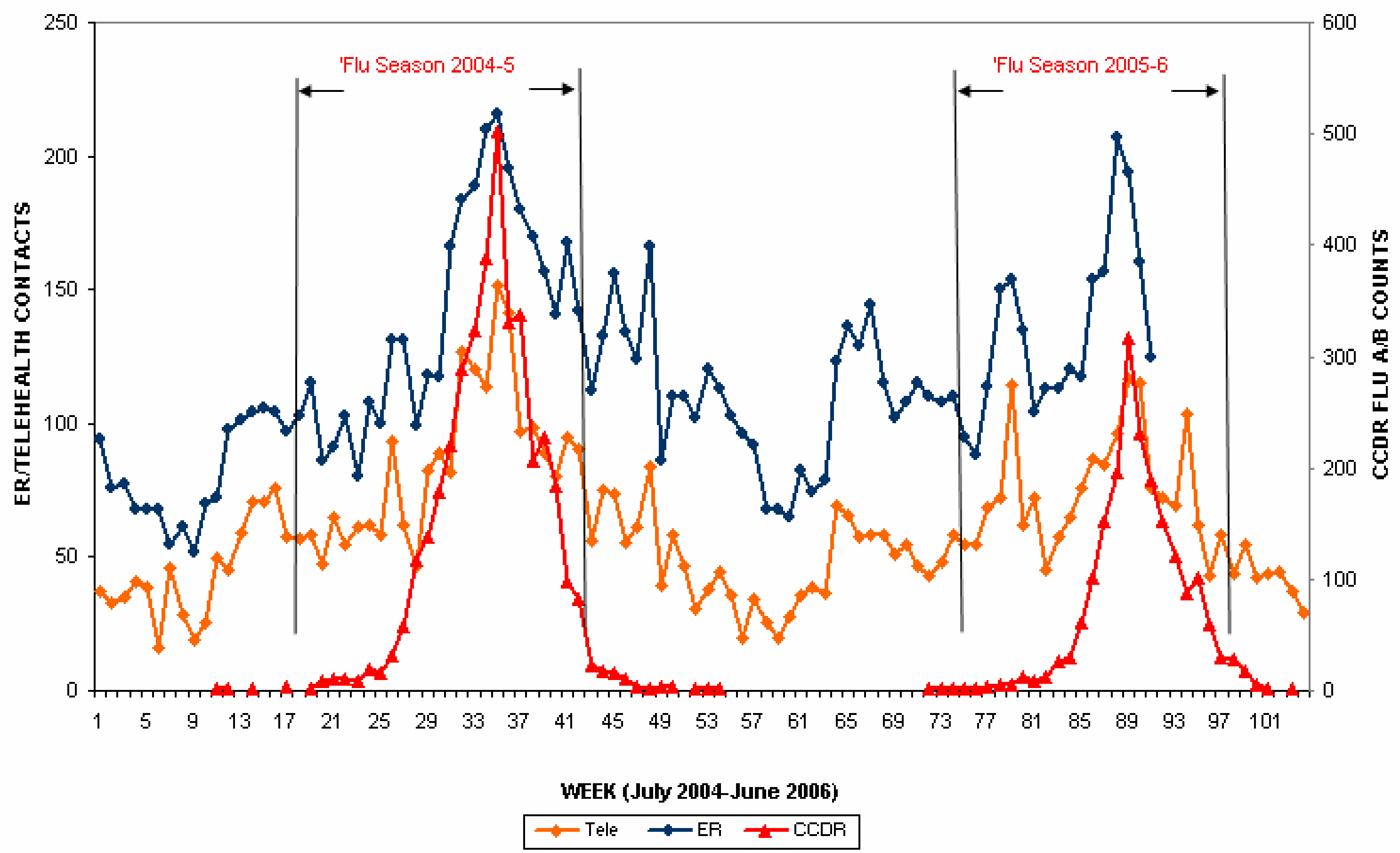


* Telehealth call data multiplied by a factor of five (5).



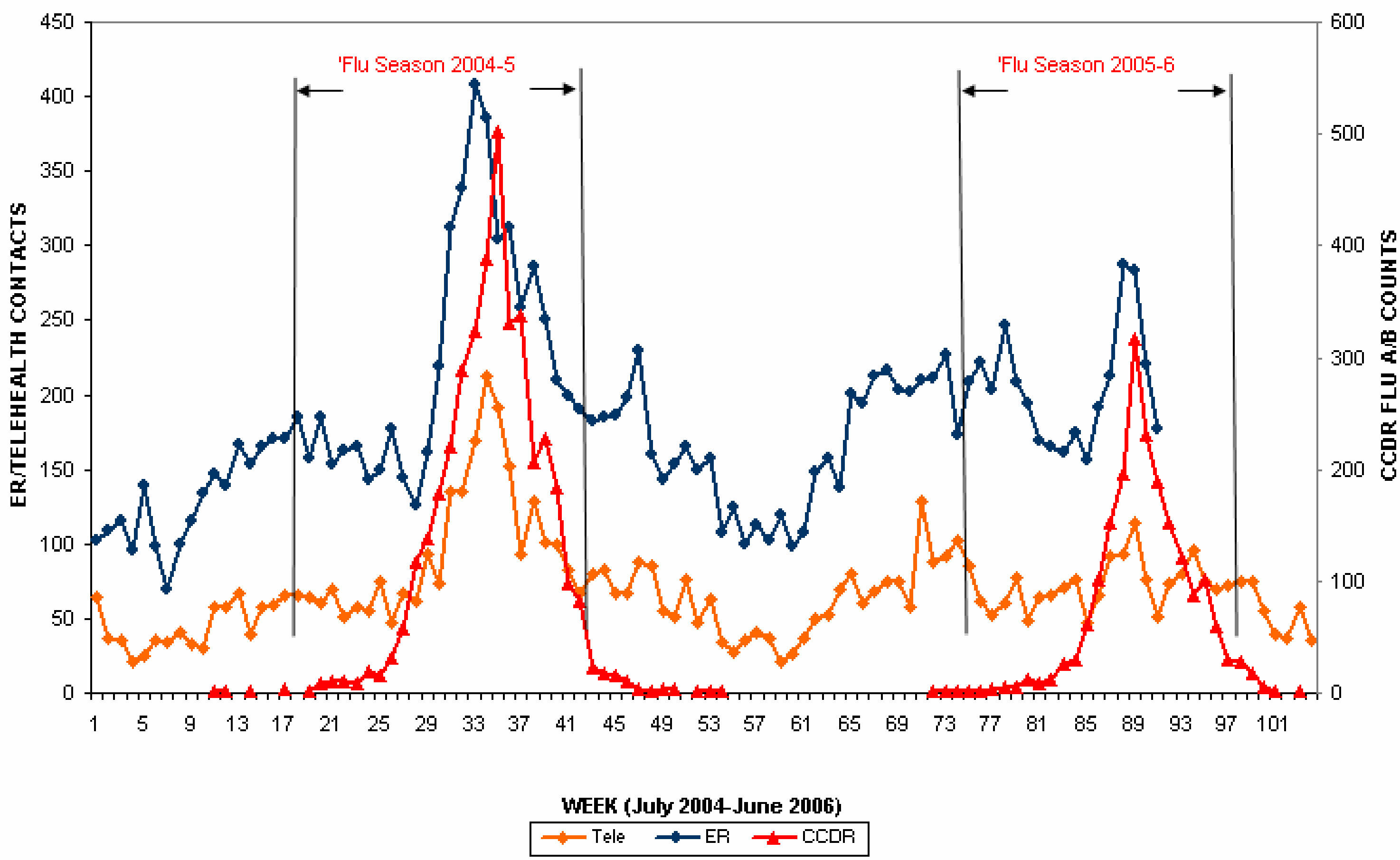
* Telehealth call data multiplied by a factor of two (2).

RESPIRATORY DATA 2004-6, SUDBURY PUBLIC HEALTH UNIT



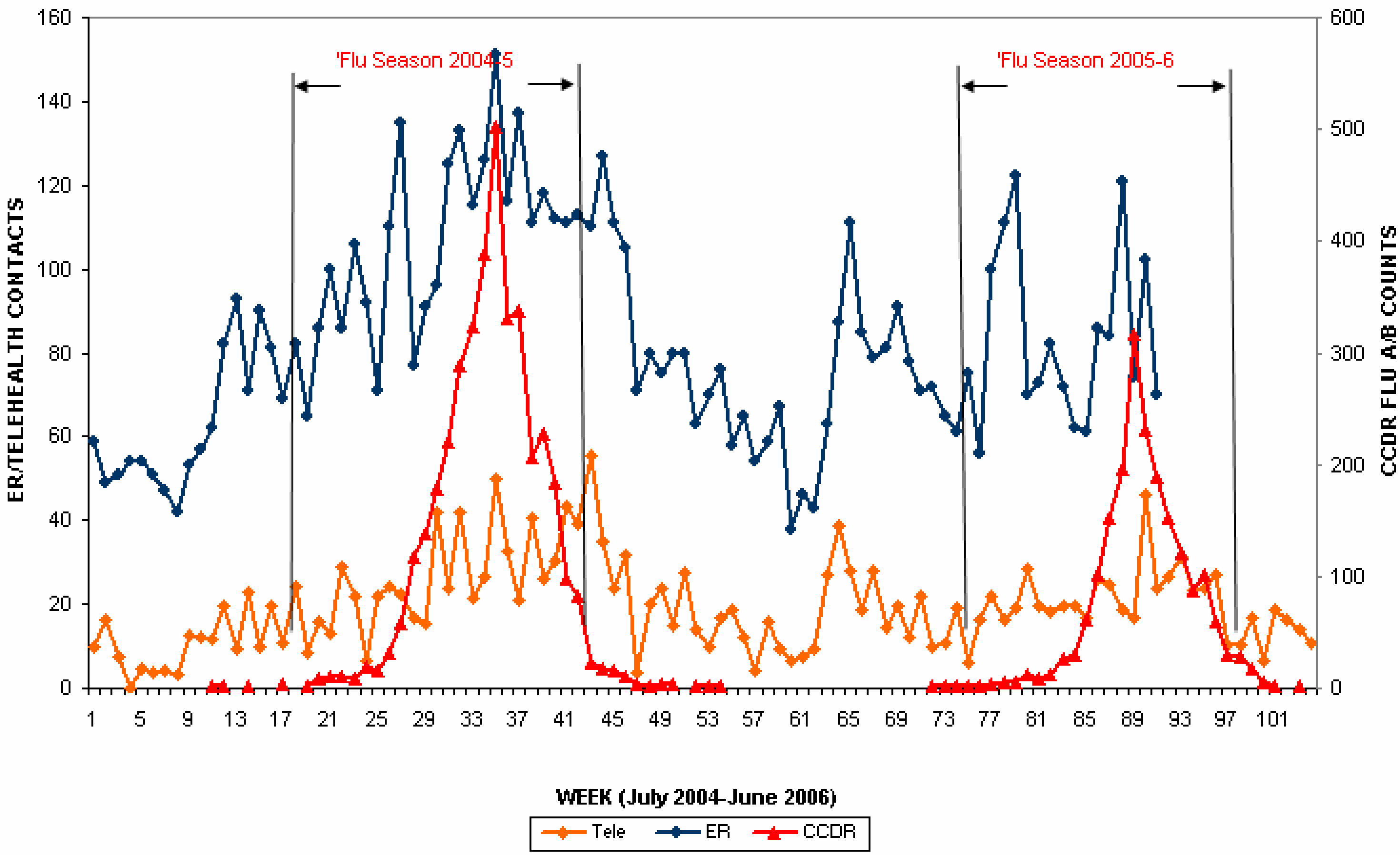
* Telehealth call data multiplied by a factor of two (2).

