

Fellow Project

The Relationship Between Weather and Hospital Emergency Department Volume
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PREFACE

Hospital emergency departments (EDs) in the United States are in a state of distress. Because of nursing shortages, the introduction of the Emergency Medical Treatment and Active Labor Act (EMTALA) of 1986, reduced inpatient bed capacity, and their role as the community safety net, EDs are overcrowded and typically lack adequate resources. In addition, the increasing number of uninsured patients requiring care and an aging population that is experiencing an increase in average life span further aggravate the situation. In 1998, more than 93 percent of the 1.47 million hospitalized self-pay patients were admitted through EDs (National Center for Health Statistics 1998).

Hospitals are struggling to deal with challenges once thought to be “ED issues,” and they now realize these are systemic issues that are not directly attributable to a single department. Of greatest significance at this time is the large number of admitted patients being held in the ED while waiting for an inpatient bed to become available, which contributes to overcrowding. In addition, longer turnaround times for ancillary departments, such as radiology and clinical laboratories, further increase an already exorbitant ED length of stay. Insufficient bed capacity in a hospital creates patient bottlenecks in the ED, which can result

in an increased number of patients who leave without being seen or treated. Now more than ever, there is a greater emphasis on preventing the use of the ED in nonemergent situations in hopes that this will mitigate the aforementioned challenges.

It has been informally hypothesized that inclement weather conditions result in reduced ED utilization because nonemergent patients opt to delay or not seek treatment at all in such conditions.

The premise and hypothesis for this thesis is that the presence of inclement weather (which will be defined using several criteria) will result in reduced ED utilization, thereby lending support to the conclusion that EDs suffer from nonemergent patient utilization.

In addition, this thesis will seek to identify the resulting implications for EDs, in terms of how they might consider the weather forecast when making allocation decisions with respect to staffing, resources, and equipment and how this might affect the hospital overall. Furthermore, there will be a discussion of nonemergent use of the ED, and how this has implications for the department, hospital, and community. Other implications that exist for hospitals will be presented with regards to reimbursement issues stemming from nonemergent use of EDs. Finally, considerations and approaches for local governments, healthcare providers, and communities will be discussed, as there is an increased need to identify alternative safety-net resources beyond the ED.

METHOD SUMMARY

To measure the relationship between weather conditions and ED utilization, an analysis of daily ED data from a major tertiary-care teaching hospital in New York City was conducted from January 2001 through June 2004 (42 months, encompassing 1,316 days). Daily volumes were assessed, and mean values for average daily volume were calculated for each month.

From this, a calculation was performed to identify the variance between the daily ED patient volume and the mean patient volume for that individual month. Once this variance was quantified, an additional analysis was performed to attribute weather patterns to the variances and determine how specific patterns affected ED utilization.

A second variable that was analyzed versus the daily weather conditions was the percent of all ED patients who were admitted for each date (known as the ED admission rate). This variable can further support or refute the hypothesis that poor weather influences a patient's decision to visit an ED. If the hypothesis is true, then one would expect to see a higher admission rate on days that exhibited poor weather conditions, because on those days only the "true" emergencies would conceivably present to the ED.

Weather data were obtained from the National Climatic Data Center (NCDC) web site (www.ncdc.noaa.gov), which is the world's largest active archive of weather data. Additionally, NCDC is the primary weather data resource

for the U.S. government, and its mission is to describe the weather and note trends and anomalies. To obtain prevailing weather conditions for the hospital ED studied on each day within the study period, data were obtained from the NCDC for observed conditions at the weather station in Central Park, New York City, which is approximately 3.3 miles away from the hospital's ED. Because the majority of ED visits are from zip codes within 11 miles of the hospital, using these data would result in accurate weather assessments for the area and for the population that typically uses its services.

Several aspects of weather were analyzed to establish multiple definitions of poor weather. The specific NCDC variables that were analyzed included average daily temperature, average deviation from normal temperature, and days with precipitation (rain or snow) to determine what (if any) relationship exists between these variables and daily ED patient volume.

Detailed Procedures Used

The primary step was to obtain a raw data file that provided the total number of patients seen in the hospital's ED for each day as well as the ED admission rate for that particular day. This information was obtained directly from the hospital information system. From this, an initial query was written to identify the average monthly volume and average monthly admission rate for each month within the study period. (Note: A relational database tool, Microsoft Access [Microsoft,

Redmond, WA], was used to perform all data analysis and query the data used in this study).

A second query was then written that quantified the variance between the average daily ED patient volume and the average patient volume for the month in which the day fell. For example, the query would identify that 85 patients were seen on April 1, and that the average daily volume in April that year was 90. Therefore, the query would calculate a variance of -5 for that particular day.

