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Modeling the Association between 2009 H1N1 influenza pandemic and Emergency Department operations in United States using national hospital ambulatory medical care survey (NHAMCS)

By

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Master of Public Health (MPH)

Epidemiology

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Dr. Stephen R. Pitts MD, MPH

Faculty Thesis Advisor

Abstract Cover Page

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Bachelor of Medicine, Bachelor of Surgery (M.B.B.S.)

Maharashtra University of Health Sciences, Nasik

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A thesis submitted to the Faculty of the
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Abstract

Modeling the Association between 2009 H1N1 influenza pandemic and Emergency Department operations in United States using national hospital ambulatory medical care survey (NHAMCS)

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Abstract

Introduction: Hospital emergency departments (ED) plays a crucial role in US society, both providing care to acutely ill and injured patients and serving as a major point of entry into US healthcare system for uninsured patients. In response to emergent health care situations like Influenza pandemic 2009, ED is primary source of contact for majority of population. Measurement of ED performance during these times is important for future development of better equipped and prepared health care system.

Methods: To estimate the effect of Influenza -09, NHAMCS national sampling survey was combined from year 2007 to 2010. ED-length of visit and ED-boarding time were primary outcome measures. The exposure ‘Influenza Activity Period’ was stratified in three levels No/Seasonal/Pandemic Influenza Activity based on CDC guidelines of WHO/NREVSS lab survey. Important covariates were classified in domains of demographic, ED/visit characteristics and hospital attributes.

Results: Pandemic Influenza period significantly (5.47% excess time, p-value 0.0038) affected ED operations when compared with No Influenza period. During pandemic times, African-Americans (12.30% more time) and Hispanics (9.11% excess time) were most affected. Ordering of any diagnostic/screening test in ED (54.85% more time) or advanced imaging techniques (26.85% more time) lead to possible ED resources utilization on acutely ill (11.66% more time) patients. Location of hospital in urban area (10.67% more time) and visit to a teaching institution (20.5% excess time) increased the overall ED-LOV. We found no significant association between ED-BTI and pandemic (p-value 0.26) or seasonal (p-value 0.32) Influenza period, but, ED-BTI was significantly associated with ED resources factors.

Conclusion: Pandemic Influenza significantly affected ED operations. Even though, seasonal Influenza followed similar trends the effects of pandemic Influenza were more pronounced. Although, there was no association of ED-BTI with Influenza activity periods, hospital infrastructure and resource factors showed positive impact signifying the fact that functional and infrastructural improvements could potentially induce positive effects on acute and long term care.

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CHAPTER 1: LITERATURE REVIEW

Background

In 1985 the Emergency Medical Treatment and Labor Act (EMTALA) mandated that all patients who present to a hospital emergency departments (ED) in the United States must receive a medical screening examination, regardless of their ability to pay (1). Although Congress required EDs all over the nation to provide this service even for "financially undesirable patients", no funding was provided to pay for it. This uncompensated directive caused many EDs to close down and also hospitals to treat their own EDs as burden on the institute finances and resort to practices like ambulance diversion. In some ways EMTALA may have diminished care (2, 3).

Traditionally, the ED has been a major point of entry for any person in health care system with an acute problem. About ten percent of ambulatory patient care and 30 percent of acute care takes place in the ED (4, 5) and the trend for ED utilization among the population is increasing over time (6) EDs have always been viewed as a center for rapid evaluation and stabilization; therefore ED's are neither staffed nor equipped to provide long-term care. The performance of an ED is put to the test in a major catastrophic event like a natural catastrophe, terrorism, or an emerging infectious disease. Strengthening disaster preparedness and response are key priorities requiring objective measures of performance.

Emergency department throughput measures recently established by the Centers for Medicare & Medicaid Services (CMS) and The Joint Commission will soon affect reimbursement and accreditation, but are also widely utilized in the health services research. One well-established model of ED performance identifies input criteria (e.g. volume surges, non-urgent visits, frequent flyer visits and influenza season), throughput (e.g. inadequate staffing, excessive intervention) and output (e.g. inpatient boarding and hospital bed shortage) factors. Among the best known ED performance measures are length of visit (ED-LOV), adverse outcome rates, and resource utilization. Of these, the ED-LOV is most frequently studied (7).

Emergency department crowding has been thought to cause various adverse outcomes: reduced quality, impaired access (7). Crowding and ambulance diversion could both potentially increase patient mortality (7-9). The public perception of good emergency care is transportation to the hospital as quickly as possible and practices like ambulance diversion are deterrent to the image of the health facility in mind of populace. Revenue lost because of the extended boarding time in ED causes providers to refer the patient to another hospital (10, 11). Emergency medical services failure of prompt services and staff job dissatisfaction are some of the additional reasons for the low efficiency in ED's (11). A large crowding literature is available, many solutions were proposed for the reduction of overcrowding, prominent among them are extra staffing, infrastructure widening, increased hospital bed access (12). But in absence of proper funding channels these solutions are difficult to attain.

To understand the impact of a disaster or mass casualty event on health services in order to evaluate its true efficacy. The July 27, 1996 Atlanta Olympic disaster presented with the similar situation where the robustness of the public health planning and response systems was tested. The response may have succeeded because of early planning and involvement of the key partners early in time (13). During the disaster response situations like this one, once crowding reaches dangerous levels, hospitals often divert inbound ambulances to other facilities. Diversion might provide a breather for a struggling hospital staff, but leads to prolongation of ambulance transport times and disrupts established patterns of care. But since crowding is not usually limited to a single hospital, one facility's decision to divert ambulances can prompt others to follow suit. When that happens, a city may experience the health care equivalent of a “rolling blackout.” Everyone's access to care is affected — the insured and uninsured alike (14).

Although the effects of ED crowding are varied, the origin of the problem is a complex interwoven network of systemic problems ranging from hospital workflow to natural/artificial disasters. Some authorities have asserted that the best way to prepare for disasters is to create an emergency and trauma care system that functions effectively on a day-to-day basis (15). This requires that great emphasis should be put on these regularly in the training, continuing education, and credentialing of emergency care professionals (14).

In order to better understand the impact of the ED response to disasters, we conducted an analysis of The National Hospital Ambulatory Medical Care Survey (NHAMCS): 2007 to 2010. We used 2009 H1N1 Influenza Activity period as an exposure for testing the effects of mass disaster on ED operations for which ED-LOV was defined as performance indicator of ED.

Database description

The National Hospital Ambulatory Medical Care Survey (NHAMCS) is conducted annually by Centers for Disease Control and Prevention's National Center for Health Statistics (CDC-NCHS)(16). It is a four stage probability sampling survey of visits to general and short stay hospitals in United States excluding Federal military and veterans’ affair hospitals. The four NHAMCS sampling frames include

1) US Geographic Primary Sampling Units (about 112 PSU’s)

2) Randomly selected hospitals within PSU (about 500 hospitals)

3) Randomly selected emergency service areas (ESA) within hospitals

3) Randomly selected visits within ESAs (systematic 28-day random sample)

The numbers of participating EDs differs each year. About 35,000 visits are sampled annually from about 400 EDs. NHAMCS is a record-based survey, i.e. data are abstracted from the patient's medical record by ED staff, or by a census bureau field representative when local ED staff are unable to do so. The benefits of provider-based healthcare surveys like NHAMCS include the clinician perspective: data related to diagnosis and services have higher reliability. Reponses are also less subject to recall bias, a problem with household surveys like the National Healthcare Interview Survey (16).

The NHAMCS data collection method is cross-sectional in nature. The unit of survey measurement is visits, which is not the same as patients (since some patients may have multiple visits during the year). Therefore, calculated estimates represent visits and not patients. In the public use data for this study, neither patients nor hospitals are identified, and patients are not followed over time.

National estimates are based on patient weighting and are rounded to the nearest thousand. Data are weighted to generate national estimates by using the three estimation processes of inflating reciprocals of the sampling selection probabilities; adjusting for nonresponse; and applying a population weighting ratio adjustment (17).

Data collection method: Patient visit information is gathered using the Patient Record Form (PRF). Some items such as patient demographics, payment sources, diagnoses, services, and medications are collected every year. Some items, however, change when the PRF is revised every four to five years.

To prevent hospitals from collecting data during the same month each year and generating potential seasonality bias, the sample of hospitals is randomly divided into 16 subsets and randomly assigned 1 to 16 of four week reporting period that rotate across each survey year. That is, each hospital is surveyed approximately once every 15 months (18).

Outcome variable

Length of visit (ED-LOV)

The primary outcome for this analysis is **Emergency Department-Length of Visit (ED-LOV).** For NHAMCS, CDC-NCHS defines ED-LOV as the time between patient arrival and discharge or admission/transfer (19). The ED-LOV includes waiting-room time, evaluation time, testing time, treatment time and transfer to the inpatient bed. For the purpose of this analysis, visits which have no data or are missing data for the primary outcome variable will not be included in the analysis of the study cohort.

Public Health Importance of ED-LOV

Length of visit is a proxy for ED overcrowding. Overcrowding, as defined by the Australasian College for Emergency Medicine (ACEM), occurs when ED function is impeded primarily because the number of patients waiting to be seen, undergoing assessment and treatment, or waiting to leave exceeds the physical and/or staffing capacity of the ED (20). The ED-LOV is directly correlated with a number of quality of care measures including patient dissatisfaction(21), ambulance diversion(8), poor patient outcome(22-26), increased adverse events for the patients with non-ST elevation myocardial infarction(27), and increased mortality (28-32), increased inpatient stays(22, 33). Monitoring the ED-LOV is an important component of ED quality assurance (23).

The ED plays a crucial role in US society, both providing care to acutely ill and injured patients and serving as a major point of entry into US healthcare system for the more than 47 million uninsured patients. In fact over 60% of hospitalizations of uninsured patients originate in EDs. Still, poor patients are not the reason for increased ED resources utilization (34). Uncompensated or insufficiently compensated care is a liability for healthcare institutions and may create a disincentive to offer or expedite ED services (3).

Some causes of overcrowding include lack of capable staff, low number of inpatient beds for critically ill patients, lack of capacity to provide focused one-on-one care required to perfectly manage critically ill patients for long-term (3, 19, 35-37). These factors lead to delays in the definitive treatment and higher chances of adverse outcomes (22, 36, 37).

Even though there are efforts to implement ED time thresholds all over the world, (38) there are no nationwide ED length of visit targets in the U.S (36). Although a median LOV of two hours is viewed as best practice, achievement of such target is still far from sight (36). A LOV of six hours or more is highly correlated with higher death rate in intensive care unit (ICU) patients, robustly supported by empirical data (22). However, specific causes of diminished performance of an emergency department differ among countries, in addition to differing between individual institutions. Therefore solutions to these problems also differ.

A qualitative study (39) evaluating the response of hospitals to the “four hour rule” mandate in Britain in 2005 found that the successful EDs depended on collaboration between ED and the hospital leadership. The mandate was perceived as an ED rule rather than hospital rule which led to increasing conflict among staff. In addition, hospitals perceived the rule to be a target instead of patients, which led to potentially placing patients at risk of ill-considered expedited decisions of mandate burdened ED physicians (36).