RESPIRATORY DATA 2004-6, THUNDER BAY PUBLIC HEALTH UNIT

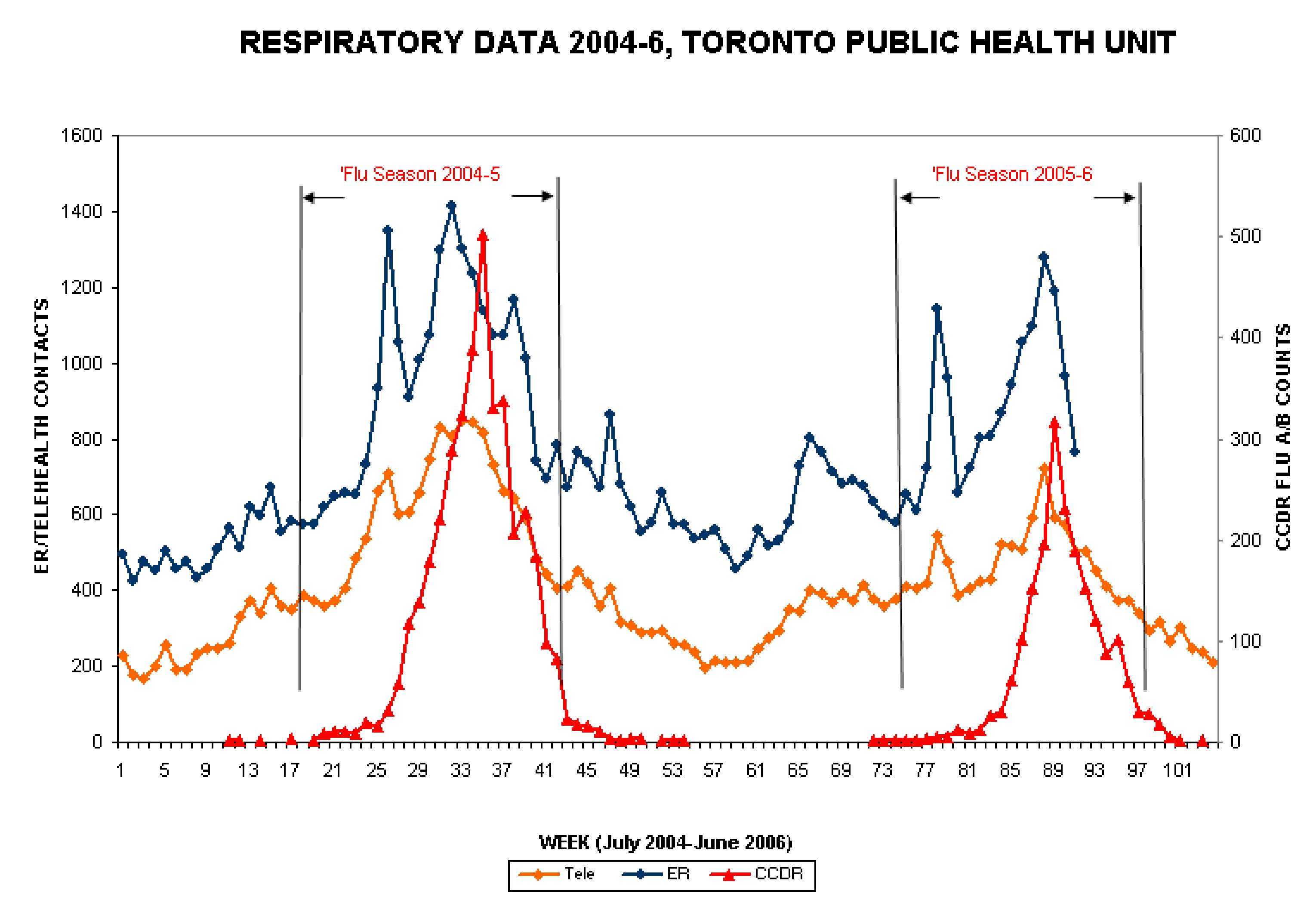


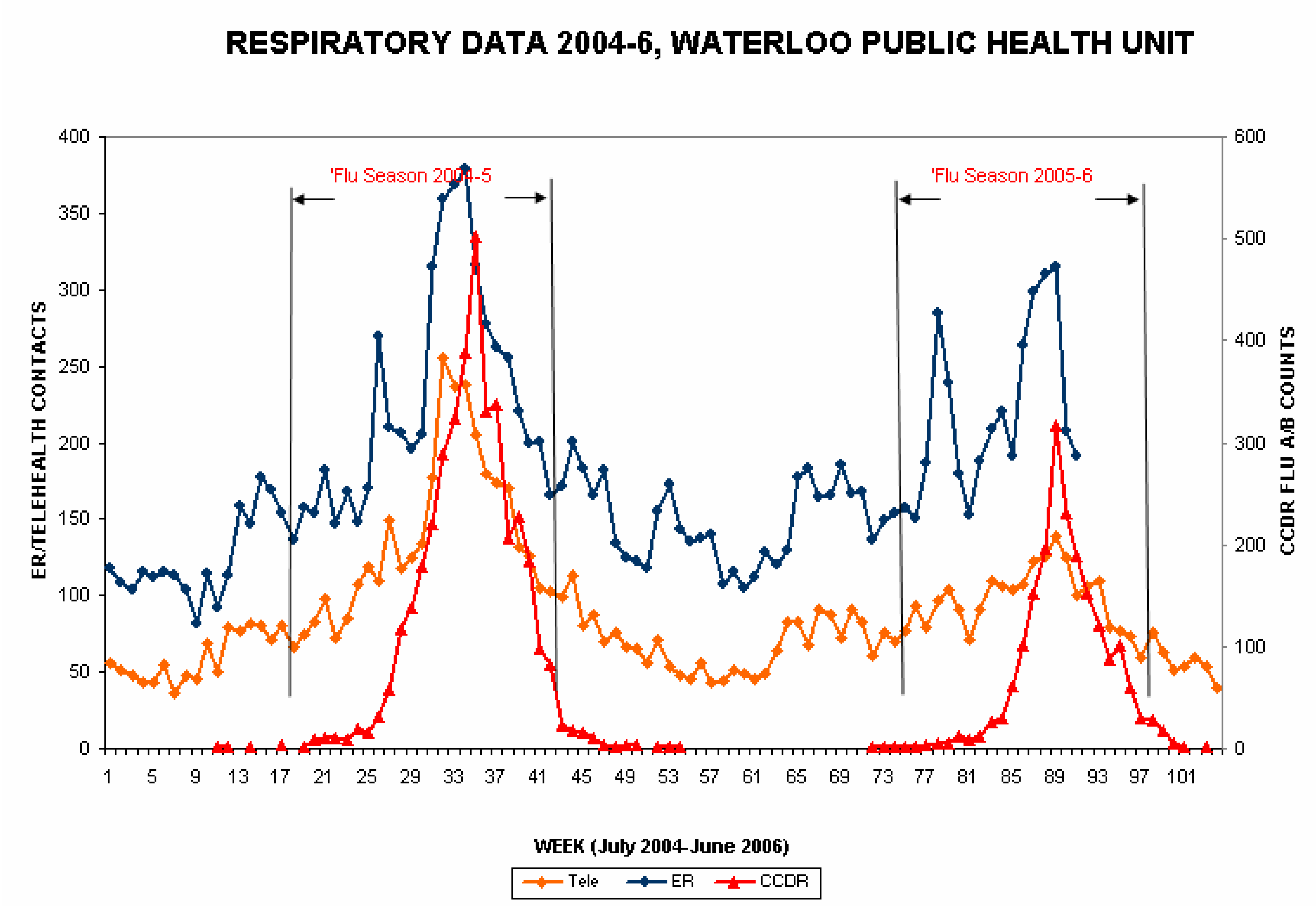
* Telehealth call data multiplied by a factor of two (2).