Additionally, this query also evaluated the variance between the daily admission rate and the admission rate for the entire month. This allowed a relationship to be defined between these two variables and the assorted weather conditions being analyzed to determine the nature of the relationship. It was thought that assessing each day's variance with respect to the overall month in which it fell would help to account for any seasonal effects or volatile swings in volume or utilization that occurred within a month.

The weather data provided by the NCDC were in a delimited text format structure that had days of the month as column headers and month and year as the row headers. In order to use this data format, a crosstab query was necessary so that the daily ED patient data could be properly correlated with the weather data using a synchronous data format.

After this it was possible to define the specific weather criteria that would determine a definition of poor weather conditions for this study. Because there is

no universal definition of poor weather, it was necessary to create several scenarios to define poor weather based on the available data. Although the descriptive data provided by the NCDC were extremely detailed, there was a need to focus on the best available criteria that could be used to determine the correlation of weather patterns with ED patient volume and admission rate.

To establish a specific scope for this analysis, eight distinct measures were created using the NCDC data set. The measures were snow accumulation, daily departure from normal temperature, selected numeric values of daily average temperatures that fell in a specific range (below freezing [32°F], below 25°F, and below 15°F), days with any type of rain, days with any type of snow, and days with any type of rain or snow. For a detailed description of all eight measures, see Figure 1.

Figure 1. Eight Specific Weather Criteria Analyzed

1. **Snow:** Any presence of snow within the 24-hour period that resulted in a measurable accumulation on the ground
2. **Departure from normal temperature:** Whenever the deviation from the normal daily temperature was less than 0
3. **Average temperature below freezing:** Whenever the average daily temperature was less than 32°F
4. **Average daily temperature below 25°F:** Whenever the average daily temperature was less than 25°F
5. **Average daily temperature below 15°F:** Whenever the average daily temperature was less than 15°F
6. **Days with rain:** Includes any day where the prevailing weather conditions included drizzle, freezing drizzle, or freezing rain
7. **Days with snow:** Includes any day where the prevailing weather conditions included snow pellets, snow grains, or ice crystals
8. **Days with rain or snow:** Includes any day where the prevailing weather conditions included drizzle, freezing drizzle, freezing rain, snow pellets, snow grains, or ice crystals

Specific queries were created in the relational database for each of the aforementioned weather criteria. When run, the queries would identify days within the study period where the specific weather criteria were met and then pull the resulting volume and admission rate data *for only those days* to produce the following metrics:

- Average ED patient volume deviation from monthly mean (monthly)
- Average ED patient volume deviation from monthly mean (cumulative across 42 months)
- Average ED admission rate (monthly)
- Average ED admission rate (cumulative across 42 months)

By independently assessing the admission rate and the deviation from the mean for ED patient volume, it was possible to (a) determine if any of the eight weather criteria affected ED patient volume and (b) describe the resulting patient acuity by noting the admission rate versus the mean admission rate for that month as well as across the entire 42-month period studied.

LIMITATIONS

It is important to note that in the period analyzed (January 2001 through June 2004), several events in New York City resulted in significant shocks to the EDs throughout the region, which likely confounds the relationship between poor weather and ED utilization and acuity. Such examples include the terrorist attacks

on the World Trade Center on September 11, 2001, the opening of a letter containing anthrax in the NBC headquarters on September 25, 2001, and the blackout from August 14 to 16, 2003. In addition, it is important to note that from September 11, 2001, until about February 2002, there were days with random spikes in volume that likely resulted from public panic and heightened sensitivity to terrorism. The greater than average volume on those days would also likely confound the data. However, given the large sample size (42 months) that was analyzed, it is expected that the overall confounding effect and, likewise, the risk of error would be minimized. Furthermore, the data will be isolated by month and year to determine if any significant outlier values within the analysis for any of these months accounted for this anomaly.

It is important to recognize that the research conducted applies to an ED in a metropolitan/urban setting. The results, findings, and implications derived from this study may not be applicable to hospitals and communities outside this type of setting, such as those located in suburban or rural locales. Studies similar to this should be conducted in environments other than metropolitan and urban communities to further validate the research findings

RESULTS

Each of the eight poor weather criteria will be discussed individually in the following section. Specific results are found in the figures and tables.

Snowfall Accumulation

The first weather criterion analyzed was days where there was snowfall resulting in measurable accumulation on the ground (Figure 2 and Table 1). There were 41 total observations of this weather behavior within the study period, the majority of which were within the typical snowfall months of December, January, and February. There were also several instances of snowfall accumulation in March and one in April 2003.

In all but two months, the net effect of the snowfall resulted in a negative variance relative to the mean ED patient volume for each month, with a magnitude of (-4.04) from the average. For these 41 observations, the average ED admission rate was 29.6 percent on days when there was a snowfall accumulation. On days where there was no snowfall accumulation, the average admission rate was 27.9 percent.