An important consideration when evaluating the importance of ED-LOV is its variability in psychiatric cases. The finding of longer LOV for psychiatric admissions as a result of a lack of psychiatric inpatient beds, (40) is contrasted by recent studies showing that the distribution of overall ED length of visit for patients is skewed by certain psychiatric conditions, like abundance of intoxicated patients requiring time to sober before being able to be safely discharged (36).

Boarding time (ED-BTI)

Boarding Time Interval (ED-BTI) is the amount of time in minutes, between when a bed is requested for an admitted patient and the time at which patient actually leaves emergency department for inpatient unit. An excessive boarding time is also called “access block” referring to the situation where a patient in the ED requiring inpatient care is unable to gain access to a hospital bed within a reasonable time period (41). In theory, the capacity of the hospital is its ability to manage a load of patients in the range of 20% of the hospital bed capacity (42), but when this limit is exceeded then the ED waiting time for boarded patients starts to increase. Previously, many studies utilized ED-LOV as a proxy for boarding time (43). The relationship between boarding time, ED overcrowding, ambulance diversion and ED activity is yet to be explored completely (41). These studies were limited by the survey structure and the information collected in the dataset. But since, year 2009 NCHS has decided to include boarding time in the publicly available dataset. ED boarding (the practice of admitted patients remaining in the ED due to lack of an available staffed inpatient bed), plays the largest role in the crowding in emergency department (36, 44). That means overcrowded emergency department can be seen as the result of backflow of hospital crowding.

Public Health Importance of ED-BTI

When a hospital is full, ED patients who need inpatient care are “boarded” in observation/exam rooms or hallways until an inpatient bed is available. Boarding of patient ties up space, equipment, and personnel that would have been otherwise be available to meet the needs of new incoming patients. Critically ill patients often wait the longest for admission, because beds in the intensive care unit are in particularly short supply

Patients who are admitted to the in-patient department (IPD) from the ED usually encounter a number of potentially rate-limiting steps from arrival to transfer to an inpatient bed. These steps require a high-level care and coordination. These steps include:

1) Evaluation of the potential emergency by triage nurse.

2) Placement in emergency Department

3) Evaluation by medical care provider (for example, interns, residents or MD)

4) Confirmation of diagnosis by test ordering, test completion, and re-evaluation

5) Treatment initiation and making decision about primary reason for admission

6) Placement of request for an inpatient bed;

7) Transfer of care to corresponding physician in patient unit

8) Admissions staff search for available beds (ICU or non-ICU);

9) Transport of patient to the bed (45).

Boarding time includes the steps from 6 to 9. In case of unavailability of the beds, or beds are reserved for other patients (for example, elective admissions), patients keep occupying the beds in the ED before transfer to their inpatient beds. Thus, it can be inferred that boarding signifies the backflow effect of the overflowing of IPD on ED. Thus, boarding impedes overall ED flow because the boarders occupy ED beds for long periods, which reduces the capacity to care for new patients (18, 45).

There is an inverse relationship between the amount of time the patient stays in the waiting room and receipt of required quality of care over time and it is associated with a high chance of an adverse outcome (22). Boarders are traditionally cared for either by physicians in the ED - who are supposed to be looking after patients in the ED - or by inpatient doctors whose admitted patients are geographically located in a different part of the hospital (43). In addition to this, ED nurses must take care of these patients as inpatients while attending to new patients. This can reduce the quality of care for both the boarders and the new patients (18).

Exposure variable: 2009 H1N1 influenza pandemic

Background

Influenza viruses have a great potential to be among the deadliest of all known pathogens. Still it can be understood from the history of influenza that all pandemic strains are not created equal (46). In contrast with other influenza strains (H5N1) the pH1N1 strain of virus has circulated consistently in human population since 1977 and is a component of annual influenza vaccines. Even though the transmission of H1N1 from pigs to humans was a new strain, prior exposure to this virus was one of the important factors in predicting the degree of protective immunity in human population (46, 47).

Two of the most recent devastating pandemics in the world, which took place in 1957 and 1968, were both caused by novel avian-human reasserting influenza viruses. Both of the pandemics share some characteristics, such as: the pathogen was first identified in Asia, and there was a small amount of information available from many countries about the disease even before these pandemics spread in United States (48). However, in contrast to these prior pandemics, the 2009 influenza A - H1N1 (pH1N1) "swine flu" pandemic, no biochemical, clinical, or epidemiologic information was available before its initial detection in the United States on 21st April 2009. Within four weeks 41 countries around the globe reported presence of H1N1. The 2009 pandemic virus quickly spread globally, and on 11 June 2009, the World Health Organization (WHO) declared the first influenza pandemic since 1968–1969(47).

Public health Importance of research on influenza:

Influenza in human populations is seasonal because seasonal environmental conditions such as low temperature and low humidity are known to be favorable for transmission (49). Apart from this winter seasonality, another independent but critical property that predicts the excess mortality in the U.S.is age distribution for Influenza (24).

Apart from influenza/pneumonia, three other major classes of disease which are traditionally considered to be measures of excess mortality during winter seasons are cardiovascular diseases, cerebrovascular diseases, and diabetes. These 4 disease classes account for about 70 to 80% of mortality during winter seasons (25). Some studies have shown that the largest cause of a higher mortality in winter in the United States is probably influenza (25). A strong correlation had been observed between magnitude of seasonal component of mortality and severity and the dominant influenza subtype of each influenza epidemic (24). Influenza epidemics cause excess mortality by invoking the inflammatory reactions to influenza viral infections, which are objectively evident by rapid increase in markers of inflammation, specifically C reactive protein which is related to higher incidence of cardiovascular events, in women and elderly (24). Also, excessive mortality in seriously ill patients of non-influenza related conditions such as, myocardial infarctions and pulmonary embolism has been observed (25).

A study of all-payer inpatient discharge abstracts conducted to determine the excessive morbidity and mortality attributable to influenza pandemic in 2009, based on excessive inpatient admissions in the hospital compared with the previous years, found out that the total IPD volume did not change much during the 2009 influenza pandemic period. The increased mortality risk during the influenza pandemic period was seen in admitted patients instead of the patients from ED (8). The performance of the hospitals in pre-pandemic period did not change by great degree during the 2009 influenza pandemic (8). But influenza did affect hospital revenue generation, through reduced IPD admissions of non-influenza related conditions. That is, during 2009 the largest reductions (5.5%) in admissions were related to gynecological and obstetric cases(8).

Primary covariates of interest

1. **Demographic factors:**

Age:

A unique characteristic of deaths attributable to Influenza during the pandemic seasons was a shift in the age distribution to younger ages. This shift in distribution was strongly correlated with dominant influenza subtype in each epidemic (50). In the majority of these times (seasons dominated by influenza A (H2N2) or A (H3N2) viruses) the all-cause mortality was much greater, when compared with influenza subtype B virus (24).

Sex:

From long-standing knowledge of influenza epidemiology, males are thought to be more susceptible to infection by influenza viruses than females because of more exposure to the aerosols present in air (25). Other studies have found contrasting results that, dominance of male mortality during the pandemics was not a result of influenza alone (25). One of the largest health-related upheavals occurred in influenza pandemic of 1918, which cost over 20 million human lives worldwide, half a million in the United States) (51).

Race/ethnicity:

Previously it was thought that, race/ethnicity was not an important determinant of ED utilization after adjusting for age, sex, payment type and source of care (21). Later studies show that with use of comparable datasets, black patients admitted through the ED have longer ED-LOV compared to non–blacks, suggesting that racial disparities may exist across U.S. hospitals (43). Another study incorporating ED-level analysis showed that most racial and ethnic disparities in

ED-LOV are accounted for by longer ED-LOV at the hospitals attended by these racial groups, rather than at the individual level. Also, the ED visit rate of Black patients for infectious diseases was strikingly higher than non-Black patients (52).

Clinical characteristics:

Fever, cough and associated flulike symptoms such as runny nose, nausea, vomiting and sometimes loose motions are non-specific symptoms which make the differential diagnosis of influenza very broad. In more than 25% of the patients during 2009 H1N1 pandemic bacterial co-infections contributed to the fatal outcomes (38). Due to similarities of symptoms of Influenza with common flu in initial stages of disease, clinical characteristic only serve as guidelines for segregating patients to be subjected to more specific diagnostic tests.

2. **Physician and Visit characteristics:**

Triage score:

Many EDs across the globe use triage systems. The intention behind triage is to improve the efficiency of emergency care and to prioritize cases by clinical urgency. Triage is many times viewed as an ethical issue (44, 53), as it places the decision of provision of treatment in hands of selected professionals. Adverse effects of triage might lead to adverse consequences like delay in providing care, compromise in privacy and confidentiality, poor physician-patient communication, failing to provide the necessary care altogether, or even having to decide whose life to save when not everyone can be saved (54). These consequences challenge the ethical quality of emergency care. Recently health researchers have tried to develop specific triage protocols for critical care during the influenza pandemics based on important issues of Influenza positive cases, like inclusion, exclusion criteria, minimum qualifications for survival and a prioritization tool (55).

The triage score has some major public health implications. Conditions that are categorized as semi-urgent or non-urgent might best be treated by primary care practitioners and might reduce ED costs (35). Improving access to primary care providers may improve the cost benefit ratio (35).

Laboratory tests:

The 2009 pandemic showed that use of specific diagnostic tests developed for the strains predicted based on previous year's experiences will most likely be unsuccessful. Metzgar et al. have urged the integration of broadly targeted assays into hospital diagnostic systems so as to allow rapid recognition of pathogen emergence in the future (56). Longini et al. suggests that strategies such as anti-viral prophylaxis of the contacts of an index case of a highly pathogenic novel influenza strain after its identification and information are critical for early containment of a pandemic. The window of success for such strategies may be as little as two days (57).

Use of screening and diagnostic testing in the ED may affect the ED-LOV (19). Blood tests and advanced imaging studies both added ~50 min to the average ED-LOV. Policies and systems to streamline the use of common tests may be useful in diminishing crowding for conditions such as influenza, where laboratory testing is often used (19).

Imaging Studies:

Although, the diagnosis of influenza does not depend much on use of advanced imaging studies such as CT scan, MRI and ultrasonography, use of advanced imaging techniques in ED increases average ED-LOV by almost 37% (3, 19). More studies are required for testing the effect of utilization of imaging techniques in ED during overcrowded conditions such as pandemics.

Physician skills:

An essential physician skill is the rapid and effective resuscitation of the very sickest patients. This quality cannot be defined with single variable (58):

1. Highest triage level
2. Hospital admission
3. Critical care unit admission
4. Death in the ED
5. Cardiopulmonary resuscitation
6. Tracheal intubation (35)

Even though the primary aim of this study does not include the evaluation of physician skills and its relationship to other ED factors, it is included in the literature review because of its importance. Some of the measures included in this analysis can be considered as proxy measures for physician skills.