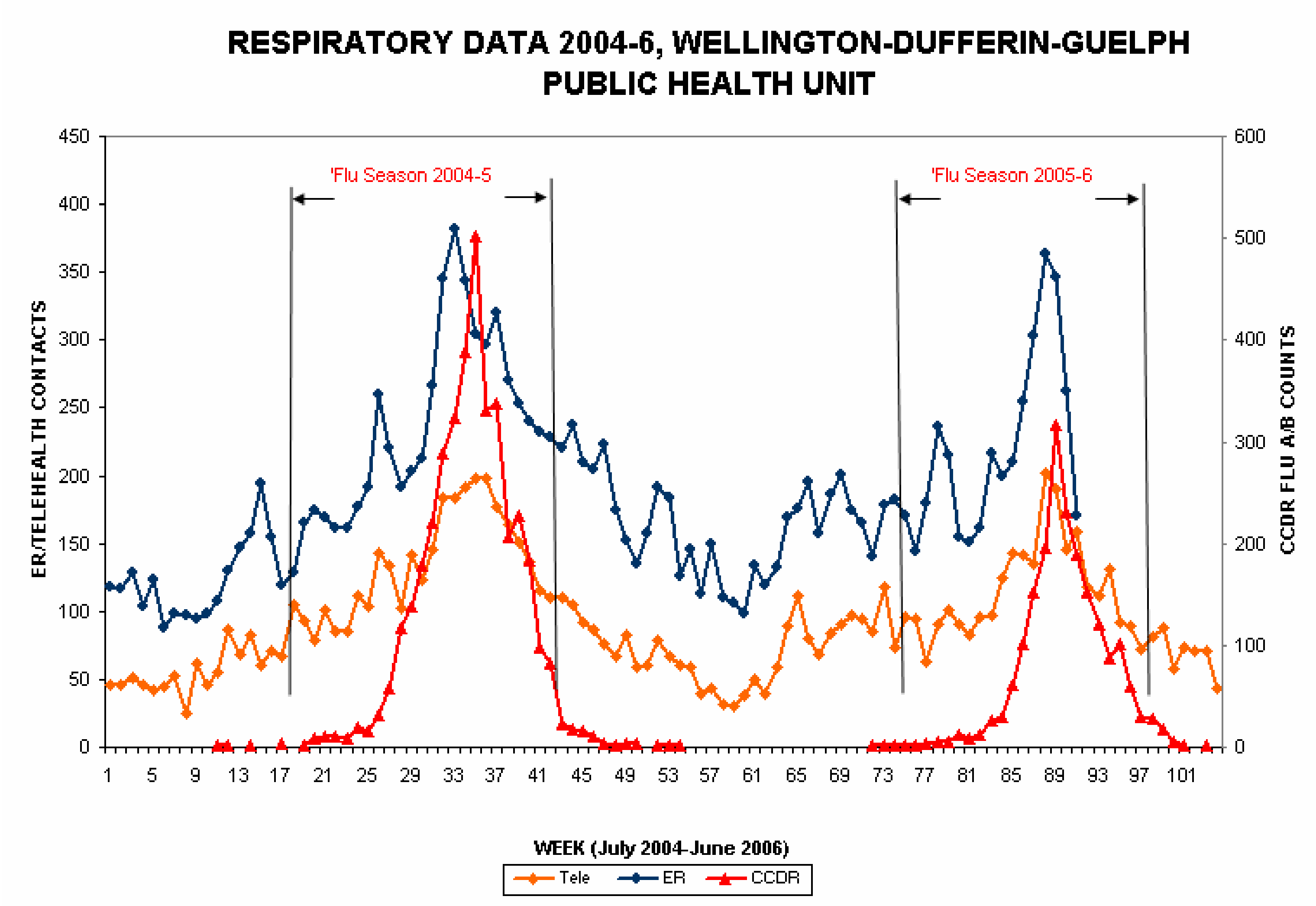
RESPIRATORY DATA 2004-6, TIMISKAMING PUBLIC HEALTH UNIT



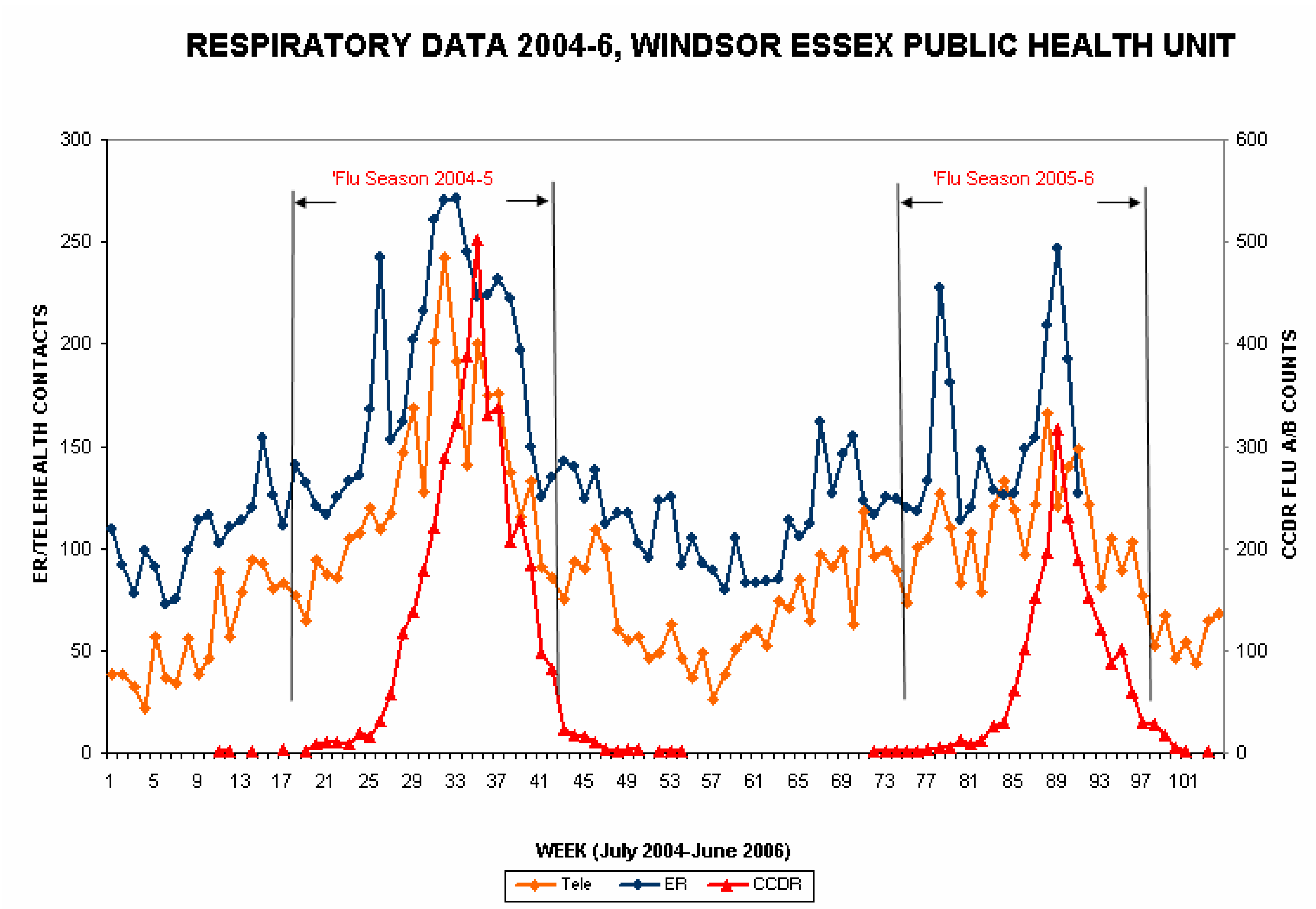
* Telehealth call data multiplied by a factor of three (3).


RESPIRATORY DATA 2004-6, TORONTO PUBLIC HEALTH UNIT
'Flu Season 2004-5
'Flu Season 2005-6
ER/TELEHEALTH CONTACTS
CCDR FLU A/B COUNTS
0
200
400
600
800
1000
1200
1400
1600
100
300
500
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101
WEEK (July 2004-June 2006)
Tele
ER
CCDR

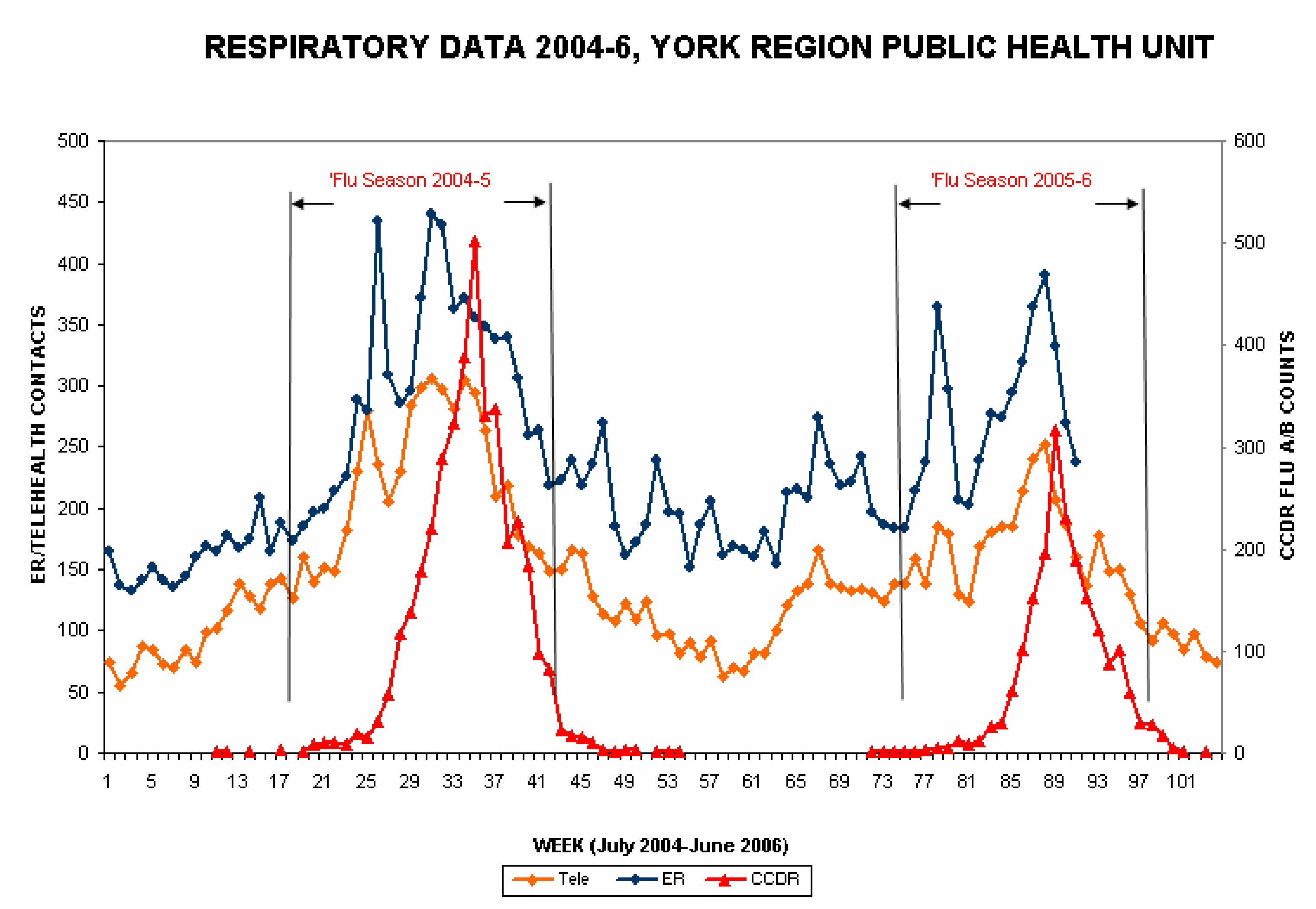

RESPIRATORY DATA 2004-6, WATERLOO PUBLIC HEALTH UNIT
'Flu Season 2004-5
'Flu Season 2005-6
ER/TELEHEALTH CONTACTS
CCDR FLU A/B COUNTS
WEEK (July 2004-June 2006)
Tele
ER
CCDR



* Telehealth call data multiplied by a factor of two (2).



* Telehealth call data multiplied by a factor of two (2).