Based on this finding, there appears to be a direct correlation between snowfall accumulation and ED patient volume, as there was an average of 5 percent fewer visits on these days, and those visits resulted in a higher than average admission rate.

Departure from Normal Temperature

The second weather criterion analyzed was days where there was a negative

departure from the normal temperature for that day (as historically calculated by the NCDC). The detailed results from this analysis can be found in Figure 3 and Table 2. .

This criterion was measured to consider the seasonal and daily patterns in temperature exclusively as a description of the weather. This criterion was the broadest one analyzed and resulted in the greatest number of observations (n=565), as it is not dependent on season-specific temperature (i.e., snow) and therefore encompasses observations in every month during the study period. Roughly 43 percent of all days within the entire study period qualified within this criterion.

A variance of (-1.29) was found between the average number of daily visits when there was a negative departure from normal temperature versus the overall mean daily ED visits. Similarly, the average admission rate was 28.8 percent when temperatures were below normal versus 27.3 percent on days when the temperature was at or above normal. These results suggest a direct correlation between below-average temperatures and ED utilization and acuity.

Average Temperature

Unlike deviation from normal temperature, average temperature allows a focus on specific weather conditions. Because it was not expected that mild or excessively hot temperatures would affect ED patient volume and acuity in the same manner

as extreme cold, this research focused on extreme cold weather conditions.

Within this overall category, three different subgroups of average temperatures were reviewed: days where the average temperature was below 32°F, days where the average temperature was below 25°F, and days where the average temperature was below 15°F. It is important to note that each of these categories is not mutually exclusive, as all days below 32°F are also in the other two subgroups. The 32°F point was selected as a baseline because of its general acceptance as the freezing point of water as a benchmark for weather data.

The benefit of stratifying three subgroups is to show the potential sensitivity of ED activity based on a larger diluted group (32°F) and on two successively smaller groups (<25°F, <15°F). By looking at the weather groups with a decreasing average temperature, the effect of cold weather on ED utilization could be more clearly defined.

Average Temperature <32°F

The detailed results from this analysis can be found in Figure 4 and Table 3.

There were 127 total observations in the sample where the average daily temperature was below 32°F. The average deviation from the mean ED patient volume was -1.64 on these days. The average ED admission rate when the average daily temperature was below 32°F was 29.6 percent versus 27.8 percent when the average daily temperature was greater than 32°F.

Average Temperature <25°F

The results of this analysis can be found in Figure 5 and Table 4. There were 41 total observations where the average daily temperature was below 25°F. The average deviation from the overall mean ED patient volume during this time was (-2.46). The average ED admission rate was 29.7 percent when the temperature was below 25°F versus 27.9 percent when the average daily temperature was greater than 25°F.

Average Temperature <15°F

The results from this analysis can be found in Figure 6 and Table 5. There were only seven total observations where the average daily temperature was below 15°F. The average deviation from the overall mean ED patient volume during this time was -6.09. The average admission rate during this period was 22.7 percent when the average daily temperature was below 15°F versus 28.8 percent when the average daily temperature was greater than 15°F.

It is interesting to note that the average ED admission rate when average temperature was less than 15°F was notably lower than that of all other times. Given the low number of observations within this group (n=7), it is likely that this sample size is not large enough to produce statistically significant values.

Range of Average Temperatures

After analyzing the prior three subgroups of average temperature, it was determined that an evaluation of specific ranges of average temperature that were mutually exclusive would be beneficial to understand if different results would be obtained. Rather than comparing the average volume during these weather bands versus the overall average, a sensitivity analysis was performed to define specific volume trends that occurred within each temperature range.

Table 6 and Figure 7 present the results from analyzing average temperature ranges and the resulting variance from mean ED patient volume and average admission rate. Although there are varying numbers of observations within each temperature band, the consistent trend that appears is that the deviation from the overall mean ED patient volume begins during the extreme cold temperatures and slowly moves toward positive values once the 50°F threshold is crossed.

With the exception of the 40°F to 50°F average temperature band, the admission rate is highest at the coldest temperatures and slowly decreases as the average temperature increases.

Days with Rain

Up to this point, the analyses have focused on cold weather conditions (low temperature and presence of snow). Because it is believed that the presence of

rain also deters ED utilization, it was important to examine this effect on ED utilization and admission rate as well.

The NCDC has preestablished data definitions for a day with rain, which includes all days that included “drizzle, freezing drizzle, and freezing rain.”

Rain is a fairly common weather occurrence throughout the year, so it was not surprising to identify 458 observations in the period analyzed (34.8 percent of all days in the study period). On days with rain, the variance from normal ED patient volume was (-0.70). The average admission rate on these days was 28.9 percent versus 27.5 percent for days without rain. Detailed results can be found in Figure 8 and Table 7. Although the net effect appears to be less pronounced with rain than with cold weather conditions, these data suggest that rainy weather conditions deter ED utilization.