To understand the effect of influenza epidemics on ED operations, we created a dichotomous categorical variable describing the receipt of any kind of treatment during that particular visit. We expect that laboratory services utilization will have a substantial effect on patients discharged from the ED (19).

3. Hospital factors

The NHAMCS obtains information related to hospital such as ownership, a region of country, and Metropolitan Statistical Area (MSA) from a commercially available database updated annually by the Verispan (Yardley, PA) (17).

The safety net status of the hospital

The predicted possibility of penalization to safety net institutions has always been the major concern for implementation of performance measures, recently it has been shown that both safety net and non-Safety net ED's perform well on ED length of stay goals that they have proposed with median ED and length of stay for both easy types well under eight hours for admissions and under four hours for discharges (59).

The importance of safety net status of the hospital as one of the confounding variables for the outcome of interest lies in the recent study conducted by CDC (40). Results of this study demonstrated that safety net ED's were more likely to be in areas with fewer primary care physicians and their patients include more African-Americans and children. Also, safety net EDs were more likely to treat non-urgent conditions, more likely to be seen by a resident or intern under the supervision of staff physician and less likely to be admitted (40).

About 36% of the nation's EDs are considered safety net EDs, since these are more frequently attended by Medicaid or uninsured patients, or both (40). The definition of safety net status of a hospital has not been re-evaluated since year 2000 by CDC-NCHS; therefore in this study we used the same criteria. Only 41% of safety net EDs receives any kind of federal assistance for treating a disproportionate share of Medicaid and uninsured patients, who are overrepresented by racial disparities and minorities. Because of these financial and socio-demographic implications, the inclusion of safety net status of hospital in the analysis is important (36).

Appendix 1 illustrates 11 studies that discuss potential variables that could influence ED-LOV. All of the studies are retrospective in design and analyze cross sectional data from either NHAMCS or similar data sets. Two studies evaluate the methodological issues related to the NHAMCS data analysis, while other studies look for the effect of the selected exposure variables on ED-LOV.

From the table the following variable immerge as potential influencing factors for the ED-LOV and other ED operations parameters.

Demographic factors: age, sex and race/ethnicity

Physician and visit characteristics: triage levels in the ED, visit payer type, use of any diagnostic/screening test, use of advanced imaging techniques(CT/MRI/USG), number of tests ordered/procedures performed,

Hospital factors: location of the hospital (rural/urban), metropolitan statistical area (MSA), ownership of the hospital, region of the hospital, type (teaching hospital), safety net status of the hospital.

This thesis analysis project is interested in the 2009 H1N1 influenza pandemic period. The most recent study by Rubinson et al (8) do a very good job of outlining factors specific to the pandemic period. They were limited by the data source of their study. They have used HCUP State In-patient Databases (SID), which contains patient age, sex, primary expected payer status, severity of illness, length of stay (IPD only). As SID contains estimates only related to the inpatient status and not specific to ED, the estimates derived from this study are related to the impact on the overall inpatient hospital system. This data set was used in conjunction with State Emergency Department Databases (SEDD). The SID and SEDD database combined has IPD data on only 26 states and ED information on 19 states only (60).

The 19 states where SID and SEDD data were used in ED analysis: Arizona, California, Georgia, Hawaii, Iowa, Indiana, Kentucky, Maryland, Minnesota, Missouri, Nebraska, New Jersey, Ohio, Rhode Island, South Carolina, South Dakota, Tennessee, Vermont, and Wisconsin - Supplemental Digital Content 1, http://links.lww.com/MLR/A418). This study evaluates the effect of pandemic 2009 H1N1 on overall US hospital system, but not on the daily utilization of ED’s, which act as most important port of entry in the hospital system.

As per the report from the State and territorial epidemiologists, geographic distribution of influenza activity was most extensive during the weeks ending October 24, 2009, when 48 states reported widespread influenza activity and all 50 states and Guam reported widespread or regional influenza activity. After which the epidemic curve started the decline and no jurisdictions reported widespread influenza activity by the week ending January 9, 2010 (61).

Rubinson et al. analyzed the effect of the 2009 pandemic via mortality risk analysis based on the surge of the Influenza activity particular hospital experienced. But this estimate is limited by the scope of database itself. The definition of pandemic that was used in study by Rubinson et al. was nationally representative period definition, which does not necessarily coincide with the local state time period definition.

For this analysis, we decided to use the definition used by CDC-NCHS to decide if a particular week is Influenza Activity week or not. A non-influenza week is defined as periods of two or more consecutive weeks in which each week accounted for less than 2% of the season's total number of specimens that tested positive for influenza (62). We applied this definition to create the time periods for the seasonal and pandemic Influenza Activity time during the 2007 to 2010 period. The data used for the same was derived from the collaborative functioning of World Health Organization (WHO) and National Respiratory and Enteric Virus Surveillance System (CDC- NREVSS) laboratories located throughout the United States that participate in virologic surveillance for influenza. These laboratories report the number of respiratory specimens tested and the number of positives for influenza types A and B each week to CDC. Some also report influenza a subtype (H1 or H3). The data obtained from these sources was used to define the week for the presence of Influenza Activity. The graphical illustration of data is presented in the **Appendix 2.**

Research Question

The two important key issues involved in the mounting of appropriate response to natural/ man made emergency situation are smooth and optimal running of ED operations in every hospital and timely inclusion of key partners in health. ED operations can be measured with ED-LOV. This measure can be affected by many factors, such as demographic factors (sex, age, race, ethnicity, expected source of payment), ED and physician characteristics (triage score, teaching hospital, availability of qualified staff, physicians acuity, provider type and diagnostic/screening tests performed and treatment given) and hospital factors (MSA status, region of the country, hospital ownership, safety net status of the hospital). All these factors will be controlled for estimating the effect of pH1N1-2009 on ED operations.

Presently we do not have any information about the effect of Influenza 2009 Pandemic (pH1N1) on ED operations performance in USA compared to no Influenza Activity time ED performance. Also, the effect of seasonal Influenza during the years 2007 – 10 compared to no Influenza Activity in ED efficiency is not studied up till now. This analysis expects to bridge this gap in knowledge by comparing influenza pandemic period with the previous years and within the same year. The present knowledge also lacks in generalizability of results to entire US population and this shortcoming can be addressed with this analysis, as the NHAMCS is nationally representative sample survey of the US population. In addition, this analysis offers great opportunity to observe the effects of the access block on ED operations, which can be analyzed through use of boarding time interval as indirect measure of hospital IPD overflow pressurizing the ED.

CHAPTER 2: MANUSCRIPT

Introduction

The four notable pandemics that occurred in 20th century (1918, 1957, 1968 and 2009) had one thing in common that, they had nothing in common. These four pandemics differed from each other in etiologic agents, epidemiology disease severity and time intervals in between them (63-65). Several other pseudo-pandemics also did occurred before but, current virologic knowledge dictates that changes in haemagglutinin subtypes that arise from genetic re-assortment with animal influenza A viruses lead to true pandemics (46). With accelerated levels of commercial and population mobility of current times, new forms of flu virus can also spread across the globe with unprecedented speed. Responding quickly and adequately to implement community response and control protocols in each outbreak becomes imperative on the part of governments and global public health organizations (66). One tool for pandemic planning is analysis of responses to past pandemics that provide insight into productive ways forward (47, 48).

On June 11, 2009, WHO declared the first influenza pandemic of the 21st century (67) which officially lasted till August 10, 2010 (68). During this period, in USA ~69 million contracted disease and 12,500 fell for it (69). Even though, H1N1 preferentially infected <25 years of age, working age adults (30 to 50 years) suffered severe and fatal infections. This was starkly different than epidemics of seasonal influenza, where most deaths occur in frail elderly people (61, 67). Although, the transmissibility of the 2009 H1N1 influenza virus was lower than previous pandemics (70), transmission occurred before the onset of symptoms and critical illness occurred rapidly after hospital admission leading to frequent use of rescue therapies(71).

Timely diagnosis of influenza and early recognition of an influenza outbreak or epidemic are key components in preventing influenza-related complications, hospitalizations, and deaths (72).

Emergency departments are the most frequent points of entry for most influenza cases and are well positioned to identify and manage influenza community outbreaks and epidemics (73). Recent studies show that, during pH1N1-09, although, 18% increase in overall ED visits was observed, the pneumonia and Influenza ED visits were twice compared to prior years (8). For successful management of ED resources, planning and drilling are the only ways to minimize deviations from the guidelines and to avoid management mistakes (42) and successful planning can only be done through analysis of the previous disasters.

This study intends to use ED-LOV as performance measure for the ED operations, which is established by CMS and joint commission. ED-LOV directly correlated with a number of quality of care measures which includes patient dissatisfaction(21), ambulance diversion(8), poor patient outcome(22-26), increased adverse events for the patients with non-ST elevation myocardial infarction(27), and increased mortality(28-32), increased inpatient stays(22, 33), and an important component of ED quality assurance monitoring (23). Also, boarding time interval -which is used as another measure of ED performance - also impedes overall ED flow because the boarders occupy ED beds for long periods, which reduces the capacity to care for new patients (18, 45).

Currently, there is no result available that compare that pandemic/seasonal Influenza duration ED utilization compared to the no Influenza Activity periods. By combining, NHAMCS data which is a nationally representative annual sampling survey, from year 2007 to 2010, the estimates generated from this analysis are robust and generalizable to US population.

Goal of analysis:

We used the National Hospital Ambulatory Medical Care Survey (NHAMCS), a large national probability sample of ED visits conducted annually by the National Center for Health Statistics (CDC-NCHS). The objective of this analysis was to examine and quantify the effect of pH1N1-09 on ED operations in US when compared to the no Influenza Activity Period. The similar analysis was done to understand the effect of seasonal Influenza on ED operations compared with no Influenza Activity Period. For this analysis this project combined the NHAMCS datasets from 2007 to 2010 to attain the sufficient measurement power. The performance measure used for ED operation measurement was ED-LOV. We hypothesized that after adjusting for potential covariates, pandemic Influenza (pdmH1N1-09) would affect ED operations by increase in ED-LOV when compared with no Influenza Activity Period.

An auxiliary analysis in the subgroup (patients admitted to the hospital from ED) of patients was done to assess the effect of new performance measure ‘boarding time interval’ (ED-BTI) for understanding the possible correlations of this measure with variables measured in the NHAMCS dataset. We hypothesized that ED-BTI would not be significantly associated with demographic or macro systemic characteristics, but it will be dependent on hospital attributes which are specific to ED and hospital infrastructure and resources.

Methods

Study design:

We performed a secondary analysis of the 2007 to 2010 National Hospital Ambulatory Medical Care Survey (NHAMCS), an annual 4-stage national probability sample survey of visits of ED’s based in general and short stay hospitals, excluding federal hospitals, hospital units of institutions, and hospitals with fewer than six staffed beds. The survey is conducted by Centers for Disease Control and Prevention's National Centre for Health Statistics (CDC-NCHS) (16). The NHAMCS uses multistage estimation procedure that produces essentially unbiased estimates (74). The institutional review board of Emory University evaluated the study prior to its initiation and determined that the study should be exempt from the further review or informed consent requirements.