RESPIRATORY DATA 2004-6, YORK REGION PUBLIC HEALTH UNIT
'Flu Season 2004-5
'Flu Season 2005-6
ER/TELEHEALTH CONTACTS
CCDR FLU A/B COUNTS
WEEK (July 2004-June 2006)
Tele
ER
CCDR

CHAPTER 6: Telehealth detection of gastrointestinal illness: An early warning system for bioterrorism

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2 Queen's University Public Health Informatics (QPHI) Team, Kingston, Canada
3 Infectious Disease Epidemiology Unit, London School of Hygiene and Tropical Medicine, London, UK
4 Department of Emergency Medicine and Community Health and Epidemiology, Queen's University, Canada

Introduction

In the post 9-11 era, the threat of bioterrorism looms large[1]. International terrorist activities have highlighted our lack of preparedness for biological attacks and have focused the attention of local and national health resources on methods to enhance detection of an event[2-6]. In North America, water supply and distribution systems and the food industry represent potential targets for terrorist activity because of the essential roles these industries play in day-to-day life and the relative ease of intentional contamination[2,7-10]. The United States government intelligence experts classify the threat to municipal water supplies as low probability but one with severe medical, public health and economic effects[11]. Terrorism through intentional food and water tampering has already occurred in the United States. In 1984 *Salmonella* contamination of salad bars was used to affect voter turnout at a local election and in 1997 a laboratory worker intentionally contaminated a co-worker's food with *Shigella*[12,13]. Health care providers must maintain a high index of suspicion for bioterrorism because intentional outbreaks may resemble naturally occurring disease and involve endemic pathogens.

The globalization of food production and centralization of food and water distribution have markedly increased society's risk of large outbreaks. In 2000 a municipal well in Walkerton, Ontario was contaminated with *Campylobacter jejuni* and *Escherichia coli* 0157:H7 resulting in 2300 ill and seven deaths[14]. Early detection of the first symptomatic cases is an important objective in bioterrorism surveillance. Pathogens most likely to be used by terrorists produce diseases characterized in their early stages by nonspecific symptoms and signs[6]. Potential benefits of early detection of infectious disease include rapid post exposure prophylaxis or treatment, allocation of health resources and implementation of public health measures (quarantine, isolation, boil water advisories, vaccination programs) to limit spread of disease[15].

Syndromic surveillance is an emerging field in the science of epidemiological surveillance developed in response to the threat of bioterrorism. Intended to be complementary to conventional methods, syndromic surveillance converts clinical data collected electronically at the point of care into surveillance information. A number of non-traditional data sources have been used for syndromic surveillance including emergency department (ED) visits[16-18] and telephone helpline calls[19-25]. Most syndromic surveillance programs in North America are integrated into the health care system at the earliest points of care. In Ontario early access points are EDs, primary care providers and Telehealth Ontario (Telehealth). Recent studies show integration of multiple data sources improves specificity but none have determined the most effective data streams or method of integration[26,27]. The National Health Service (NHS) Direct helpline in the United Kingdom is a system of 22 independent call centers that use real-time call data for health surveillance. Retrospective and prospective evaluation of NHS Direct shows promise as an early warning system for influenza and GI illness[19-22]. Although analogous to NHS Direct, Telehealth is better suited to provincial health surveillance because of its centralized database and standardized computerized decision tree. The objective of this study is to examine the temporal relationship of ED visits and Telehealth calls for GI illness. It is hypothesized that Telehealth calls will be a complimentary data source for Ontario ED discharges thereby enhancing options for early detection of bioterrorist events.

Methods

Study design

This is a retrospective study of GI illness data for a 22-month period between June 1st, 2004 and March 31st, 2006. Anonymized data were obtained from the Telehealth and the Canadian Institute of Health Information (CIHI) NACRS databases. Use and storage of data complied with the privacy policies and procedures of Kingston, Frontenac, Lennox and Addington Public Health. The Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board approved this study as part of a larger research project by the Queen's University Emergency Syndromic Surveillance Team (QUESST).

Agents of Bioterrorism

The Centers for Disease Control and Prevention published a system classifying key agents according to their potential for adverse public health impact[28]. Category A agents are associated with the highest mortality and transmissibility, require specialized laboratory testing and medical treatment, and have the highest potential for intentional release. Category B agents result in lower, but significant, mortality and morbidity. Category C agents reflect emerging infectious diseases that may present future bioterrorist risk. (Table 1) Except for anthrax (Category A), outbreaks of gastrointestinal (GI) illness following a bioterrorist event will most likely be caused by Category B agents, particularly those associated with food and water safety[7,29,30].

Background on the National Ambulatory Care Reporting System (NACRS)

As of July 2006, 186 institutions in Ontario submit clinical, administrative and demographic data to the NACRS using ICD-10-CA diagnostic codes[31,32]. Data abstraction is done by trained hospital health records staff at the conclusion of each patient visit. CIHI audits all submitted data to identify duplicate records, missing data or inconsistencies in data transmission. If errors are found, the submitting facility is asked to correct these abstracts. Reliability of coding data collected by CIHI ranges from 74-96%[33]. Only ICD-10-CA codes that dealt with a communicable GI illness were included in the data set. (Table 2)

Background on Telehealth Ontario

Telehealth is a toll-free helpline provided by the Ontario Ministry of Health, Long Term Care (MOHLTC) and is available to all residents of the province. Services have been contracted to Clinidata since December 2001. Trained, experienced registered nurses provide confidential advice for any general health question. The service is available 24 hours a day, 7 days a week and 365 days a year (24/7/365) and is offered in the Canadian official languages, English and French, with translational support available in 110 languages[34]. Other than the official languages Mandarin, Cantonese, Farsi, Italian and Portuguese are most often requested[34]. Each nurse-led call lasts an average of 10 minutes and concludes with a disposition to the most appropriate form of care. The decision-based software is evidence-based, expert driven, and uses dichotomous questioning[35].

Data is collected in the form of 486 guidelines which have been reviewed and approved by a team of university-affiliated medical experts[35]. Telehealth guidelines were categorized by QUESST *a priori* into one of 32 syndrome names (e.g. respiratory upper, trauma, GI, etc) after review of classifications used by existing syndromic surveillance systems including the Rapid Outbreak Detection System (RODS), Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) and the NHS Direct. For the purpose of this study only calls coded as GI were analyzed. (Table 3)

Statistics

The Telehealth and NACRS data sources were compared by fitting time-series models and estimating a cross-correlogram at different lags (weekly). Data sets were transformed and detrended by differencing and autoregressive moving average models were fitted to the differenced series to ensure the residuals were normally distributed and independent. Autocorrelation and partial autocorrelation functions of the models were examined to determine autoregressive and moving average parts of the models. Residuals were checked for normality against the fitted values, and checked for white noise by the Portmanteau test. Spearman rank tests were performed and then cross-correlations were estimated for residuals (to account for seasonality and trends) at different lags with the limit of statistically significant correlation being $2/\sqrt{(N-1)}$ where N is the number of intervals in the data set. This method of analysis has been previously demonstrated in NHS Direct research[36]. All statistical procedures were generated with SAS software, version 9.1 (SAS Institute, Cary, NC, USA).

Results

Telehealth received over 2 million calls during the study period of which 184 904 (9%) were for GI complaints addressed by selected guidelines. The NACRS database registered 17.5 million abstracts of which 34 499 (0.2%) were for the ICD-10-CA coded GI diagnoses. More patients in the 0-4 year age category (44%) visited the ED for their illness whereas Telehealth was contacted equally for the 0-4 year (40%) and 18-64 year (42%) groups. Only 6.4% of Telehealth calls and 7.4% of ED visits for GI complaints were for patients greater than 65 years old. (Table 4)

Vomiting, diarrhea and rectal bleeding guidelines were used most often by Telehealth to determine caller disposition. Adults aged 18-64 years reported an equal incidence of vomiting and diarrhea (35% and 37% respectively) and a 21% incidence of rectal bleeding. In the 0-4 age group symptoms of vomiting (59%) were more common than diarrhea (31%). The incidence of rectal bleeding in the pediatric population was negligible. The most frequently reported ICD-10-CA code was A08 (viral enteritis) accounting for 75% of ED discharges. (Figure 1) An additional 15% of ED visits were coded as A09 (diarrhea and gastroenteritis of presumed infectious origin). Diagnosis of specific foodborne illness was rare (3.5%) but if diagnosed was more likely to be in adult patients.

Two corresponding peaks for GI Telehealth calls and ED discharges in the data set occurred in January and March 2005. (Figure 2) The time-series analysis comparing data sets calculated the Spearman correlation coefficient at 0.90 ($p<0.0001$). One statistically significant correlation was found between the Telehealth and the NACRS GI data at lag (weekly) 0 indicating increases in both series can occur simultaneously. (Table 5) The absence of a positive lag indicates changes in Telehealth GI call volume do not precede corresponding ED discharges for GI complaints.

Discussion

Prompt detection of bioterrorism is a primary concern for Public Health, emergency and security management organizations. To address the issues of delayed outbreak recognition and intervention inherent in traditional health surveillance methods, syndromic surveillance programs have been integrated into the health care system at the earliest points of access. These programs use real-time, existing data streams for prompt analysis and identification of infectious disease outbreaks[37]. Use of multiple, non-traditional data sources to enhance surveillance systems and increase specificity is supported in the literature[16-25,38]. Although Telehealth was not intended for surveillance, results from this study suggest integration of Telehealth data into a real-time surveillance system may be a complimentary tool for the detection of GI illness in Ontario.

Comparisons of Telehealth to NACRS data on GI illnesses show both curves are highly correlated. The time-series cross-correlogram demonstrated Telehealth data can document increases in GI calls simultaneously with, but not preceding, NACRS ED visits. NACRS data is based on physicians' diagnoses converted into ICD-10-CA codes at the conclusion of each patient visit. Telehealth syndrome guidelines are not equivalent to ICD-10-CA codes, however, Telehealth calls are potentially proxy measures for ED discharge diagnosis of communicable GI illness.

The success of a surveillance system depends on its simplicity, flexibility, data quality, acceptability, sensitivity, representativeness and timeliness[39]. Utility of the NACRS as a provincial surveillance tool is limited by the timeliness of data submission and analysis which may be delayed by months[31]. Analysis of discharge data before they are amalgamated in the NACRS database would require the manual searching of each individual hospital database. In contrast, Telehealth is high volume, universally accessible, available 24/7/365 and allows real-time electronic data collection using a centralized database[34]. These characteristics permit earlier detection of communicable GI illness despite the absence of a positive lag on statistical analysis.