Days with Snow

Noting the possible relationship of accumulated snow to ED utilization, it was interesting to determine the relationship of all types of snow (not just those snowstorms that resulted in measurable accumulation). The NCDC provided a data field for days with snow that includes any day where the prevailing weather conditions included snow pellets, snow grains, or ice crystals.

The total number of observations for this group was 94, which was more than twice the number of observations found for days where there was snow

accumulation. This was not surprising, given the different types of snowfall that were grouped in this category.

The variance from the overall mean ED monthly volume was (-3.06). The average admission rate was 30.2 percent on days with snow versus 27.8 percent when there was no snowfall of any type. The detailed results from this analysis appear in Figure 9 and Table 8.

Although the variance from the mean monthly volume was smaller than it was on days with accumulated snow, it still indicated lighter ED patient volume on days with any snow conditions (with measurable accumulation or not). This is equally supported by the higher admission rate that occurs on days with snow conditions. Some significant variances from mean monthly ED patient volume were identified during the months of December 2002, February 2003, and February 2004 (-27, -11, and -16, respectively), most likely because of heavy snowstorms in February 2003 and February 2004.

Days with Rain or Snow

After analyzing snowfall and rain as mutually exclusive weather conditions, it was important to blend both categories to determine the overall effect of a day with rain or snow.

There were 545 total observations within this group, with an average deviation from the overall mean ED monthly volume of -1.1. The average

admission rate was 29.2 percent on days with rain or snow versus 28.8 percent when there was no rain or snow. The detailed results from this specific analysis appear in Figure 10 and Table 9.

By conducting this specific category analysis, the error rate was minimized because of the increased sample size. The 545 total observations encompassed 41.4 percent of the days in the overall study period, thus deriving adequate statistical significance. This would further help to instill greater confidence in the values identified for this group.

Specifically, an outlier value was noted for the month of October 2001. As already mentioned, the national events taking place around this time presented random shocks to ED utilization, which resulted in a peak ED patient volume spike for this month that resulted in a significant variance from monthly ED patient volume. However, because this represented six observations (approximately 1 percent) of all total observations within this group, sufficient normalization of data will likely counterbalance this confounding effect.

DISCUSSION

Results from the aforementioned analyses (as summarized in Table 10) all point toward a definable correlation between poor weather conditions (defined using various criteria) and ED utilization.

Specifically, the results from this analysis indicate a tendency for ED

patient volume to be lower on days when the poor weather occurred than on days when the specific weather phenomenon did not occur. In addition, the ED admission rate was higher during the eight defined poor weather scenarios than on days when the weather condition was not present. The only exception to this was for the scenario where average daily temperature was $<15^{\circ}\text{F}$, which may be attributable to the small number of observations within that group ($n=7$). This same scenario reflected the largest deviation from normal ED patient volume (-6.09). However, both of these values should be discarded because of the low sample size.

Aside from this, the weather patterns that demonstrated the greatest impact on ED utilization were days where there was snow accumulation and days where there was any type of snow (accumulated or not), both of which demonstrated negative deviations of -4.04 and -3.06 , respectively, from the normal ED patient volume.

In addition, the average admission rates were higher by at least 2 percent on days when there was any type of snow versus days when there was no snow at all. This lends support to the theory that snow (of any kind) generally deters ED utilization and that ED acuity on these days is higher (hence, the higher admission rate).

Much like snow conditions, extreme cold temperature conditions also seemed to affect ED utilization. Greater negative deviations from monthly ED

patient volume were observed when the average daily temperature was $<25^{\circ}\text{F}$ versus when the average temperature was $<32^{\circ}\text{F}$; the values were -2.46 and -1.64 , respectively. In both scenarios there was also a higher ED admission rate than on days when temperatures were higher. This indicated that the overall ED patient acuity was higher on these days. It could be inferred that as the average temperatures became lower, the negative variances became greater in magnitude.

When there was a negative departure from normal daily temperatures, there appeared to be a slight negative variance (-1.29) versus normal ED monthly volume and a slightly higher admission rate (28.8% vs. 27.3%). This category had the highest number of observations (565), representing almost 43% of all samples in the group; therefore, it is likely that the results for this group would be statistically significant.

Because this category spanned across all 12 months of the year, it was a more representative sample and provided another example of how lower temperatures generally result in reduced ED utilization, even if the temperatures are not extremely cold.

The presence of rain, which is more prevalent throughout the year than any other precipitation, indicated a very slight negative variance versus normal ED patient volume (-0.70) and a slightly greater admission rate (28.9 percent vs. 27.5 percent), also leading to the conclusion that rain will influence a patient's decisions to visit the ED, although much less so than snow or any of the other

eight weather criteria that were studied.