Study settings and the population:

The purpose of this analysis was to study the effect of pandemic H1N1 Influenza /seasonal Influenza Activity Period on ED operations. We combined and analyzed the recent NHAMCS survey years of 2007 through 2010. This was done to ensure the an adequate sampling of the events and improvement of the associated standard error of the estimates and (75). The survey is conducted by staff at the sampled hospitals, under guidance of NHAMCS field representatives, from Patient Record Forms (PRF). The information is collected on demographics, visit characteristics, and hospital factors for all ED visits (16). To prevent same hospitals from collecting data during the same month each year and generating potential seasonality bias, full NHAMCS hospital sample is partitioned into 16 panels which are rotated into the sample over 16 periods of 4 weeks each, so that only 13 panels are used in each year (74). A detailed description of the data collection, abstraction, and cleaning procedures is available from the CDC (16). These data are publicly available and de-identified.

For testing the effect of outcome variables, the entire dataset (NHAMCS 2007 - 2010) was stratified into three categories of time periods by designating a month (the ultimate unit of time in NHAMCS dataset) as no influenza activity/seasonal influenza activity/pandemic influenza activity. For this designation, by CDC-NCHS definition was used. *A non-influenza week is defined as periods of two or more consecutive weeks in which each week accounted for less than 2% of the season's total number of specimens that tested positive for influenza* (62). The data decision was taken based on the WHO – NREVSS collaborative functioning surveillance system (76). The graphical illustration of data is presented in the **Figure 1.**

Study protocol:

The **primary** outcome for this analysis was ED-LOV. The NHAMCS, CDC-NCHS defines ED-LOV as, the time between the moment a patient arrival until discharged, or admitted, or until the time patient left the emergency department (19). Study sample was missing ED-LOV data on

6901 (4.95%) of visits, so these visits were not included in the analysis cohort. The secondary outcome of interest for the purpose of this analysis was Boarding Time Interval (ED-BTI). ED-BTI can be understood as the time in minutes between the requests for bed is made for admitted patients and the time at which patient actually leaves ED for inpatient unit. ED-BTI is only recorded in the patients who are admitted in IPD through ED. For this sub-analysis with ED-BTI as outcome variable only visits with recorded boarding time were considered (6412 visits, 4.60% of the dataset).

Covariates:

PRF's used by CDC-NCHS data collection teams include patient demographics, visit related questions, use of diagnostic⁄screening tests and imaging, discharge diagnoses, and disposition and hospital information. Detailed description of PRF is available at CDC website (76). For the purpose of this analysis, age was categorized in 4 categories based on predisposition of Influenza to affect certain age range (65). Race and ethnicity are usually entered by hospital staff based on hospital practices, in case of doubts NCHS imputes missing values with values randomly assigned from patient records with similar characteristics (36). This analysis combined race and ethnicity and created 4 mutually exclusive categories as non-Hispanic white, non-Hispanic black/African American, Hispanic, and other (3, 36, 43).

Triage score coding in NHAMCS did not change much for the study duration. From 2005 to 2008, CDC-NCHS used 5-point numeric scale, which from 2009 was renamed as characters format, “Immediate,” “emergent,” “urgent,” “semi-urgent,” and “non-urgent,”. This study considered that both the coding pattern were equivalent to each other based on the literature review (35). The payer status of each visit was analyzed using five categories: Private, Medicare, Medicaid, Uninsured, and Other. Visit was considered to be uninsured if expected payment source was self-pay or no charge. Computed tomography (CT), magnetic resonance (MR), and ultrasound (US) were considered to be advanced imaging techniques. Any of these imaging techniques defined the binary covariate used in this analysis. Use of diagnostic and screening tests were analyzed both as indicator variable with use of test at all and as binary variable with 4 or more tests as covariate of interest. Disposition of the patient was used as covariate of interest with three categories defined as discharged, admitted and transferred.

Covariates of interest on hospital-level were Metropolitan Statistical Area (MSA) status, region of the country, and hospital ownership. Region (Northeast, Midwest, South, and West) and Standard Metropolitan and Micropolitan Statistical Area (MSA) categories represent standardized geographic divisions defined by the United States Census Bureau. An MSA is defined as an urban area of at least 50,000 inhabitants and its adjacent communities (77). If physician provider was an intern or resident then our analysis designated that hospital as a teaching hospital, and all other visits occurring in the same hospital in same year were considered as visits to teaching hospital. We created an additional variable called safety-net status for designation of hospital that serves the majority of underserved population. By CDC definition, A hospital is considered as safety-net hospital if more than 30% of total ED visits were either Medicaid or uninsured as the expected source of the payment, or combined both payer sources greater than 40% of total ED visits (40).

For testing the effect on pandemic Influenza Activity Period on ED-BTI, apart from the above mentioned variables we used other ED and hospital level variables which are collected through the same survey. We expected that it is less likely for ED-BTI to be affected by demographic or physician level characteristics as the patient is already admitted. We hypothesized that ED infrastructure related attributes will be more significantly associated with ED-BTI. The NHAMCS collects data on some of the ED infrastructure related components, e.g. presence of bed coordinator in ED, presence of computerized system in ED for bed availability, availability of observation unit in ED and practice of boarding admitted patient in ED/hospital elsewhere before they go their actual designated beds.

Data analysis:

To generate national estimates all analyses used weights, stratum, and PSU design variables provided by the NHAMCS (16). Both ED-LOV and ED-BTI are non-normally distributed continuous variables. To test for normality, three methods were used, Anderson-Darling test, the mean-median difference and standard deviation to mean ratio (78). Natural log transformation was used for ED-LOV and ED-BTI prior to regression analysis to account for the data skewing due to outliers (78). Descriptive statistics present median ED-LOV with interquartile ranges (IQRs) across the three Influenza Activity periods defining the dataset under analysis across patient demographics, ED and visit characteristics, and hospital factors **(Table 2)**. Similarly, **table 3** presents the findings of median ED-BTI with its IQR stratified based on the three Influenza activity categories across the patient, ED and hospital attributes.

To estimate the excess percentage of time taken in ED by an average visit during either pandemic or seasonal Influenza Activity periods, two different multivariable models were developed. First model considered Pandemic Influenza Activity period as primary predictor against no Influenza Activity period with log-transformed ED-LOV as outcome variable and conceptual domains of covariates as independent predictors, while for other model Seasonal Influenza Activity period against no Influenza Activity period was primary exposure variable with other predicators added in similar fashion. All covariates that might contribute to variation in ED-LOV/ED-BTI were selected based on literature review of previously published studies. The potential predictors were then categorized into conceptual domains of demographic features (age categories, sex, and race/ethnicity), ED/visit attributes (payer status, triage levels, use of advanced imaging or screening tests, disposition category) and hospital characteristics (region of hospital, metro/rural location, safety-net status and teaching hospital). Complex analytic models were built by adding these domains were sequentially into our sample survey multivariate linear regression model, using natural log-transformed ED-LOV or ED-BTI as the outcome. All possible covariates were tested in the model (except, safety net status and patient insurance status was not included in the any of models simultaneously for the suspicion of collinearity, since they were derived from same variable.) Testing for interaction and confounding was performed on all inclusive model, variables that were not significantly associated with outcome of interest were removed from the model. The linear regression beta coefficients were reported as percent change in ED-LOV/ED-BTI (based on the mean of the log-transformed data) with respect to a reference group with 95% confidence intervals (CIs). A two-tailed $p < 0.05$ was considered statistically significant. All analysis were performed using SAS version 9.3 (SAS institute, Cary, NC) and SUDAAN version 10.0 (Research Triangle Park, NC) to account for the complex sampling design and patient weights.

Results

Characteristics of ED department visits:

From 2007 to 2010 NHAMCS collected data on 139,502 visits sampled over 350 hospitals; 23,015 (16.50%) were during the pandemic period. The entire dataset was weighted to represent 552,738,785 visits nationally over the study period. During the pdmH1N1-09 period 2,315,050 (2.47% of total ILI cases) weighted cases visited the ED's. This distribution of ILI cases with characteristics of population is depicted in the **table 1**. **Table 2** and **3** depict the distribution of median, Quartile 1 and 3 ED-LOV and ED-BTI respectively over the study period stratified by the Influenza Activity period.

Overall effect on ED operations:

The overall ED-LOV for the entire study period was 156 minutes. The seasonal Influenza Activity period had greater median ED-LOV than any other Influenza Activity Period on which population was stratified on **(Table 2).** The median ED-LOV increased with increasing age and was more for females compared to males in any of the Influenza Activity period. The ED-LOV was significantly less for the whites than any other race/ethnicity category. Non-Hispanic Blacks overall had higher ED-LOV than any other race, but during the pandemic Influenza time Hispanics and blacks shared same amount time. Visits with payer status as “other” such as workers compensation, enjoyed shortest amount of ED-LOV, while highest were for Medicare patients. As previous studies have indicated (19), this analysis found similar results for ordering five or more diagnostic/screening tests affected ED-LOV more than anything else along with use of advanced imaging (CT/MRI/USG) in ED. No Influenza Activity Period was exception to this pattern.

Overall, of all the four geographic regions of USA, Midwest region had least ED-LOV in the all three influenza activity periods compared to other three regions. Location of the hospital had great implication for ED-LOV; hospitals in metropolitan area had significantly longer ED-LOV than those with non-metropolitan area. Visits made in the teaching hospital took longer time in ED as compared to the non-teaching hospital. Ownership of the hospital had implications in increasing the ED-LOV over all three time periods. Government hospital had highest ED-LOV than any other hospital like private or proprietary. As per the findings of the previous studies we did not find any significant results for the inclusion of safety net status of the hospital as for either of them the ED-LOV did not differed from each other significantly. Overall, seasonal Influenza Activity Period dominated the other two periods for the ED-LOV.

Effect on Emergency Department – Length of Visit:

Table 4 presents the results of combined adjusted and unadjusted effects of pandemic Influenza Activity Period against No Influenza Activity Period and Seasonal Influenza Activity Period against No Influenza Activity Period. After adjusting for all covariates, it was found that, visiting an ED during pandemic influenza activity period took 5.47 % longer time when compared to no Influenza Activity Period, which was statistically significant. In contrast to pandemic influenza, even though seasonal influenza significantly affected (9.14%) emergency Department operations, the magnitude of effect was reduced (7.5%) when adjustment for the covariates was performed.