GI illness resulting from intentional contamination of food or water is likely to affect a wide demographic. Telehealth receives a large volume of calls regarding pediatric patients and a marked deficiency in those over the age of 65. This inadequate representation of the elderly population may be explained by their hesitation to use or lack of awareness of the Telehealth program, or their preference for other points of access to health care[40]. Integrating Telehealth data into ED surveillance systems will allow a larger percentage of health care users to be monitored including patients not subject to conventional surveillance methods. Patients that do not seek medical care by a physician or receive laboratory confirmation of their illness and those directed by Telehealth to remain at home will be included in an integrated surveillance system. Formal infectious disease surveillance will also be extended to Northern Ontario, an area of widely dispersed populations that is traditionally underserviced by health care resources.

The majority of the NACRS ED visits were assigned to the A08 (viral enteritis) and A09 (diarrhea and gastroenteritis of presumed infectious origin) codes. This is in keeping with the nonspecific symptom profile of many bioterrorist pathogens. Although a constellation of symptoms may suggest a communicable disease process it is unlikely a specific pathogen would be diagnosed during the initial ED visit. Further, most physicians do not perform laboratory evaluation in uncomplicated cases of GI illness. The ICD-10-CA codes in this study are similar to those used by ESSENCE except for helminthic and mycotic disease which are unlikely to be used for bioterrorism and were excluded[41].

Real-time detection of a bioterrorist event allows rapid introduction of strategies to mitigate the associated mortality and morbidity. Because bioterrorism agents have short incubation periods (3-5 days) traditional surveillance methods are too slow to facilitate an effective response[29]. Early detection by Telehealth surveillance can limit spread of disease through rapid introduction of post exposure prophylaxis or treatment, allocation of health resources and implementation of public health measures[15]. Patterns of infectivity will depend on the agent and the source; widespread infection is expected for waterborne sources versus a more limited distribution of illness from a food delivery source. Once an outbreak is recognized, further spatial analysis and real-time geographic mapping of Telehealth data to corresponding public health units or water distribution systems can facilitate targeted epidemiologic investigation and effective resource allocation. Conversely, during periods of increased security concerns, Telehealth surveillance can provide reassurance that an infectious disease outbreak is not occurring thereby allowing modification of aberration detection tools to lower thresholds for investigation of statistical alerts.

Limitations

This study relies on retrospective administrative data which have inherent weaknesses. Although data are provided by experienced physicians, nurses and health records staff, human error in coding or diagnosis is possible. The NACRS has effective filters for incomplete or inaccurate data, however, Telehealth does not. The forward sortation area field of the NACRS and the age and sex fields of the Telehealth data showed minimal missing values (data not shown). These data points permit geographical presentation of data and real-time spatial analysis, however, were not used in the time-series analysis so would not affect results.

Selection bias may have been introduced by people that do not seek any form of medical attention but is likely of little significance in this study due to the universal access to health care for all Canadians. Conclusions of the study reflect only the 22 months of data and may not be representative of longer trends for GI illness.

Conclusions

Telehealth data can serve as proxy measures for ED discharge diagnosis data for GI illness in Ontario. This represents a novel use of Telehealth as a health surveillance tool. Integration of Telehealth Ontario data into real-time ED syndromic surveillance programs for GI illness can provide an early warning system for the detection of bioterrorist events.

Table 6-1: Centers of Disease Control and Prevention biological agent categories for disaster and public health preparedness

Biological Agent		***Disease***
Category A	*Variola major* ***Bacillus anthracis*** *Yersinia pestis* *Clostridium botulinum* *Francisella tularenis* *Filoviruses, Arenaviruses*	Smallpox Anthrax Plague Botulism Tularemia Viral Hemorrhagic Fevers
Category B	*Coxiella burnetii* *Brucella* species *Burkholderia mallei* *Burkholderia pseudomallei* Alphaviruses (VEE, EEE, WEE) *Rickettsia prowazekii* **Toxins** (ricin, staphylococcal enterotoxin B) *Chlamydia psittaci* **Food safety threats** (*Salmonella, E. coli 0157:H7)** **Water safety threats** (*Vibrio cholerae*, *Cyptosporidium parvum)**	Q fever Brucellosis Glanders Melioidosis Encephalitis Typhus fever Toxic syndromes Psittacosis Gastroenteritis Gastroenteritis
Category C	Newly emerging agents (Hantavirus, Nipah virus)	

VEE – Venezualan equine encephalitis; EEE – Eastern equine encephalitis; WEE – Western equine encephalitis
Bold= agents with potential to present as a gastrointestinal syndrome
* not an inclusive list

Table 6-2: Communicable gastrointestinal syndromes coded by hospital health coder post-discharge from ICD-10-CA classifications

ICD-10-CA Code*	***Code Description***
A00	Cholera
A01	Typhoid and Paratyphoid Fevers
A02	Other Salmonella Infections
A03	Shigellosis
A04	Other Bacterial Intestinal Infections
A05	Other Bacterial Foodborne Intoxications
A06	Amoebiasis
A07	Other Protozoal Intestinal Diseases
A08	Viral and Other Specified Intestinal Infections
A09	Diarrhea and Gastroenteritis of Presumed Infectious Origin
A22	Anthrax

* Includes any subcodes for each category listed

Table 6-3: Syndrome grouping of gastrointestinal illness with corresponding Telehealth Ontario guideline

Syndrome	***Telehealth Ontario Guideline***
Gastrointestinal	Diarrhea (Adult After Hours) Diarrhea (Pediatric After Hours) Stools – Blood In (Pediatric After Hours) Stools – Unusual Color (Pediatric After Hours) Stools – Unusual Color (Adult After Hours) Vomiting (Adult After Hours) Vomiting (Pediatric After Hours)

Table 6-4: Age distribution of the National Ambulatory Care Reporting System's (NACRS) emergency department visits and Telehealth Ontario calls for gastrointestinal illnesses in Ontario, Canada from June 2004 to March 2006

Age group (yrs)	*NACRS (n=34 499)*		*Telehealth (n=184 904)*	
	n	*%*	*n*	*%*
0-4	15 067	43.6	73 284	39.6
5-17	6 825	19.8	22 091	11.9
18-64	10 061	29.2	77 654	42.0
65+	2 546	7.4	11 875	6.4

Table 6-5: Schematic representation of cross correlations of residuals (weekly) for National Ambulatory Care Reporting System (NACRS) and Telehealth Ontario gastrointestinal data

Variable	***Lag***																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NACRS	++	/	/	/	/	/	/	/	/	-	/	/	-	/	/	/	/	/	/	/	/
Telehealth	++	/	/	/	/	/	/	/	/	-	/	/	/	/	/	/	++	/	/	+	/

+ is > 2 standard error
- is < -2 standard error
/ is between

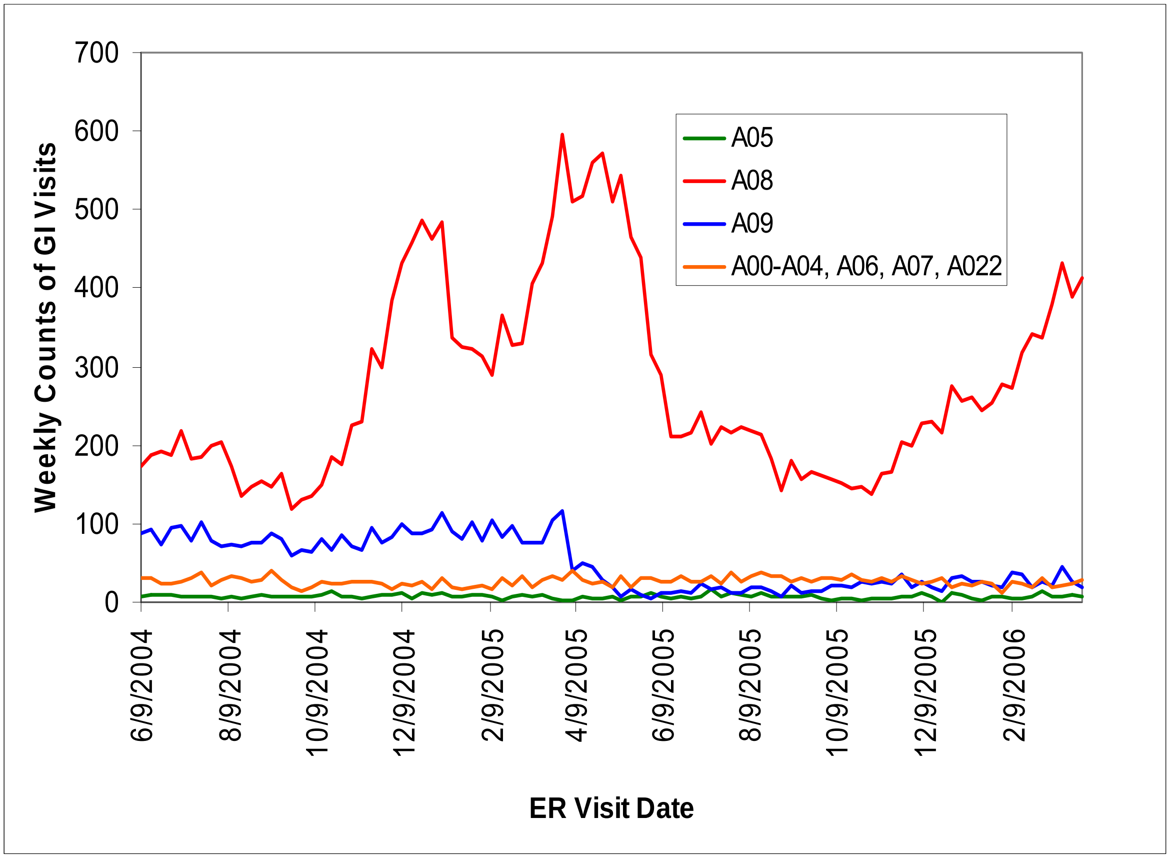
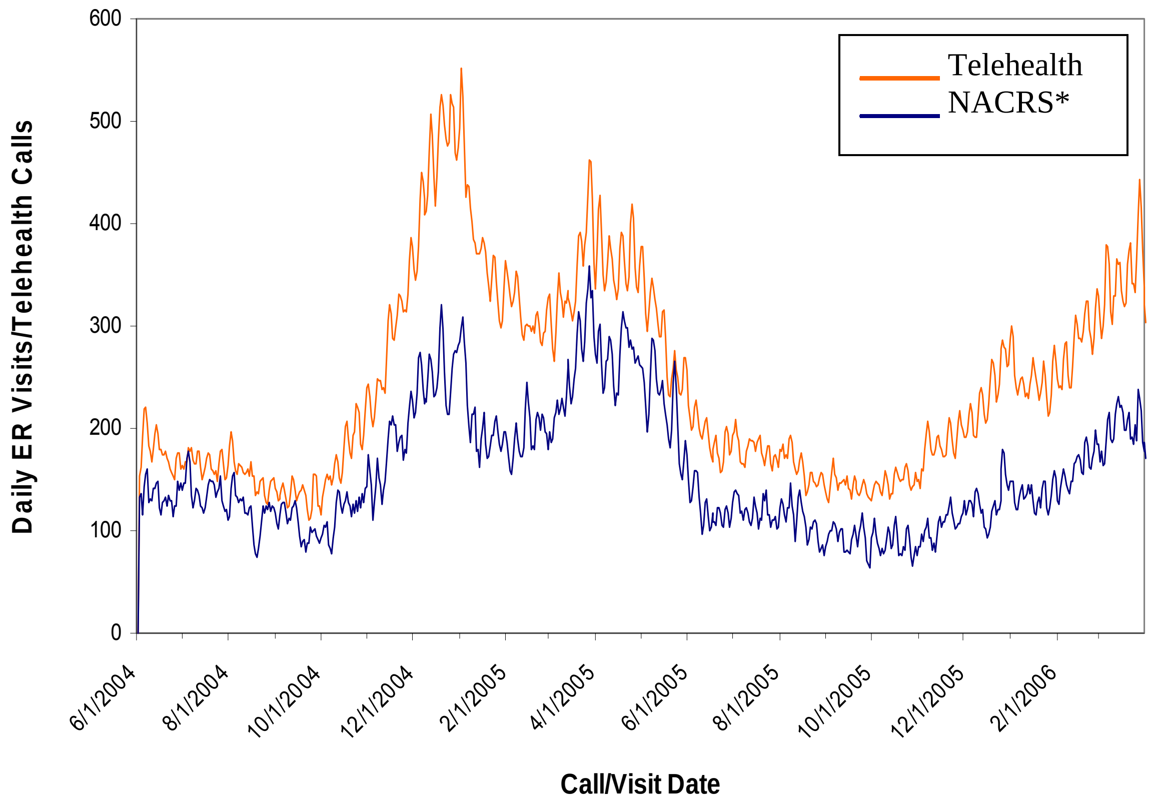