Intuitively, one would think that it is generally more difficult or daunting to travel in the snow than the rain. Snowfall creates greater hazards than rain (e.g., greater chance of slipping, poor vehicle operation), not to mention the additional burden of colder weather. Rain occurring at comfortable temperature levels may not dissuade patients from using the ED as much, as it does not present the same challenges and degree of unpleasantness.

It is important to note that during the poor weather conditions analyzed, patients may experience difficulty traveling to the ED. Although our results indicate a tendency for such weather conditions to “dissuade” patients from visiting the ED, one might argue that the reason is exclusively related to accessibility issues where patients were unable to get to the ED, perhaps because emergency medical service providers have an increased response time, the patient has no available mode of transportation, or there is an increased health risk related to traveling in the poor weather condition..

Because these considerations go beyond the scope of the data collected, it would be advantageous to assess patients’ ability to travel to an ED during these weather conditions. These considerations are discussed in the Contrarian Viewpoint section.

Although general descriptive statistics have been provided for the analyses, conducting more in-depth statistical testing to understand the true

statistical significance of the resulting data would be beneficial (such as p value calculations). In addition, other statistical calculations, such as correlation coefficient (r^2), may provide even greater definition to the relationship between the weather conditions analyzed and ED utilization and acuity. With a statistically significant data set, it would also be possible to perform a linear regression model to better understand the nature of the relationship.

RELATED RESEARCH

Prior research has assessed variations of the relationship between weather conditions and ED utilization. A comprehensive literature search identified numerous studies that assessed and defined some type of relationship between weather patterns and ED utilization.

Diehl, Morris, and Mannis (1981) looked at ED utilization in relation to calendar day of the week and overall seasonal trends and weather conditions. They concluded that staffing levels could be adjusted based on predictive values for weather patterns. The findings of the current study lend support to this notion and may have major implications for the ED as a department and for the hospital overall.

Several international studies have also focused on this topic. MacGregor (2002) found that warm sunny weather resulted in a higher number of ED visits

for pediatric injuries in the United Kingdom.

Another international study conducted by Rusticucci, Bettolli, and de los Angeles Harris (2002) assessed the effect of weather on ED utilization with respect to diagnostic categories.

In the United States, Christoffel (1985) studied the effect of weather on ED usage by pediatric patients, using similar weather criteria (extreme hot and cold temperatures, degree of precipitation, and departure from normal temperature) and found a correlation between seasons and ED usage. He also concluded that stormy or cold weather conditions reduce ED usage by 5–20 percent, which would be further supported by results from the current study.

Furthermore, Christoffel concluded that only about 80–95 percent of the anticipated ED patient volume presented to the department on poor weather days. Nevertheless, he concluded that season had a stronger correlation with ED usage than weather.

Although Christoffel measured somewhat different dimensions and focused on a pediatric population, the findings are similar to the current study in their collective reliance on numeric weather data (temperature and weather conditions) to assess volume. In addition, Christoffel takes an additional step by assessing the acuity (using ED admission rate as a proxy).

Makie et al. (2002) analyzed meteorological and day-of-the-week factors versus ambulance transports to the ED and found declines in specific diagnostic

presentations during and directly after poor weather; there were slightly elevated volumes after 3 days.

Other studies (Lage et al. 1999; Weitbrecht and Simon 1990; Panagiotakos et al. 2004; Graber, Dly, and Dawson 2004) have analyzed the impact of weather and climate on ED and/or overall hospital utilization, sometimes targeting a specific diagnostic category of patients.

Tollefsen and Dickstein (2000) concluded that there is no relationship between the number of ED admissions and what was defined as “good” weather, although they recognized an increase in patient admissions on days with rain and snow, which is consistent with the current findings.

Furthermore, they identified a slight inverse relationship between temperature and admission rate. This too is consistent with the findings of this study, in addition to the assumption that admission rate is considered an acceptable proxy for the acuity of ED patient cases.

Bhattacharyya and Millham (2001) found that rain is associated with a decrease in overall trauma volume. Generally, they concluded that there is a significant relationship between weather and trauma center activity.

Two other studies (Attia 1998; Attia and Edward 1998) analyzed the effect of weather on ED pediatric patient volume and found that bad weather did not affect pediatric ED utilization. The data presented in this thesis challenge this finding for an overall ED population in a metropolitan setting.

Although several studies have attempted to analyze weather patterns (both good and bad) versus ED utilization, the hypothesis of the current study is slightly different in terms of scope and geographic region analyzed. Additionally, it is reassuring to find the results of the analysis conducted here to be consistent with the findings of the aforementioned studies.

IMPLICATIONS FOR DEPARTMENTS AND HOSPITALS

The data support an identifiable correlation between several definitions of poor weather and ED utilization, which is most significantly seen on days with cold weather or snowfall and to a lesser degree on days with rain. These findings have several implications for EDs and for the hospital organization itself.