Pandemic Influenza Activity Period:

In multivariate analysis of all visits **(table 5),** longer ED-LOV was found among non-Hispanic blacks (12.30%) and Hispanics (9.11%) patients, when compared to non-Hispanic white patients. Females (3.51%) and older age (9.03%) group patients required longer ED-LOV. Medicare (6.3%) visits required significantly longer ED-LOV as compared to visits with private insurance. Similar to the previous studies done in past, we found that, use of advanced imaging techniques (26.85%), diagnostic screening tests in ED (54.84%), higher number of tests (37.29%) significantly increased ED-LOV during pandemic period as compared to doing fewer tests or not doing any tests at all. As compared to discharged patients, transferred (31.79%) or admitted (24.14%) patients clogged ED's for significantly longer amount of time. Pronounced effect of patient acuity was found during pandemic influenza period, where acute patients spent more time in ED. While geographic location of hospital in Midwest region of USA was least influenced by pandemic influenza when compared to other regions of USA; hospitals in urban (10.67%) area were responsible for longer ED-LOV. We found no significant difference, between visiting an ED in the safety net hospital when compared to non-safety net hospital, in contrast to which visit were teaching hospital (20.48%) was significantly associated with longer ED-LOV. Proprietary hospitals (-10.47%) prove to be better at keeping ED-LOV lower when compared to non-profit hospitals, while government (7.09%) hospitals suffered from longer ED length of visit.

Seasonal Influenza Activity Period:

Estimates for the seasonal influenza activity period against no influenza activity times followed similar trend as that of the estimates for pandemic Influenza Activity Period, also, they were pronounced in some key features. Older population (8.47%) and African-Americans (11.99%) as well as Hispanics (9.73%) took longer time in ED; females (4.2%) required significantly higher

ED-LOV. The excess time for the payer status of the visit was similar to effect of pandemic influenza, as were the estimates for use of advanced imaging techniques (27.3%), use of any diagnostic/screening tests (54.78%) and ordering of five or more tests in ED (37.54%). Effect of patient disposition on ED-LOV for transferred (32.73%) and admitted (24.83%) patients was much higher compared to discharged patients. In contrast to pandemic influenza period, effect of patient triage acuity (9.04%) on ED-LOV was lower in seasonal influenza period.

Effect on Emergency Department - Boarding Time Interval (ED-BTI):

We found no significant association **(Table 6)** between pandemic influenza period and ED boarding time interval (p value 0.2575). Although, adjustment for possible covariates reduced the overall estimate, this association was not found to be significant. Similarly seasonal influenza activity period had no significant impact on ED boarding time interval (p value 0.3193).

Multivariate adjusted percentage changes in ED-BTI for pandemic Influenza Activity Period are shown in **table 7**, for year 2009 only. We found that presence of observation unit in ED (40.96%) significantly increased boarding time interval during pandemic periods. Hospital practice of boarding admitted patient for more than two hours in ED/observation unit (42.05%) or someone else in the hospital (19.1%) was responsible for significantly longer boarding time interval. We found no significant association for effect of pandemic influenza period on boarding time interval for any demographic feature of visit (age, sex, and race/ethnicity). Similarly, none of the ED/visit characteristics or hospital level characteristics was significantly associated with boarding time interval during pandemic influenza period except for urban (17.21%) location of the hospital and visit to a teaching hospital (36.88%).

Discussion

Findings of this analysis suggest that, during pdmH1N1-09, ED operations were significantly affected, when compared with the no influenza activity periods. An average ED visit during pandemic time took 5.47% excess time. Several patient and hospital characteristics as well as ED processes were significantly associated with increased ED-LOV. Distinct association was found in Hispanics, African-Americans, use of diagnostic testing or advanced imaging in ED and location of the hospital in urban areas. Both during pandemic and seasonal influenza times blood tests and advanced imaging had the largest effect, weekly services each reading at least 40% of excess minutes to an average ED encounter. Similar to this visit to a teaching hospital was responsible for extra 20% of time. Analysis of seasonal influenza yielded similar results. It can be surmised from these results policies implemented to streamline the utilization of these common tasks can have a significant impact on ED operations.

Our results show that both pandemic influenza period and seasonal influenza period had no significant impact on emergency Department boarding time interval. We found that ED-BTI was significantly impacted during pandemic influenza time if hospital practiced dumping the admitted patients in ED/observation room or elsewhere in the hospital. An established system for continuous availability of better census data (computerized or human) had substantial effect on boarding time. These results are in conjunction with secondary hypothesis of this analysis.

ED’s has always been viewed as a center for rapid evaluation and successful stabilization of the patient; therefore ED’s are neither staffed not equipped to provide long-term care. Even though, it is recommended that two hours should be the "best practice target" for ED-LOV (79), in our study, we found that only lower 25% of weighted population was within the range of this recommended target. It suggests that, policies and training is required for streamlining the use of

ED system to diminish the crowding. We speculate that, this is a result of increased complexity of hierarchy and requirement of interdisciplinary coordination could have been the reason for 20% extra time required for an average visit to a teaching hospital during pandemic times. Our analysis supports the hypothesis we made, that ED-BTI is less likely to be dependent on input or throughput factors, but more likely to be influenced by hospital infrastructure and resources. Poor ED-BTI is a result of lack of output (i.e. less inpatient beds available for admitted patients). This is the first study that ventures on finding the association between ED boarding time and demographic or hospital traits during times of distress. Our finding of, unsubstantial impact of macro systemic factors (demographic, geographic and ED input and throughput factors) along with significant association of hospital/ED infrastructure attributes on length of the boarding time suggest that improvement in the process flow of ED would lead to reduced boarding time in hospitals.

This analysis strengthens the evidence is found by previous studies (37), that longer ED-LOV in Hispanics (14% of total visits with 9% added time) speculated to be related to language barriers. Longer ED-LOV for African American (23% of total visits and 12% more time) population indicates possible presence of racial disparities in health care provision (43). Use of advanced imaging techniques in ED (27% excess time), and ordering more diagnostic tests (37% excess time) was liable for increase in ED-LOV (19). Also, an additional finding of this study is more diagnostic tests were ordered for the patients with higher acuity. It is possible that, in acutely ill patients this increased ED-LOV is because of time required for the patient preparation, transport, testing and receipt of the results. This is in contrast with the ambulatory patients who are either require less tests or the tests results can be collected later. We also found that ED-LOV or ED-BTI does not differ based on safety net status of institution (36).

By combining datasets over recent years this study estimates the burden of influenza in United States emergency departments. Although large sample size and analysis of a nationally generalizable dataset are the strengths of this analysis, still the study should be viewed in the context of several other limitations.

Data was missing on 6901 (4.95%) of visits of all number of visits for ED admission or discharge time for main outcome. There was significant difference on demographic and hospital characteristics between the visits with data on ED-LOV and those without. Since, this proportion was small; the possibility of a major bias in our analyses is unlikely. Since, NHAMCS does not collect information on socio economic indicators of population. We used payer status of the visit being uninsured as a proxy measure for the SES. Bias related to use of such proxy measure are likely to be associated with this analysis. NHAMCS database is an independently conducted National sampling survey and it is not linked to inpatient hospital administrative department data. Because of which, several hospital infrastructure related attributes are not measured, which may affect the results produced for ED boarding time interval (36). Although, combining datasets over the years incrementally improves the prediction of standard errors, the practice of information masking in NHAMCS database in publicly released files put some constraints on this analysis. It is not possible to know the location of the particular EDs that participated in the survey; therefore, it is difficult to make the confirmed predications about the demographic features, SES of neighboring population and health care use in the particular area which could have been disproportionately sampled. The possibility of over or underestimation of standard errors because of use of masked data can carry from 12% to 46% (80).

This analysis presents only an estimation of effect of pandemic on ED operations. Since, database does not allow for the modeling of the specific scenarios with regard to the time of visit in particular location. Influenza 2009 Pandemic was limited from April of 2009 till April of 2010. Since it is not possible to map the available data with the geographic location the exact estimation of effect of pandemic is not possible.

We analyzed ED visits by all age categories, without excluding any particular category. It has previously been shown that children are seen at dedicated pediatric EDs or specialized areas within a given ED and their ED-LOV are dependent on the factors that are distinct from adult patients (35). As a result of this the study might have suffered from the biases resulting from such factors.

In conclusion, this analysis reports the significant impact of 1009 H1N1 pandemic on average ED visits when compared with no influenza activity times. Even though similar trend of results was also found in seasonal influenza, this analysis has important implications related to disaster preparedness and emergency planning of hospital emergency departments. Even though we found no significant Association between ED boarding time and pandemic/seasonal influenza period, this analysis suggests that macro systemic factors such as demographics and attributes of ED modus operandi are less likely to affect ED boarding time interval than hospital infrastructure related factors.

CHAPTER 3: PUBLIC HEALTH IMPLICATIONS:

Fundamental precepts in hospital-based planning include having a comprehensive well-rehearsed disaster plan that is based on a threat and vulnerability analysis. The 2009 influenza pandemic can be considered one of such situations of distress for EDs, when in many places crowding had reached dangerous levels (30). At the inception of the pandemic in 2009, a wave of ILI symptoms swept through the nation at a striking speed, which led to critical care systems becoming overwhelmed (31). This was testing point for many of the health care systems which based on the availability of the resources could later collapse or adapt. It has been suggested that the best way to prepare for disasters is to create an emergency and trauma care system that functions effectively on a day-to-day basis. According to this view, key aspects of disaster response should be addressed regularly in the training, continuing education, and credentialing of emergency care professionals (14). Many perceive that disasters are just like daily emergencies and can be effectively managed by the expanded mobilization of personnel, equipment, and supplies. This view holds that logistic problems faced in disasters are not usually caused by a shortage of medical resources, but rather from a failure to coordinate their distribution (42).

A WHO meeting in 1969 proposed solutions for the highly unpredictable nature of Influenza pandemics (81). It involved improvement of influenza surveillance systems and laboratory capacity for influenza diagnosis, based on constant evaluation, along with rapid risk assessment to respond most effectively to an emerging threat. Understanding the 2009 pandemic in context of previous influenza pandemics faced by world and its implications for future pandemics requires careful experimentation and in-depth historical analysis (63). Currently, there is no cost analysis for the effects of pdmH1N1-09 available... We currently do not have nationally generalizable estimates of effects of pdmH1N1-09 on US hospital ED operations and resource utilization. This analysis offers a unique opportunity to consider the broader linkages between ED operations and disaster preparedness.

Our literature review demonstrates that from a systems view, ED crowding is a local manifestation of a systemic “disease”. The causes of ED crowding involve a complex network of interwoven processes ranging from hospital workflow characteristics to viral epidemics. The effects of ED crowding are numerous. Infectious diseases (influenza for this analysis) remain a burden on public health care system. Centuries-old human interactions with influenza have taught us that the prevention and treatment of this disease does not require an advanced level of care. The diversion of some of this huge disease burden to primary care practitioners or home care rather than EDs might lead to significant relief on ED resource utilization.

Even though efforts to implement ED time guidelines are ongoing all over the world, (38) the United States, does not presently have any nationally standardized ED-LOV targets (36). Although two hours is the best practice, achievement of such target is still in the distant future (36). This study found out that only the lower quartile of the population in the analysis was within the range for this best practice target, even without influenza activity. Emergency departments need specific infection control measures to curb the spread of influenza in the ED and hospital during the influenza season(73).