Figure 6-1: Breakdown of time-series for gastrointestinal International Classification of Diseases 10th revision, Canadian Enhancement (ICD-10-CA) codes, weekly – Ontario, Canada, June 2004 – March 2006



* NACRS data multiplied by a factor of 3

Figure 6-2: Telehealth Ontario (upper line) and the National Ambulatory Care Reporting System (lower line) time series for gastrointestinal illnesses, weekly – Ontario, Canada, June 2004 – March 2006

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Chapter 7: Integrating Ontario's Telehealth program into a provide-wide public health surveillance system: Evaluation and Recommendations

Introduction

Public health surveillance requirements in Ontario are mandated by the Ontario Health Protection and Promotion Act. This mandate includes the development and maintenance of reportable disease lists (including case definitions) as well as adherence to reporting standards (which includes prospective surveillance of health events).

Events such as Walkerton and, to a larger extent SARS, forced Ontario to realize that its disease surveillance infrastructure was inadequate and prone to collapse in times of surge capacity[1-3]. Much of the government-mandated literature on SARS suggests a number of strategies to address the shortcomings that were brought to the spotlight during SARS. It is clear that completely overhauling the disease surveillance infrastructure in Ontario is neither realistic nor necessary – for example, case definitions used by the province's system were never an issue of contention. However, the ease of communication between levels of government within the province (e.g. regional versus provincial) as well as the delay in reporting of diseases were and continue to be a significant issue.

The SARS Report is most vocal in stating that that the failures in public health surge capacity could be potentially addressed by "hav[ing] a well-developed system for real-time data sharing and reporting, and for the rapid dissemination of surveillance information" [4]. In particular, the report mentions the potential to "broaden the information collection capacity of Telehealth as a syndromic surveillance tool" [4]. In fact, the notion to use Telehealth as an early-warning system predates SARS and the recommendations that followed it. In 2002, Hogenbirk *et al*. conducted an evaluation of the pilot implementation of Telehealth in Ontario. In this evaluation, the authors suggest that "…teletriage services could be used for surveillance purposes such as the monitoring of infectious diseases, environmental health hazards such as toxic spills and even bio-terrorism."[5]

In an effort to build upon these suggestions, funding from Physicians Services Inc. was secured in 2005 to investigate and evaluate the utility of data collected through Ontario's Telehealth program as a potential component of a comprehensive early-warning system for the province. There are very few Ontario-wide health utilization databases that could conceivably contribute to a near real-time surveillance system. The basic approach taken in this study was to (1) investigate the utility of Telehealth data for surveillance early outbreak detection by comparing it to more traditional sources of health data (eg., emergency room visits and laboratory confirmations), and (2) to assess the feasibility of integrating Telehealth data into a province-wide real-time surveillance system. Two years of Telehealth data (July 1, 2004 to June 30, 2006) were provided and used in this investigation and a series of studies were conducted. In this chapter, the Telehealth program and results from the previous chapters (Chapters 1-7) are reviewed in the contents of CDC's *Framework for evaluating Public Health Surveillance Systems for Early Detection of Outbreaks*[6].

Methods

Investigation of Ontario's Telehealth program as a potential contributor of data to a province-wide early-warning surveillance system was based on the CDC's *Framework for evaluating Public Health Surveillance Systems for Early Detection of Outbreaks*[6]. This framework was originally developed following the publication in 2004 of an evaluation of the usefulness of 35 bioterrorism surveillance systems. The majority of these evaluations were of very poor quality and incomplete[7,8]. These guidelines were subsequently developed to supplement existing CDC guidelines to evaluate public health surveillance systems[9] specifically for syndromic surveillance systems. As the CDC framework was designed for the evaluation of mature and fully operational surveillance systems[10], it was necessary to modify the approach in our study. As the study consisted of evaluating retrospective data, and not data feeding real-time into a surveillance platform (e.g. RODS, ESSENCE, etc), the focus of the evaluation was (1) investigating if the data themselves are of value for surveillance and early outbreak detection, and (2) assessing the feasibility of integrating Telehealth data into a province-wide real-time surveillance system.

Telehealth program description

Details of the overall Telehealth program were obtained by reviewing key documentation and by consulting with key stakeholders. Understanding how data are currently collected, manipulated, and stored was key to assessing their utility towards a potential province-wide surveillance and early warning system. A detailed description of the Telehealth program has been provided elsewhere (Chapters 2 and 3). Presented here are key elements relevant to the surveillance evaluation.

Surveillance and outbreak detection capacity of Telehealth data

Telehealth data surveillance and outbreak detection capacity was evaluated by assessing the temporal and temporal-spatial relationships between Telehealth data and datasets associated with two independent programs, the National Ambulatory Care Reporting System (NACRS) and the national FluWatch program. Two illness groups were the focus of the evaluation, acute respiratory and gastro-intestinal associated conditions. Analyses methods and results have been presented and discussed in detailed elsewhere (Chapers 3, 4, 6). Presented here are key elements relevant to the evaluation.

Temporal investigation: Briefly, Telehealth, NACRS, and FluWatch data were compared by fitting time-series models and estimating correlations at different lags. Data sets were transformed and detrended by differencing. Autoregressive moving average models were fitted to the differenced series to ensure the residuals were white noise. The autocorrelation and partial autocorrelation functions of the models were examined to determine autoregressive and moving average characteristics. Residuals were checked for normality against the fitted values, and checked for white noise by the Portmanteau test. To test for cross-correlations, Spearman rank tests were performed. The cross-correlations were estimated for residuals (to account for seasonality and trends) at different lags.

Temporal-spatial investigation: Respiratory related emergency room visits (NACRS database) and Telehealth calls were geocoded to Ontario public health unit as previously described (Chapter 5). Public health unit Telehealth call intensity adjusted rates were compared to public unit health emergency room visit intensity adjusted rates over two influenza seasons (October 31, 2004 to April 30, 2005; December 11, 2005 to May 27, 2006) by generating weekly maps.

Technical feasibility of a province-wide real-time surveillance system

The Telehealth program and data were evaluated from a technical perspective for ease of integration into a province-wide real-time surveillance system.

Results & Discussion

Telehealth program description

The Ontario Telehealth Telephone Helpline was first implemented in Ontario in 2001. It was initiated as a pilot study, which included the Greater Toronto area (416 and 905 calling areas), as well as the Northern area of Ontario (705 calling area). The Northern Pilot was subsequently evaluated and results suggested that the program may have contributed to decreased visits to emergency departments[11]. One of the original goals of Telehealth was to “lead to more appropriate use of emergency departments” [12].

The program was expanded province-wide at the end of 2001, and has been administered by Clinidata since then, a private contractor hired by the Ontario Ministry of Health and Long-Term Care. The helpline is available 24 hours a day, 7 days a week, including holidays, at no cost to the caller. The calls are answered by registered nurses who are required to have multiple years of clinical experience prior to their involvement with Telehealth. Although calls are primarily answered in both official languages (English and French), the system has the capability of responding to calls in 110 different languages within 60 seconds (with the help of translators in a three-way calling setup) [13].

Calls are handled by four calling centres that use identical decision rules (algorithms) and store all call information into one centralized data repository. The calls are usually approximately 10-minutes, patient based, and are directed by trained nurses who use an electronic clinical support system that can be used to provide either clinical guidelines (approved by a panel of clinicians), health information, care information, and a health care referral system. All calls are classified as a health information call, a referral call, or a symptom call. All symptom calls are triaged using a decision tree, which leads to one out of a possible 440 algorithms. Depending on the final algorithm and/or the severity of the patient's condition, a disposition is assigned to each call: Information call (calls initially coded as symptom calls, but where no care is recommended); Community service; 911 Ambulance/Dispatch; ED (Guideline directed); ED (No alternative); Pharma; Physician reference; Poison control; Self-care; Other health care provider; Other.

Surveillance and outbreak detection capacity of Telehealth data

Traditionally, a syndromic surveillance system's aptitude at accurately predicting aberrations is determined by measuring its sensitivity, specificity and positive predictive value. According to Doroshenko [14], in the context of syndromic surveillance, this is difficult to achieve. The unit of analysis is the detection of an outbreak or trend, but not an individual illness. Such a detection is frequently based on drawing information from various sources and ultimately on professional judgment. The standard needed for calculations is rarely available and frequently represents a variable itself. Another approach is to determine the correlation between data derived from different surveillance (and related) systems. Consequently, we also opted to use a comparative approach to evaluate the surveillance utility of Telehealth data. Detailed results are provided in previous chapters. Summary results are presented here.