Once a pattern has been defined for reduced ED utilization during these weather conditions, weather forecasting information has the potential to be a useful tool for hospitals in predicting expected volume.

Fundamentally, departments should develop internal processes for projecting volume to ensure ample supply to meet patient demand and the efficient allocation of resources. Primarily, EDs should rely on historical data that span at least a 24-month historical period to account for expected growth and seasonal effects with respect to volume. However, understanding local weather forecasts would likely strengthen such predictions of ED patient volume. More specifically, on days where rainfall, snow, or extremely cold weather are

expected, the ED should expect lower patient utilization.

Numerous resources are available for weather forecasts, including web sites (e.g., www.weatherchannel.com), the local weather station, or an almanac. Greater reliability in predictions would likely result from consulting several such resources.

As mentioned, more accurate forecasting of volume will help ensure that there is enough supply to meet the anticipated demand and, similarly, that the risk of oversupplying the department is minimized. This pertains to resources allocated to the ED, including staffing, supplies, and equipment. However, it also extends to financial implications and quality of care issues in the department.

Staffing Implications

Nursing shortages resulting from a declining nursing workforce threaten patient quality and safety (Dunn et al. 1995), and hospitals must currently overcome such challenges when allocating scarce nurse staffing resources.

Although ED nurses specialize in treating ED patients, there is a degree of skills crossover that exists with critical care units, step-down units, and even general medicine beds. Many ED nurses worked in these units before working in the ED.

On days with poor weather, because ED patient volume is generally lighter than usual, there may be times throughout the day where ED nursing staff

has additional human resources above their needs (an infrequent, but not rare event). On occasions when staffing demand for ED nurses is lower than normal (as shown by the data), ED staff could be allocated to departments where demand is higher than usual or where nursing staff is “on call.”

This would not only represent an efficient use of a scarce resource, but it would also seek to reduce the high labor expense associated with nurse coverage. Developing a cross-training program to allow ED nurses to float to other units during times when the ED is overstaffed would help an institution minimize nurse labor expenses.

Another solution would be to implement on-call programs for ED nurses instead of relying on costly overtime. Quite often, the ED may resort to offering overtime opportunities (applies to existing staff who work greater than 40 hours per week) to nursing staff to provide a monetary incentive to staff to maintain established staffing levels. A significant cost avoidance would be associated with creating an on-call program for nurses during days with poor weather, as nurses taking calls would remain available to come in and be compensated anywhere from 10 to 25 percent of wages for this, as opposed to 150 percent of wages, which is typically associated with staff who work overtime. Over the course of a fiscal year, the savings would not be insignificant.

Beyond the financial savings opportunities that would result from offering fewer or no overtime opportunities in the ED is a greater focus on quality of care.

Nurse overtime has been associated with increased risk of medical errors (Rogers 2004), and less reliance on overtime to fill nursing shifts will help to minimize this risk.

A greater understanding of the way poor weather patterns affect ED utilization can also increase the effectiveness and efficiency of a hospital's established nursing float pools. Hospitals sometimes establish float pools to add or pull nurses when there is an increased/decreased demand for nursing care so they can reduce the expense that would result from using staffing agency nurses (*ED Nursing* 2005). As already mentioned, on days when poor weather is expected, it may be possible to float ED nurses to other units where demand is higher. The flexibility of a float pool should also permit the ED to pull nurses when milder weather conditions return.

Supply/Equipment and Other Financial Implications

Beyond staffing considerations, implications exist for EDs and hospitals overall with regards to supply and equipment costs. Next to personnel costs, the supply chain is the largest expense center for hospitals. Supply-chain costs represent as much as 15–30 percent of overall hospital net patient revenue, and it has been shown that a 5–15 percent savings in supply chain costs equals a 1–3 percent improvement in a hospital's operating margin (Williams 2004). With an emphasis on nonpayroll budgetary expenditures as well, hospitals are welcoming creative

solutions for reducing existing operational expenses.

The “cost of carrying” concept relates to hospitals holding excessive inventory, which all too often can negatively affect a hospitals’ cash position. Although the effect will likely be indirect, if the ED is better able to predict demand and utilization based on pending weather, it may be possible to convert current expenses (and cost of carrying) to deferred expenses. Over the course of a single day or several days, this would not likely result in substantial savings; however, over a quarter or budget year, the potential can be significant.

EDs should establish a direct link with the hospital supply chain. Ongoing communication between purchasing departments is beneficial to ensure that excessive ordering of supplies and equipment does not occur. Better predictive capability, using weather patterns, can help to alleviate the cost burden of excessive inventory.

Quality-of-Care Implications

The previous sections identify how better anticipation of ED demand (related to weather) can translate into a financial savings for hospitals, by way of reducing payroll and nonpayroll costs alike. However, of greater importance is the quality of care provided in hospitals.