Financial support has always been a major concern for ED resource availability. The 1986 the emergency medical treatment and labor act (EMTALA) mandated that EDs stabilize all patients before transfer, irrespective of their ability to pay. But this unfunded mandate (52) has led to the ED becoming a financial liability. The ED should be viewed as the place for optimal and rapid stabilization of acute patients. We found that patient triage acuity and advanced imaging and laboratory services had a significant impact on ED-LOV during pandemic times. Since all patients must share a single pool of critical care resources it is important that during emergent times ED processes such as triage system and need to adapt for coping up with increased demand for healthcare.

The disproportionately high ED-LOV for African-Americans and Hispanics despite being lesser population proportion for ED visits in comparison to whites requires more attention. The contrasting results shown by Pines et al. (43) and Baker et al. (21), should be examined further. The inability to include detailed socio-economic determinants of disease to perform multilevel regression using the public files of NHAMCS limits these conclusions.

ED boarding due to access block plays a major causal role in ED crowding (36), reducing the capacity to care for new patients (18, 45) and leading to low number of inpatient beds for critically ill patients, lack of capacity to provide focused one-on-one care required to manage critically ill patients for long-term (3, 19, 35-37). These factors lead to delays in definitive treatment, poor patient outcomes (22-26), patient dissatisfaction(21), and ambulance diversion (8). Our findings suggest that ED boarding time has no significant association with any particular social determinants of disease, but is associated with hospital infrastructure attributes and process systems flow. This suggests that ED-BTI is more dependent on the hospital infrastructure and processes efficiency. Functional and infrastructure related improvements have huge potential to induce positive effects on acute and long-term care. This analysis underscores the importance of requirement of further research for determination of effective measures and strategies to bring ED boarding time under control.

The following are some include several possible solutions for improvement of ED-LOV/ ED-BTI. Involvement of primary care physicians based in remote locations, having an established hospital wide disaster management plan, identification of command system during emergent situations, frequent drills/simulations for understanding the bottlenecks in emergency room, diagnostic department, and operating rooms. Identification of high surge hospitals during pandemic times and diverging patients away from such hospitals by emergency medical services could have potential good impact on their overall survival (8). Establishment of valid computerized process flow system in emergency departments might have a significant impact on ED functionality. The use of language services and advanced diagnostic techniques require further evaluation for reduction of ED-LOV. Provision of additional support during times of distress has benefit of possible improvement in the performance of hospitals with underlying quality issues.

Tables

Table 1: Characteristic of the ED visits for ILI (NHAMCS) year 2009			
Visit characteristic	**Estimated (weighted) number of visit for ILI in ED**	**% Distribution in data**	**Weighted % Distribution of total ED visits in NHAMCS 2009**
Demographic			
AGE			
Under 15 years	3,532,981	44.57	2.6
15-24 years	1,653,265	20.86	1.21
25-44 years	1,829,180	23.08	1.34
45-64 years	620,017	7.82	0.46
65-74 years	141,087	1.78	0.1
75 years and over	150,148	1.89	0.11
Total	7,926,678		5.83
SEX			
Female	4,506,503	56.85	3.31
Male	3,420,175	43.15	2.51
RACE			
White	3,806,458	48.02	2.8
Black	2,047,762	25.83	1.5
Hispanic	1,653,277	20.86	1.22
Non-Hispanic Other	419,181	5.29	0.31
Total	7,926,678		5.83
ED and Physician characteristics			
Triage categories			
Unknown	119,275	1.5	0.09
Immediate	402,383	5.08	0.3
Emergent	2,404,589	30.34	1.77
Urgent	3,899,771	49.2	2.87
Semi-urgent	808,023	10.19	0.59
No urgent	292,637	3.69	0.22
ED did not conduct triage	7,926,678		5.83
Self-Payment of Treatment			
No	6,496,855	81.96	4.77
Yes	1,429,823	18.04	1.05
Payer Status			
Private insurance	2,607,532	35.16	2.05
Medicare	333,733	4.5	0.26
Medicaid	3,125,220	42.14	2.46
Worker's compensation	4,470	0.06	0
Self-pay	1,127,592	15.2	0.89
No charge	58,204	0.78	0.05
Other	159,251	2.15	0.13
Total	7,416,002		5.84
Ordering the Advanced Imaging in ED			
No	7,661,689	96.66	5.63
Yes	264,989	3.34	0.19
Total	7,926,678		5.83
Ordering of Any type of blood test in ED			
No	6,234,906	78.66	4.58

Yes	1,691,772	21.34	1.24
Total	7,926,678		5.83
Any medications given in ED			
No	3,560,779	44.92	2.62
Yes	4,365,899	55.08	3.21
Total	7,926,678		5.83
Admission status			
Discharged	7,618,115	96.11	5.6
Left against medical advice	82,559	1.04	0.06
Transferred	33,970	0.43	0.02
Died in ED	0	0	0
Admitted	192,034	2.42	0.14
Total	7,926,678		5.83
Admission in Unit			
Critical care unit	28,307	0.36	0.02
Step-down unit	14,747	0.19	0.01
Other bed/unit	146,936	1.85	0.11
DNA	21,139	0.27	0.02
Not Admitted	7,715,549	97.34	5.67
Presence of any comorbidities in ILI patient			
No	7,505,034	94.68	5.52
Yes	421,644	5.32	0.31
Total	7,926,678		5.83
Hospital characteristics			
Visit in safety net hospital			
No	1,949,811	24.6	1.43
Yes	5,976,867	75.4	4.39
Total	7,926,678		5.83
Geographic Region of USA			
Northeast	1,193,119	15.05	0.88
Mid-west	1,809,179	22.82	1.33
South	3,200,348	40.37	2.35
West	1,724,032	21.75	1.27
Total	7,926,678		5.83
Ownership of the hospital			
Voluntary non-profit	5,846,127	73.75	4.3
Government, non-Federal	1,197,938	15.11	0.88
Proprietary	882,613	11.13	0.65
Total	7,926,678		5.83
Metropolitan Statistical Area			
MSA	6,572,075	82.91	4.83
Non-MSA	1,354,603	17.09	1
	7,926,678		5.83
Visit in Teaching Hospital			
No	7,149,063	90.19	5.25
Yes	777,615	9.81	0.57
Total	7,926,678		5.83

ILI = Influenza Like Illness, NHAMCS = National Hospital Ambulatory Medical Care Survey; #N = Unweighted number of observations in the data set for years 2007–2010; Proportions are calculated using survey weights.

Table 2: Median ED-LOV in NHAMCS data (2007- 2010) based on Influenza activity									
Characteristic	**No Influenza Activity n = (82,545)**			**Seasonal Influenza Activity n = (27,999)**			**Pandemic Influenza Activity n = (22,057)**		
	%*	**ED-LOV**	**(Q1-Q3)**	**%***	**ED-LOV**	**(Q1-Q3)**	**%***	**ED-LOV**	**(Q1-Q3)**
All patients	59.8	154	(88-254)	21.5	164	(95-273)	18.7	157	(90-261)
Demographic characteristics									
Patient age (years)									
Under 15 years	18.7	111	(68, 175)	20.5	121	(74, 199)	20.9	119	(73, 185)
15-24 years	16.2	137	(81, 224)	15.6	147	(87, 249)	15.1	145	(85, 231)
25-65 years	50.0	165	(94, 272)	48.8	175	(101, 293)	49.3	168	(96, 284)
>65 years	15.1	208	(129, 314)	15.1	216	(135, 325)	14.7	203	(127, 319)
Patient sex									
Female	54.6	161	(93-262)	55.0	170	(99-280)	54.9	163	(96-266)
Male	45.5	145	(83-243)	45.0	156	(90-265)	45.1	150	(86-254)
Patient race⁄ethnicity									
White	62.0	146	(85-241)	60.0	155	(90-255)	60.3	149	(86-245)
Black	21.7	167	(96-277)	21.7	177	(102-301)	22.6	170	(99-282)
Hispanic	13.2	161	(93-270)	14.1	181	(104-311)	13.2	169	(98-295)
Other	3.1	163	(91-268)	4.1	162	(95-268)	3.9	173	(98-285)
ED and Physician characteristics									
Payer Status									
Private	41.6	151	(88, 245)	42.8	160	(94, 259)	42.2	154	(91, 247)
Medicare	12.8	206	(122, 316)	11.8	216	(130, 334)	11.5	204	(121, 326)
Medicaid	24.1	140	(81, 238)	25.9	156	(89, 273)	26.7	145	(84, 248)
Uninsured	17.4	151	(86, 250)	15.7	158	(90, 264)	16.3	154	(88, 260)
Other	4.1	132	(76, 227)	3.9	137	(80, 234)	3.3	148	(84, 259)
Triage categories									
Acute	84.1	150	(87, 246)	84.4	160	(93, 267)	88.3	154	(90, 254)
Not Acute	16.0	195	(113, 309)	15.6	200	(116, 326)	11.7	210	(122, 348)
Uninsured status of the visit									
No	55.0	159	(91-259)	54.8	166	(97-273)	53.2	162	(95-265)
Yes	45.0	148	(85-248)	45.3	161	(91-274)	46.8	150	(87-257)
Patient Disposition in ED									
Discharged	86.0	139	(82, 226)	85.8	150	(88, 246)	86.1	144	(85, 234)
transferred	1.8	230	(138, 371)	1.7	250	(145, 400)	1.8	254	(152, 421)
Admitted	12.2	273	(180, 400)	12.5	276	(177, 416)	12.1	281	(184, 413)
Admission in Unit									
Critical care unit	29.4	240	(150-364)	26.6	246	(150-362)	26.1	260	(153-395)
Step-down unit	40.1	288	(203-396)	41.5	290	(197-405)	51.2	297	(207-413)
Operating room	10.9	240	(145-366)	9.3	268	(144-398)	9.3	272	(126-374)
Mental health	17.6	305	(191-556)	21.0	389	(205-1469)	12.1	295	(148-510)
Cardiac cath.	2.1	177	(72-309)	1.6	250	(120-446)	1.3	145	(83-267)
Use of Advanced Imaging in ED									
No	81.5	134	(79-222)	82.9	146	(85-243)	82.3	140	(82-229)
Yes	18.5	252	(171-365)	17.1	263	(178-386)	17.8	260	(174-376)
Use of diagnostics tests in ED									
Four or less	71.1	121	(73-197)	71.6	132	(79-216)	72.5	127	(77-205)

Five or more	28.9	253	(175-365)	28.4	261	(180-386)	27.5	261	(179-377)
Hospital characteristics									
visit in safety net hospital									
No	28.9	153	(87-250)	28.0	160	(94-264)	27.5	158	(92-261)
Yes	71.1	154	(88-256)	72.0	165	(95-278)	72.5	156	(90-261)
Geographic Region of USA									
Northeast	23.0	165	(92-283)	28.3	186	(103-316)	28.1	171	(95-297)
Mid-west	22.3	141	(80-236)	18.4	141	(82-233)	21.2	145	(81-243)
South	35.8	153	(91-248)	35.4	158	(95-256)	36.3	152	(91-245)
West	19.0	156	(89-256)	18.0	170	(98-285)	14.4	166	(96-273)
ownership of the hospital									
Voluntary non-profit	73.7	152	(88-250)	73.3	160	(92-264)	75.1	155	(90-256)
Government, non-Federal	16.4	174	(95-303)	18.0	187	(103-339)	15.9	180	(101-325)
Proprietary	10.0	138	(81-220)	8.7	154	(95-245)	9.0	140	(86-222)
Metropolitan Statistical Area									
MSA	87.0	162	(94-266)	86.5	175	(102-289)	83.7	170	(100-281)
Non-MSA	13.0	106	(62-174)	13.5	110	(65-173)	16.3	106	(62-168)
Visit in Teaching Hospital									
No	50.4	137	(80, 223)	50.2	144	(85, 235)	46.3	138	(81, 225)
Yes	49.7	170	(97, 283)	49.8	184	(106, 308)	53.7	176	(102, 293)

NHAMCS = National Hospital Ambulatory Medical Care Survey *- Weighted percentages
[#]N = Unweighted number of observations in the data set for years 2007–2010. Proportions are calculated using survey weights.