When considered on a province-wide basis, weekly Telehealth call volumes relating to respiratory conditions closely reflect weekly emergency department visit volumes associated with respiratory conditions and Ontario influenza data derived from the national FluWatch program. When considered on a province-wide basis, weekly Telehealth call volumes relating to gastrointestinal conditions closely reflect weekly emergency department visit volumes associated with gastrointestinal conditions.

Time-series analysis comparing NACRS emergency department respiratory associated complaints and Telehealth Ontario respiratory associated calls demonstrated very good correlation (0.93; P-value < 0.0001) at a lag of 0 weeks. Comparing Telehealth Ontario call volume and weekly respiratory virus isolations also showed good correlation at 0.84 ($p<0.0001$) at a lag of 0 weeks. Furthermore, statistically significant cross correlations of were found up to lag 3 weeks suggesting that rises in calls to Telehealth Ontario for respiratory-related illnesses may precede laboratory confirmed data of influenza A and B by as much as 3 weeks.

Time-series analysis comparing NACRS emergency department gastrointestinal associated complaints and Telehealth Ontario gastrointestinal associated calls demonstrated very good correlation (0.90; P-value < 0.0001) at a lag of 0 weeks.

Stratification of weekly NACRS and Telehealth respiratory data by public health unit demonstrated considerable consistency in volume trends when mapped over the 2004-05 and 2005-06 influenza season. Results thus suggest that Telehealth data could be potentially used not only for provincial surveillance, but also for local surveillance. The restriction of the geographic coding of released data to 3-digit postal codes (FSAs) forced the introduction of estimation techniques in generating PHU counts for Telehealth Ontario calls. While reasonably robust, any such estimates require assumptions about local distribution of calls which are not easily testable. It would be useful to explore ways of releasing more detailed geocodes (such as 6-digit postal codes or coding to Statistics Canada Dissemination Areas) while maintaining appropriate protection of individual privacy. This would be an important step if links to other resources such as local socio-economic and demographic profiles available from the Census were desired for further analysis of factors affecting the spread of epidemics.

Although additional refined analyses are needed to further investigate the surveillance capacity of Telehealth data (eg. stratification by age group and other socio-demographic characteristics, and the examination of other syndromes), the analyses conducted to date strongly suggest that Telehealth call volume is a very good proxy for population level acute respiratory and gastrointestinal activity both temporally and spatially. Results also suggest that Telehealth respiratory activity may be a good early warning for Influenza activity.

Technical feasibility of a province-wide real-time surveillance system

Although only a preliminary assessment, it appears that Telehealth data can be easily integrated into a real-time surveillance system (eg RODS, ESSENCE, etc) with minimal effort. Described below are the basic steps that would be required to integrate Telehealth data into a real-time surveillance system:

(1) The development of a simple interface to pull data from the central Teleheatlh database at regular intervals.

- Databases have the same basic design and all that is needed is the right ‘select’ statements to pull data from the provincial database and script/code to format data into HL7.
- Data would be anonymized and all personal identifiable information would be removed prior to transmission.

(2) Establishment of a secure data transfer protocol/network to transfer data from the Telehealth database to the real-time surveillance system.

- A port would be opened at the Telehealth database and data would be securely transferred to the syndromic surveillance system. The transfer could occur across a VPN or via the Smart Systems for Health (SSH) infrastructure.

(3) Implementation of an HL7 parser to read the formatted records and make the data available to the real-time surveillance system.

- An existing HL7 parser currently implemented for the EDSS project could be configured. Alternatively, ESSENCE utilizes ms sql server DTS which makes parsing of records for insertion into a database relatively simple. Writing an HL7 parser is not a difficult exercise.

(4) Implementation of a Quality Assurance (QA) process to validate the data transfer.

- Regular QA cycles would be performed to ensure that the found at the real-time surveillance system database matches the data at Teleheatlh Ontario.

Conclusions and Recommendations

Prompt detection of infectious disease events is a primary concern for Public Health. To address the issues of delayed outbreak recognition and intervention inherent in traditional health surveillance methods, efforts are currently underway in many jurisdictions in Canada and the United states to leverage timely non-traditional data sources. Although the Telehealth Ontario program was not originally designed for real-time surveillance, results of several analyses presented in this compendium, and summarized in this chapter, support the integration of Telehealth Ontario data into a real-time province-wide surveillance system.

Although additional analyses are needed to further investigate the surveillance capacity of Telehealth data, analyses conducted to date strongly suggest that Telehealth data are good proxies for both acute respiratory and gastrointestinal conditions. Results also suggest that Telehealth respiratory activity may be a good early warning for Influenza activity. Technical investigations to date suggest that little effort would be required to integrate Telehealth data into a real-time province-wide surveillance system.

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Appendix A: Simulation of Telehealth Alert Capacity for Influenza Outbreaks: A Preliminary Cost Benefit Analysis Report

(Prepared by Walker Economics Inc. - DRAFT)

Simulation of Telehealth Alert Capacity for Influenza Outbreaks: A Preliminary Cost-Benefit Analysis Report (DRAFT)

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Overview

What would be the potential benefit of an "early alert system" for influenza in a large jurisdiction which would allow the public health authorities to intervene earlier than previously? Would it reduce the number of people contracting influenza, the number of deaths, and costs of the outbreak?

Walker Economics Inc (WEI) was asked to study this question by Queen's University Emergency Syndromic Surveillance Team in 2005 and again in 2007 for a different approach to outbreak detection.

In the 2005 project we wrote a simulation model to explore the effects of earlier alert times for a population the size of Kingston, Ontario. The model was a "system dynamics" model. The target variables, shown in Table 1, were used to estimate the status of the population on each day from outbreak until the end of the epidemic.

The contrast we sought was between:

- traditional time to detect an outbreak (at least 7 days) based on taking samples by a physician, submitting them to a laboratory, reporting back to the physician, reporting by the physician to public health authorities
- time to detect an outbreak using a process of "syndromal surveillance" based on immediate automated electronic reporting and alerting from emergency departments. If the system is installed in all ERs, reports can be available immediately to Public Health, and permit a much earlier decision about an outbreak in its early stages.

In 2007 we were asked to consider a new approach to detecting an influenza outbreak that relied on suspected influenza cases telephoning the Telehealth Ontario Helpline. The nurses staffing these calls worked from a protocol to assign callers' cases to an influenza or other syndrome, and this information could be immediately available to public health authorities via automated temporal and spatial analysis. This required the simulation of the Ontario population of 12.6 million people.

Our earlier model, a system dynamics model, was not suited for a task of this size, and therefore we wrote a new simulator “Systemwide”. It a “discrete event” simulation platform, and is capable of simulating the experience of every individual in the population.
In developing these simulations we have used the information for population wide parameters in Table 1. In particular we make no assumptions about:

- population dynamics
- living arrangements
- contact patterns
- no age, gender , socio-economic differences
- travel patterns
- differential susceptibility

A significant advantage of a Telehealth based approach to outbreak detection is that the infrastructure for gathering and reporting this information is already in place and usable for detecting disease outbreaks at minimal additional costs.

Syndromal Surveillance through Telehealth allows a much shorter detection time than traditional methods, as documented in this compendium. The determination of an outbreak locally is based on daily spikes in observed cases, or rates of increase on cumulative cases. We simulate the province as though it were a single entity.

Quarantine Effectiveness (QE) Levels of 90% or more have the following effects:

- deaths ≤ 10,000 for intervention delays of 6 days or less
- total cases ≤ 400,000 for delays of 4 days or less
- max daily Inpatient occupancy ≤ 17,000 for delays of 5 days or less
- max ER daily visits ≤ 225,000 for delays of 6 days or less
- max GP/FP daily visits ≤ 40,000 for delays of 4 days or less
- total medical costs ≤ $1 billion for delays of 6 days or less
- total compensation costs ≤ $50 billion for delays of 4 days or less.

Tables 2a and 2b display the relationship between QE and Intervention Delay for eight variables. At the bottom of each table is a “No Intervention” value, which for most variables is about the same as an 11 day delay.

Late intervention yields poor results and at some stage is no better than no intervention. QE of 50% is of little value and even 80% is very inferior to higher levels. Costs depend on the compensation paid to people for lost income (or as an incentive to remain quarantined) and on medical costs. Payments are $150 per weekday to persons in the labour force (66%) and $100,000 per death. Medical Costs (see Table 1 for values) are incurred for Inpatient Care, ER Visits and FP/GP visits.

Conclusions

a. Both QE and Intervention Delay are critical to controlling an epidemic:
    - QE of less than 90% cannot control an outbreak
    - delays of more than four days result in much greater damage than earlier intervention
b. An uncontrolled intervention will yield over 80,000 deaths and cost approximately $12 billion.
c. Control will have much better demographic results but will cost upwards of $50 billion.
d. The population must be quarantined for the duration of the epidemic, or public health must have other evidence based interventions in place, such as rapid screening of cases, contact identification, antiviral delivery to contacts, or contact isolation.
e. Our work provides no more than an insight into the importance of quarantine and intervention delay.
f. Whether the population will agree to quarantine, and how the economy and personal life will fare is unknown. Clearly, the population would have to be highly prepared, quarantine would have to be enforced, and financial and service continuation issues would be very important.

This analysis is a work in progress, based on feedback from infectious disease and modeling experts, we will be running further simulations with variations in the standard parameters.