Overcrowding and inappropriate use of the ED interferes with the care of critically ill patients (Dowling and Dudley 1995). If contributing factors that stem

from the community result in overcrowding and unnecessary utilization of the ED, then the contributing factors and drivers of these phenomena must be addressed.

The ability to predict upcoming volume can help reduce length of stay by 50 percent in the ED (*ED Management* 2005); thus, it would be advantageous to forecast volume patterns using any information available. The results of the data analysis show that this would represent an additional forecasting tool in efforts to reduce length of stay, which improves quality of care and patient satisfaction.

Inappropriate/Nonemergent Use of the ED

The findings of this research point toward the potential inappropriate/nonemergent use of the ED, as there is a trend toward a difference in the volume and acuity of patients on poor weather days. This notion holds the most significant implications for EDs, hospitals, and the community at large.

It has long been argued that many factors in today's society have resulted in inappropriate use of the ED, and that clinical presentations treated in the ED could be appropriately treated in alternative settings, such as outpatient clinics, physicians' office, or urgent care centers. Roughly 58 percent of patients visiting the ED could have been seen in such alternative locations (*ED Management* 2003).

From a cost perspective, it is more expensive to treat patients in the ED than other locations because of the hospital's high level of fixed costs relative to that of the alternative locations. However, with the increasing number of uninsured in the United States in addition to regulatory standards (i.e., EMTALA), the ED has become the place of choice for medical treatment, which has sent hospital expenses skyrocketing to the point where hospital margins have been eroded to nominal or even negative levels. These reasons similarly explain how and why patients bypass all preventive and primary care interventions and directly access ED care. The ED is an accessible resource, open 24 hours per day and 7 days a week, and it provides all levels of medical treatment from routine care to advanced life-saving interventions.

For this reason, the ED has been dubbed as the community "safety net," because it is the fail-safe option for patients to receive care when all other community options fail or go unsought. Given the stresses on the ED as a safety net, it comes as no surprise that it is generally "underfunded and underresourced" (Marx, Hockberger, and Walls 2002). Herein is the critical problem, which requires a solution that identifies and addresses the contributing factors within the community.

Some would challenge the argument that current ED utilization comprises patient visits that are truly emergent in nature. Others believe the ED is used predominantly by those who do in fact possess healthcare insurance and have

access to a primary care physician (Weber 2005; Byrne 2003). However, the current research identifies how, when all other variables are made equal, a change in the weather results in decreased overall ED utilization and higher admission rates, which is indicative of higher patient acuity. This result shows that even appropriate levels of healthcare coverage and primary care access cannot alone address the healthcare needs of the population.

While some might question the validity of the data analyzed in this study, one of the strengths of the research is the use of a 42-month period. This helped to adjust the data for seasonal patterns, minimize statistical error, and normalize random outlier values in the measurements.

Once the problem of nonemergent use of the ED has been acknowledged, steps must be taken to remedy this. The primary step is to identify obstacles within society that could potentially be aggravating factors toward the inappropriate use of the ED (Richardson 1999). Such factors can include barriers to primary care (Cooke and Finneran 1994), increased referrals to the ED by those practitioners within the primary care arena (Baker, Stevens, and Brook 1995), accessibility issues (*Hospital Practice* 2000), impoverished portions of the population who cannot afford treatment, homelessness, drug addictions, lack of education, unemployment rate, and lack of self-care and preventive behavior (*Hospital Practice* 2000). Other forces, such as the increase in malpractice premiums, have resulted in some physicians relocating to areas with lower

premiums or seeking early retirement, which further contributes to the shortage of community healthcare resources. Collectively, these factors present a formidable challenge. For these issues to go unaddressed within communities is to place the very burden of them on the overused and underresourced ED as the default solution.

Failure to implement broad, sweeping changes to address these issues will result in hospitals' inability to financially sustain EDs, as has already been seen in the state of California. In Los Angeles County alone, six EDs have closed within the past 20 months (Vogt 2004). EDs that continue to lose money may limit a hospital's ability to sustain other valuable service lines or medical programs.

In 2005, New York State identified a trend of bed count reductions over the past decade (Perez-Pena 2005) and began assembling a committee to target hospital closures (Odato 2005). In the not-too-distant future hospitals in New York may follow suit with their counterparts in California by closing their EDs or risking the financial health and viability of the entire institution.

Various groups have established policies that address ED closures (American Public Health Association 2001; American College of Emergency Physicians 1999). Most professional societies and public interest groups disapprove of ED closures. If there were alternative solutions for providing a safety net for the community that resulted in greater efficiencies, there might not be such strong resistance toward closures. It does not appear that an ongoing cash

infusion to support ED operations is likely.