Table 3:
Median boarding time/ ED-BTI (IQR) in NHAMCS data (2009- 2010) based on influenza activity time

Characteristic	**No influenza n = (82,545)**			**Seasonal influenza n = (27,999)**			**Pandemic influenza n = (22,057)**		
	%*	**ED-BTI**	**(Q1 - Q3)**	**%***	**ED-BTI**	**(Q1 - Q3)**	**%***	**ED-BTI**	**(Q1 - Q3)**
All patients	48	75	(35-144)	19	68	(29-134)	34	81	(36-162)
Demographic characteristics									
Patient age (years)									
Under 15 years	5	75	(41, 122)	7	83	(40, 128)	4	66	(24, 112)
15-24 years	6	65	(27, 130)	5	48	(16, 125)	5	70	(22, 162)
25-65 years	48	80	(36, 153)	48	70	(28, 128)	46	84	(35, 165)
>65 years	42	73	(33, 137)	40	69	(29, 140)	45	81	(38, 163)
Patient sex									
Female	55	74	(33, 140)	51	65	(24, 136)	53	82	(36, 167)
Male	45	76	(36, 148)	49	71	(34, 128)	47	81	(35, 157)
Patient race⁄ ethnicity									
White	67	72	(33-138)	60	63	(28-123)	64	79	(33-157)
Black	17	82	(39-165)	26	73	(28-155)	20	80	(39-154)
Hispanic	10	79	(35-135)	11	95	(33-185)	11	95	(38-194)
Other	5	82	(38-125)	3	79	(37-245)	6	107	(53-189)

Ed and physician characteristics									
Payer status									
Private insurance	44	73	(34, 137)	45	64	(26, 125)	47	75	(34, 151)
Medicare	28	80	(35, 151)	28	67	(32, 136)	28	85	(40, 171)
Medicaid	18	79	(35, 153)	17	73	(25, 145)	14	79	(27, 169)
Uninsured	9	70	(35, 126)	7	76	(37, 138)	9	85	(37, 147)
Other	3	60	(21, 129)	3	73	(50, 128)	3	108	(44, 172)
Triage categories									
Acute	71	75	(35, 139)	71	70	(30, 135)	71	76	(35, 150)
Non-acute	29	80	(38, 151)	29	67	(27, 128)	29	98	(45, 187)
Self-payment of treatment									
No	63	74	(34-141)	63	67	(30-131)	65	84	(39-165)
Yes	37	77	(35-148)	37	70	(27-140)	35	76	(30-155)
Admission in unit									
Critical care	38	81	(38-158)	33	68	(30-122)	25	65	(29-152)
Step-down unit	35	85	(45-157)	46	101	(47-181)	59	84	(45-165)
Operative	12	68	(27-121)	9	51	(23-86)	7	54	(25-138)
Mental health	11	90	(45-175)	8	52	(0-125)	8	75	(15-194)
Cardiac cath.	4	60	(30-109)	3	5	(1-61)	1	80	(9-140)
Ordering of the advanced imaging in ED									
No	63	72	(32-138)	62	65	(27-128)	60	76	(30-155)
Yes	37	80	(38-150)	38	76	(34-145)	40	92	(41-178)
Use of diagnostics tests in ED									
<= 4	21	63	(23-135)	23	59	(16-120)	19	62	(20-145)
>= 5	79	79	(38-147)	77	70	(32-136)	81	85	(40-167)
Hospital characteristics									
Visit in safety net hospital									
No	30	73	(31-149)	29	52	(20-118)	28	88	(36-164)
Yes	70	75	(36-141)	71	73	(33-139)	72	79	(35-160)
Geographic region of USA									
Northeast	31	91	(44-177)	29	66	(20-143)	30	92	(40-197)
Mid-west	20	67	(30-124)	19	61	(26-124)	27	76	(26-160)
South	32	70	(30-125)	33	71	(33-131)	31	75	(40-138)
West	17	74	(31-146)	19	72	(29-134)	12	82	(30-157)
Ownership of the hospital									
Voluntary	75	79	(37-149)	75	69	(30-130)	83	84	(37-160)
Government	18	66	(32-128)	18	60	(20-122)	12	81	(35-176)
Proprietary	7	62	(21-113)	7	78	(36-195)	5	60	(30-125)
Metropolitan statistical area									
MSA	90	79	(37-150)	91	73	(30-141)	90	88	(40-171)
Non-MSA	10	45	(15-87)	9	42	(20-69)	10	33	(15-75)
Visit in teaching hospital									
No	42	65	(27, 129)	38	54	(22, 109)	38	54	(23, 110)
Yes	58	82	(42, 153)	62	80	(33, 145)	62	103	(47, 188)

NHAMCS = national hospital ambulatory medical care survey, Q1 - Q3 = quartile 1-3
[#]n = unweighted number of observations in the data set for years 2007–2010. Proportions are calculated using survey weights.

Table 4: Percentage Change in ED-LOV (minutes) during Pandemic and Seasonal Influenza Activity Periods						
	Pandemic Influenza Activity period			**Seasonal Influenza Activity Period**		
	%	**(95% CI)**	**p-value**	**%**	**(95% CI)**	**p-value**
Unadjusted	4.62	(0.11, 9.34)	0.0446	9.14	(4.22, 14.29)	0.0002
Adjusted	5.47	(1.74, 9.34)	0.0038	7.5	(3.65, 11.48)	0.0001
* Reference group for both % changes is 'No Influenza Activity Period'.						

Table 5: Multivariate Adjusted Percentage Change in ED-LOV by Selected Characteristics, NHAMCS 2007 – 2010						
	Adjusted Percentage Change in ED-LOV (minutes)					
	Pandemic Influenza Activity period n = (104,602)			**Seasonal Influenza Activity Period n = (110,544)**		
Patient sex						
Female	3.51	(2.35, 4.68)	<.0001	4.2	(3.22, 5.2)	<.0001
Male	(Reference)			(Reference)		
Patient age (years)						
< 15 years	-4.56	(-6.62, -2.45)	<.0001	-4.34	(-6.44, -2.18)	0.0001
15 - 24	(Reference)			(Reference)		
25 - 64	7.87	(5.99, 9.78)	<.0001	7.4	(5.7, 9.13)	<.0001
> 65 years old	9.03	(6.41, 11.72)	<.0001	8.47	(5.77, 11.23)	<.0001
Patient race⁄ ethnicity						
White	(Reference)			(Reference)		
Black	12.30	(8.15, 16.61)	<.0001	11.99	(7.66, 16.48)	<.0001
Hispanic	9.11	(6.12, 12.18)	<.0001	9.73	(6.02, 13.57)	<.0001
Other	1.52	(-5.93, 9.55)	0.70	0.27	(-7.05, 8.16)	0.9443
Patient insurance type						
private	(Reference)			(Reference)		
Medicare	6.30	(4.45, 8.18)	<.0001	6.34	(4.35, 8.36)	<.0001
Medicaid	2.71	(0.64, 4.82)	0.01	3.13	(1.01, 5.28)	0.0037
uninsured	2.89	(-0.12, 6)	0.06	3.05	(0.55, 5.6)	0.0165
other⁄ unknown	-1.35	(-5.77, 3.28)	0.56	-0.9	(-5.15, 3.54)	0.6864
Patient triage acuity						
Acute	11.66	(8.7, 14.7)	<.0001	9.04	(6.08, 12.08)	<.0001
Non-acute	(Reference)			(Reference)		

Use of Advanced imaging						
No advance imaging	(Reference)			(Reference)		
Advanced imaging	26.85	(24.94, 28.79)	<.0001	27.3	(25.26, 29.38)	<.0001
Use of any diagnostic screening tests						
No	(Reference)			(Reference)		
Yes	54.85	(51.36, 58.43)	<.0001	54.78	(51.3, 58.34)	<.0001
# of tests ordered						
Four or fewer	(Reference)			(Reference)		
Five or more	37.29	(34.16, 40.5)	<.0001	37.54	(34.51, 40.65)	<.0001
Patient disposition						
Discharged	(Reference)			(Reference)		
Transferred	31.79	(25.05, 38.89)	<.0001	32.73	(25.6, 40.26)	<.0001
Admitted	24.14	(19.21, 29.28)	<.0001	24.83	(20.21, 29.64)	<.0001
Hospital Location						
Rural	(Reference)			(Reference)		
Urban	10.67	(6.19, 15.34)	<.0001	11.5	(6.81, 16.39)	<.0001
Metropolitan Statistical Area						
Non- MSA	(Reference)			(Reference)		
MSA	-17.95	(-22.93, -12.65)	<.0001	-18.12	(-23.15, -12.75)	<.0001
Hospital owner						
Nonprofit	(Reference)			(Reference)		
Government	7.09	(0.31, 14.32)	0.04	3.04	(-3.68, 10.23)	0.3829
Proprietary	-10.47	(-16.29, -4.25)	0.00	-9.48	(-14.28, -4.41)	0.0004
Hospital location						
Northeast	9.00	(1.9, 16.6)	0.01	12.65	(5.4, 20.4)	0.0005
Midwest	(Reference)			(Reference)		
South	6.72	(0.06, 13.82)	0.05	7.18	(0.67, 14.11)	0.0301
West	4.26	(-3.35, 12.46)	0.28	6.99	(-0.87, 15.47)	0.0825
Visit to ED in Teaching hospital						
Non- Teaching	(Reference)			(Reference)		
Teaching	20.48	(14.7, 26.56)	<.0001	17.8	(12.11, 23.78)	<.0001
ED payer mix						
Non–safety net	(Reference)			(Reference)		
Safety net	0.63	(-2.56, 3.94)	0.70	2.22	(-1.22, 5.79)	0.2087

Table 6: Percentage Change in ED-BTI (minutes) during Pandemic and Seasonal Influenza Activity Periods

	Pandemic Influenza Activity period			**Seasonal Influenza Activity Period**		
	%	**(95% CI)**	**p-value**	**%**	**(95% CI)**	**p-value**
Unadjusted	43.78	(1.32, 104.05)	0.0421	-2.29	(-20.5, 20.1)	0.8253
Adjusted	27.96	(-16.69, 96.55)	0.2575	-9.96	(-26.82, 10.78)	0.3193

* Reference group for both % changes is 'No Influenza Activity Period'.