Table A-1: Influenza Parameters

Parameters	2005 System Dynamics	2007 Discrete Event
Population	189,000	12.6 Million
Daily Spontaneous Cases if Outbreak	1	1
Fraction of Pop Initially Resistant	0	0
Avg Daily Contacts	4	5
Hospital Capacity	(no constraint)	(no constraint)
Daily Vaccine Rate	0	0
Attack Rate	0.35	
Infectivity		0.31
Duration Incubation	3	2
Duration Amb Treat	5	N/A
Duration Latency	1	1
Duration Infectious	4	4
Duration SubClinical	5	N/A
Duration Hosp Treat	10	5
Duration Quarantine	5	General - length of outbreak
Costs		
Ambulatory Care per Day	$100	$100
Hospital Care per Day	$600	$600
Quarentine Day (compensation)	$150	$150 per week day
Sickness Lost Day (lost income)	$150	$150 per week day
Death (compensation)	$100,000	$100,000
Proportion Clinical Disease`	0.55	0.55
Proportion Sub-Clinical Disease	0.45	0.45
Patient Proportion to ER	0.40	0.40
Patient Proportion to FP	0.60	0.60
Proportion Clinical to Hospital	0.06	0.09
Hospital Fatality Rate	0.229	0.229
Proportion Recovered Patients Immune	1.00	1.00

Table A-2a: Quarantine Effectiveness and Intervention Delay for Deaths

Deaths	Intervention Delay (days)	Quarantine Effectiveness				
		50%	80%	85%	90%	95%
	1	80,940	31,920	1,490	270	410
	2	81,140	31,570	1,680	470	130
	3	82,750	30,970	3,720	1,270	680
	4	82,000	33,480	6,840	2,200	1,680
	5	81,130	35,830	15,810	6,470	2,360
	6	80,400	40,100	20,630	7,700	8,040
	7	81,400	48,160	27,590	33,060	12,360
	8	80,120	52,890	41,990	38,600	41,250
	9	83,640	66,160	62,190	57,030	61,110
	10	82,880	74,830	75,970	71,770	74,230
	11	87,050	83,800	83,390	83,640	83,640
	12	84,880	85,170	85,250	83,060	81,830
	13	84,640	85,630	84,500	87,730	85,530
	14	84,250	87,480	84,600	86,200	85,990
				'No Intervention' Value:		**85,180**

Table A-2b: Quarantine Effectiveness and Intervention Delay for Maximum Inpatient Utilization

Max IP Util		Quarantine Effectiveness				
		50%	80%	85%	90%	95%
Intervention Delay (days)	1	215,820	16,620	1,070	630	1,350
	2	218,640	15,980	1,240	1,220	670
	3	219,980	17,170	2,960	3,620	2,270
	4	217,220	21,540	7,740	4,950	5,770
	5	220,190	28,490	22,120	16,450	8,960
	6	225,350	44,940	36,160	20,010	29,110
	7	231,920	100,270	57,630	105,510	42,420
	8	256,770	119,160	112,260	125,250	157,680
	9	294,590	219,190	214,530	209,700	238,950
	10	308,670	275,120	288,840	279,310	306,500
	11	329,030	334,950	324,240	330,140	329,750
	12	325,660	330,830	327,630	328,310	326,150
	13	328,590	324,950	329,070	330,700	329,510
	14	327,690	327,970	328,330	328,180	331,770
				'No Intervention' Value:		327,736

Table A-2c: Quarantine Effectiveness and Intervention Delay for Total Infected

Total Infected		Quarantine Effectiveness				
		50%	80%	85%	90%	95%
Intervention Delay (days)	1	11,849,870	4,588,680	231,810	37,260	56,330
	2	11,852,480	4,531,470	278,470	72,860	30,970
	3	11,856,790	4,609,570	584,030	199,280	91,510
	4	11,852,200	4,930,540	1,080,150	313,310	244,280
	5	11,855,410	5,211,710	2,208,670	891,450	367,550
	6	11,874,520	5,796,550	3,059,040	1,081,510	1,177,400
	7	11,909,920	7,114,830	4,052,750	4,840,260	1,730,690
	8	11,956,890	7,557,140	6,000,410	5,597,670	6,066,500
	9	12,146,480	9,811,970	9,114,300	8,449,920	8,872,290
	10	12,240,860	11,045,900	11,127,160	10,513,540	10,985,780
	11	12,415,300	12,137,550	12,236,370	12,148,600	12,113,430
	12	12,454,030	12,359,510	12,404,660	12,378,290	12,160,020
	13	12,473,720	12,471,680	12,444,930	12,463,650	12,455,320
	14	12,484,180	12,473,460	12,476,860	12,471,030	12,480,700
				'No Intervention' Value:		12,488,931

Table A-2d: Quarantine Effectiveness and Intervention Delay for Total Cost

Total Cost ($thousands)		Quarantine Effectiveness				
		50%	**80%**	**85%**	**90%**	**95%**
Intervention Delay (days)	**1**	47,122,773	133,066,135	128,910,426	33,336,980	23,455,933
	2	48,053,067	133,919,593	128,940,606	41,466,062	18,921,130
	3	45,517,376	132,975,939	128,320,693	46,079,157	25,292,141
	4	49,929,117	113,510,381	120,665,086	50,700,073	24,531,213
	5	45,348,783	98,522,195	90,347,345	42,279,653	24,630,655
	6	41,677,439	85,594,493	79,343,944	50,549,704	26,306,932
	7	42,692,457	61,535,225	73,996,346	43,248,713	29,579,330
	8	38,971,421	55,828,093	51,637,622	38,598,817	32,679,247
	9	33,067,972	39,720,761	37,356,760	33,974,202	28,179,192
	10	30,315,833	32,799,403	31,139,602	30,562,262	26,428,365
	11	26,291,599	26,800,821	25,854,208	26,773,238	25,868,563
	12	25,167,194	25,179,306	25,194,068	23,166,064	22,989,578
	13	23,361,085	22,554,661	23,335,485	21,873,869	21,647,302
	14	22,415,425	21,844,452	23,349,420	21,718,980	22,597,671
				'No Intervention' Value:		**11,711,881**

Table A-2e: Quarantine Effectiveness and Intervention Delay for Duration of Outbreak

Duration of Outbreak		Quarantine Effectiveness				
		50%	80%	85%	90%	95%
Intervention Delay (days)	**1**	46	149	149	42	32
	2	47	149	149	52	27
	3	45	149	149	58	35
	4	50	129	141	64	36
	5	46	113	107	55	35
	6	44	99	94	64	37
	7	46	72	88	55	42
	8	43	65	62	49	42
	9	37	47	45	41	35
	10	34	38	36	36	32
	11	31	32	31	32	31
	12	32	31	31	29	29
	13	30	29	29	28	28
	14	30	29	31	29	30
				'No Intervention' Value:		**31**

Table A-2f: Quarantine Effectiveness and Intervention Delay for Medical Costs

Medical Costs ($thousands)		Quarantine Effectiveness				
		50%	**80%**	**85%**	**90%**	**95%**
Intervention Delay (days)	**1**	3,028,053	1,171,561	58,852	9,314	14,465
	2	3,038,329	1,160,001	70,032	18,234	7,752
	3	3,041,692	1,176,365	146,137	51,239	23,637
	4	3,028,343	1,260,203	278,692	79,065	62,727
	5	3,035,099	1,337,323	564,581	231,825	94,169
	6	3,036,827	1,482,891	779,414	278,714	302,428
	7	3,051,827	1,818,127	1,035,942	1,241,939	442,772
	8	3,058,863	1,938,121	1,537,704	1,438,151	1,553,707
	9	3,103,540	2,504,149	2,337,184	2,170,680	2,267,796
	10	3,127,455	2,815,953	2,842,188	2,684,848	2,805,041
	11	3,186,311	3,120,515	3,114,920	3,108,932	3,104,275
	12	3,178,924	3,162,036	3,168,798	3,159,830	3,106,344
	13	3,196,851	3,191,445	3,185,251	3,200,671	3,194,104
	14	3,190,209	3,196,254	3,189,186	3,198,782	3,198,455
				'No Intervention' Value:		**3,193,881**

Table A-2g: Quarantine Effectiveness and Intervention Delay for Percent Infected

Percent Infected	Intervention Delay (days)	Quarantine Effectiveness 50%	80%	85%	90%	95%
	1	94.0%	36.4%	1.8%	0.3%	0.4%
	2	94.1%	36.0%	2.2%	0.6%	0.2%
	3	94.1%	36.6%	4.6%	1.6%	0.7%
	4	94.1%	39.1%	8.6%	2.5%	1.9%
	5	94.1%	41.4%	17.5%	7.1%	2.9%
	6	94.2%	46.0%	24.3%	8.6%	9.3%
	7	94.5%	56.5%	32.2%	38.4%	13.7%
	8	94.9%	60.0%	47.6%	44.4%	48.1%
	9	96.4%	77.9%	72.3%	67.1%	70.4%
	10	97.1%	87.7%	88.3%	83.4%	87.2%
	11	98.5%	96.3%	97.1%	96.4%	96.1%
	12	98.8%	98.1%	98.4%	98.2%	96.5%
	13	99.0%	99.0%	98.8%	98.9%	98.9%
	14	99.1%	99.0%	99.0%	99.0%	99.1%
				'No Intervention' Value:		**99.1%**

Table A-2h: Quarantine Effectiveness and Intervention Delay for Compensation Costs

Compensation Costs ($thousands)		Quarantine Effectiveness				
		50%	**80%**	**85%**	**90%**	**95%**
Intervention Delay (days)	**1**	44,094,720	131,894,574	128,851,574	33,327,666	23,441,468
	2	45,014,738	132,759,592	128,870,574	41,447,828	18,913,378
	3	42,475,684	131,799,574	128,174,556	46,027,918	25,268,504
	4	46,900,774	112,250,178	120,386,394	50,621,008	24,468,486
	5	42,313,684	97,184,872	89,782,764	42,047,828	24,536,486
	6	38,640,612	84,111,602	78,564,530	50,270,990	26,004,504
	7	39,640,630	59,717,098	72,960,404	42,006,774	29,136,558
	8	35,912,558	53,889,972	50,099,918	37,160,666	31,125,540
	9	29,964,432	37,216,612	35,019,576	31,803,522	25,911,396
	10	27,188,378	29,983,450	28,297,414	27,877,414	23,623,324
	11	23,105,288	23,680,306	22,739,288	23,664,306	22,764,288
	12	21,988,270	22,017,270	22,025,270	20,006,234	19,883,234
	13	20,164,234	19,363,216	20,150,234	18,673,198	18,453,198
	14	19,225,216	18,648,198	20,160,234	18,520,198	19,399,216
					'No Intervention' Value:	**8,518,000**

Table A-3: Quarantine Effectiveness and Intervention Delay for 2 and 7 days ($ amounts in 000's)

Quarantine Effectiveness	85%		90%		95%	
Intervention Delay (Days)	2	7	2	7	2	7
Deaths	1,680	27,590	470	33,060	130	12,360
Total Cost ($1,000s)	128,940,606	73,996,346	41,466,062	43,248,713	18,921,130	29,579,330
Total Infected	278,470	4,052,750	72,860	4,840,260	30,970	1,730,690
% Infected	2.21%	32.16%	0.58%	38.41%	0.25%	13.74%
Duration of Outbreak	149	88	52	55	27	42
Max IP Utilization	1,240	57,630	1,220	105,510	670	42,420
Max ER Utilization	11,760	488,840	9,830	843,590	6,030	329,950
Max GP Utilization	5,580	246,520	6,190	560,200	4,590	256,450
Medical Costs ($1,000s)	70,032	1,035,942	18,234	1,241,939	7,752	442,772
Compensation Costs ($1,000s)	**128,870,574**	**72,960,404**	**41,447,828**	**42,006,774**	**18,913,378**	**29,136,558**

N.B.
Daily ER visits in Ontario approx. 12,600
Stock of Ontario GP/FP approx. 11,000
Stock of acute care beds in Ontario approx. 18,300
Ontario total annual wages and salaries $385 billion

167

168

Figure A-1: Quarantine Effectiveness vs. Intervention Delay for Four Variables