Table 7: Multivariate Adjusted Percentage Change in ED-BTI, NHAMCS 2009			
Characteristic	**%**	**(95% CI)**	**p-value**
Age			
Under 15 years	[Reference]		
15-24 years	16.74	(-16.01, 62.26)	0.3534
25-65 years	22.1	(-6.26, 59.04)	0.1371
>65 years	29.83	(-0.11, 68.75)	0.0509
Sex			
Female	-1.51	(-13.85, 12.59)	0.8215
Male	[Reference]		
Race			
White	[Reference]		
Black	-2.29	(-16.05, 13.73)	0.763
Hispanic	4.64	(-14.42, 27.95)	0.6553
Other	17.91	(-4.08, 44.93)	0.1165
Insurance status			
Private insurance	[Reference]		
Medicare	1.09	(-11.79, 15.84)	0.8753
Medicaid	-13.81	(-28.12, 3.34)	0.1074
Uninsured	-2.94	(-18.93, 16.22)	0.7434
other	0.57	(-34.92, 55.42)	0.9795
Triage categories			
Acute	-5.29	(-19.08, 10.85)	0.4948
Non-acute	[Reference]		
Use of advanced imaging in ED			
No advanced Imaging used	[Reference]		
Advanced imaging	11.14	(-1.18, 24.99)	0.0775
Use of diagnostics tests in ED			
Four or less	[Reference]		
Five or more	12.22	(-7.62, 36.31)	0.2425
Use of any kind of diagnostic testing			
No	[Reference]		
Yes	21	(-33.36, 119.72)	0.5277
Metropolitan Statistical Area			
No	-2.54	(-33.48, 42.77)	0.8938
Yes	[Reference]		
ownership of the hospital			
Voluntary non-profit	[Reference]		
Government, non-Federal	-20.38	(-38.74, 3.49)	0.0877
Proprietary	-20.07	(-46.33, 19.04)	0.2673

Presence of Bed coordinator in ED			
No	[Reference]		
Yes	0.52	(-20.25, 26.7)	0.9644
Hospital bed census data availability			
Instantaneously	[Reference]		
4 Hours or more	-11.04	(-23.2, 3.04)	0.1175
Location of hospital			
Metro	17.21	(2.3, 34.28)	0.0226
Rural	[Reference]		
Visit in Teaching Hospital			
No	[Reference]		
Yes	36.88	(16.71, 60.54)	0.0002
presence of Observation unit in the ED			
No	[Reference]		
Yes	40.96	(16.11, 71.13)	0.0007
Boarding of admitted ED patients for > 2 hours in the ED or Obs. Unit			
No	42.05	(10.99, 81.81)	0.0057
Yes	[Reference]		
Boarding of admitted ED patients for > 2 hours in hospital, but not in ED			
No	19.1	(1.42, 39.85)	0.0333
Yes	[Reference]		

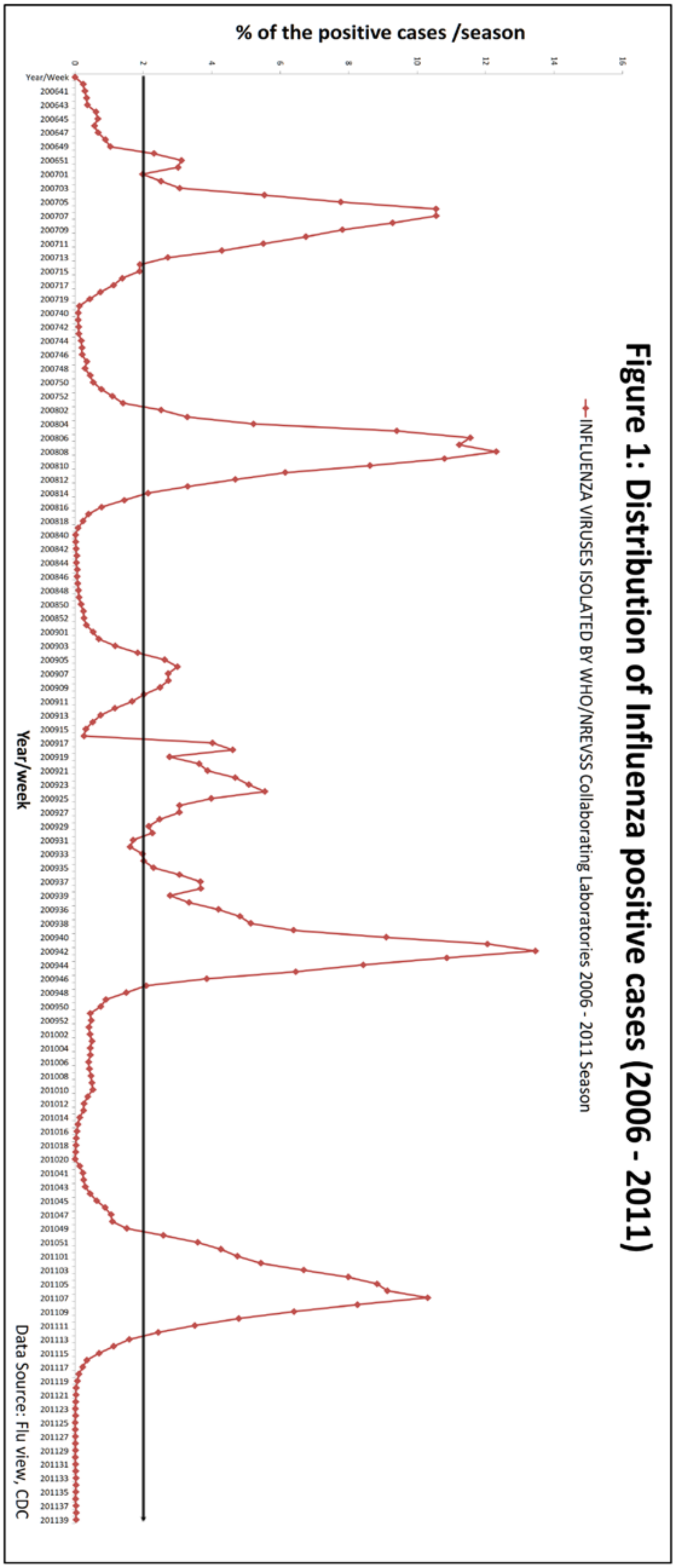
Figure 1: Distribution of Influenza positive cases (2006 - 2011)
INFLUENZA VIRUSES ISOLATED BY WHO/NREVSS Collaborating Laboratories 2006 - 2011 Season
% of the positive cases /season
Year/week
Data Source: Flu view, CDC

Figure 1

Appendix 1: Literature Review Table

Author(s)	**Year**	**Study database**	**Research question**	**Outcome variable**	**Exposure variables**	**Results of analysis**
Rubinson L, Mutter R, Viboud C, et al	2013	HCUP and CDC-ILI net data combined	Impact of pH1N1 surge on US health care system	1. ED admission volume 2. IPD mortality from selected conditions	pH1N1 fall wave used as exposure variable	Increase in hospital mortality risk from other factors for patients compared with no surge hospitals.
Kocher KE, Meurer WJ, Desmond JS, et al.	2012	NHAMCS 2006-2008	Effects of testing and treatment of patient on ED-LOV	ED-LOV	Testing and treatment	Significant effect of diagnostic testing on ED-LOV, less significant by treatment.
Fee C, Burstin H, Maselli JH, Hsia RY.	2012	NHAMCS 2008	Compliance of ED with proposed ED-LOV target measures	ED-LOV	Patient, ED and hospital factors	Safety-net EDs. more likely to receive young and minority patients, and less likely to need emergent or urgent care in both admitted and discharged populations.
Green SM.	2012	NHAMCS 2002 - 2009	Physicians acuity differs by patient age	Continuous - Triage score Binary - hospital admission, admission to critical care unit, death on ED arrival/visit, CPR performance, ET intubation performance.	Age of the patient	Adults consistently showed higher odds of getting adverse outcome in ED compared to children.
Zhu M, Chu H, Rice TM, Carter MW.	2011	NHAMCS 1999 - 2006	Comparison of measures of association between masked data and unmasked data.	Count or rate of ED visits, for each year.	Year as a continuous linear term	Masked data overestimated standard error by 20%, and with masked data the change, over time was not statistically different from zero.
Qualls M, Pallin DJ, Schuur JD.	2010	NHAMCS 2006	Effects of incorrect use of nonparametric inferential statistical methods for	ED-LOV	Patient, ED and hospital factors	Failure to use nonparametric bivariate tests, results in type II statistical error and in multivariate models

			analysis NHAMCS database			
Jesse M. Pines et. Al.	2009	NHAMCS 2003–2005	Effect of racial disparities on ED-LOV	ED-LOV, binary variable (ED-LOV > 6 hrs.)	Black race as a dummy variable.	Admitted Black patients have ~ an hour longer wait time than nonblack patients.
Herring A, Wilper A, Himmelstein DU, et al.	2009	NHAMCS 2001 - 2005.	Trend analysis of ED-LOV from 2001 to 2005 answer related factors	ED-LOV and Year of the visit	Patient, ED and hospital factors	Median ED-LOV increased 3% per year from 132 minutes in 2001 to 154 minutes in 2005
Adekoya N.	2007	NHAMCS 2001	Effect and of infectious diseases on ED operations.	Visits classified as infectious disease	Patient, ED and hospital factors	Descriptive distribution of ID in ED. children <15 years old 36% of visits related to ID, females 37% more likely to visit than males for ID. Black visit rate more than non-blacks
Gardner et. al.	2006	NHAMCS 2001-2003	Determine the factors associated with a longer ED length of stay.	ED-LOV	Patient, ED and hospital factors	Causative factors for longer ED-LOV: Hispanic ethnicity, advanced imaging techniques, hospital location in MSA

EMORY UNIVERSITY

Institutional Review Board

February 15, 2013

Dattatraya Patil
MPH Candidate-Epidemiology
Rollins School of Public Health, Emory University

RE: Determination: No IRB Review Required
Impact of the 2009 H1N1 influenza epidemic on emergency department use
PI: Dattatraya Patil

Dear Mr. Patil:

Thank you for requesting a determination from our office about the above-referenced project. Based on our review of the materials you provided, we have determined that it does not require IRB review because it does not meet the definition of research involving "human subjects" or the definition of "clinical investigation" as set forth in Emory policies and procedures and federal rules, if applicable. Specifically, in this project, you will be analyzing publically accessible information gathered during the 2009 H1N1 Influenza Pandemic in on eof the non-federal and short stay hospitals, located in the 50 states and the District of Columbia. This data is completely de-identified and the study does not require any contact or interventions with human subjects.

This determination could be affected by substantive changes in the study design, subject populations, or identifiability of data. If the project changes in any substantive way, please contact our office for clarification.

Thank you for consulting the IRB.

Sincerely,

Steven J. Anzalone, M.S.
IRB Research Protocol Analyst
This letter has been digitally signed

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