Although many government officials and public interest groups have supported and even been successful in earmarking funds for hospitals to support EDs, this only treats the symptoms of a larger problem within the community. In 2005, President Bush announced that hospitals would be receiving additional financial support for providing emergency medical care for illegal immigrants in the United States (Pear 2005). Unfortunately, this level of support only remains in effect until 2008, and even the state allocations are barely enough to cover the expense of this care. For example, the state of California estimates that it provides \$500 million in care to illegal immigrants, yet it will receive only \$70.8 million annually, which leaves 86 percent (or \$429 million) of the expense to be borne by California hospitals. As the expense burdens on EDs grow, for example, as the treatment of illegal immigrants increases, it raises the question if equivocal increases in funding will similarly take place.

Although ED usage may help to improve the medical presentation of patients without the need for further community resources (Diesburg-Stanwood 2004), it is once again clear that hospitals cannot continue to single-handedly subsidize the community healthcare needs.

EDs and hospitals already bear the cost burden of providing care to the uninsured and underinsured (Irvin, Fox, and Pothaven 2003), because of the enactment of the EMTALA, which ensured public access to emergency services

regardless of the patient's ability to pay. Further complicating hospital fiscal stability are issues related to nonemergent ED reimbursement, which may be reduced if the visit is deemed to be inappropriate for treatment in an ED. At worse, payment for services may be denied, and at best they may be deferred to the patient's responsibility.

In the latter scenario, hospitals have found it difficult to collect directly from self-pay patients with any true consistency. In addition, there would be a deferred recognition of revenue along with an increase in administrative costs in the process of collecting any outstanding charges. This is primarily attributable to the fact that hospitals receive denials from the insurers for the initial bill and have to reconcile the guarantor responsibility for the claim, hence, requiring that another bill be sent out and further delaying the revenue. Furthermore, should a collections agency be engaged because of a hospital's inability to successfully collect directly from the patient, the agency's collection fees would be additional administration costs. Collectively, this would result in an increase in days in accounts receivable for a hospital, which could cause additional damage to an institution's cash position. The ramifications of this are a decreased ability to fund new initiatives and existing programs, invest capital, or support operations (opportunity cost).

Another financial consideration for hospitals that becomes complicated by ED reimbursement issues is if there has been debt issued in the form of bonds.

Long-term effects of reduced ED reimbursement or difficulty in collections from self-pay patients may result in lower bond ratings for a hospital. This can often result in an increase in bond interest rates so that additional interest becomes due on existing bonds or it may increase the cost of capital. Although hospitals with smaller EDs may not be affected significantly, those with larger volume departments or trauma centers might recognize such a financial impact.

CONSIDERATIONS FOR GOVERNMENT, INDUSTRY, AND PUBLIC INTERVENTION

While hospitals struggle to continue supporting the health needs of the public through its EDs, local, state, and federal government should work with healthcare providers and health insurers to identify strategies for addressing the sizable public health challenges within the community.

Ongoing coalitions or groups comprised of representatives from healthcare providers, government, and companies serving the healthcare industry should actively assess and continuously monitor community health needs and the impact of specific interventions targeted toward improving the state of public health. All parties should have a common interest in improved public health, better access to care, financial savings, and increased capacity to meet consumer demand. In addition to community benefit, all participants would benefit from achieving these goals.

For example, health fairs have been effective as a means for identifying health risks in populations and reinforcing prevention, both of which effectively improve the population health and reduce the cost of medical care (Ginn 2004; Huang 2002; Ness 2003). Government benefits from knowing that it has accomplished goals by serving the people. Industry benefits by gaining opportunity to improve sales to consumers. Insurers benefit by enjoying lower medical loss ratios and can effectively pass on savings to consumers in the form of reduced premiums, further promoting health insurance benefits for those who are currently uninsured. Providers benefit from the relief granted by the improvement in community health. Finally, consumers are the true winners, as they are able to live healthier lives because of such efforts.

On a related tangent, and more specific to the this thesis, communities should identify methods to minimize the surge in ED utilization that usually occurs after poor weather, such as ensuring the availability and accessibility of clinics, treatment programs, and shelters. The findings of this study are indicative of excessive use of EDs for nonemergent cases, so it is important for communities to understand how to best deal with this issue, which is currently facing EDs. Are there enough community resources? Do they sufficiently address the population needs? This is a broad question that should be answered by comprehensive investigation, supportive data, and fact.

CONTRARIAN VIEWPOINTS

Although this research points to the relationship between poor weather and ED utilization and patient acuity as an indication of inappropriate use of the ED, there are contrarian viewpoints that could challenge the findings. Therefore, it is important to recognize such views within the scope of this paper.

Primarily, contrarians might argue that poor weather creates accessibility issues for patients, not the concept of nonemergent ED use, which results in lower ED utilization.

However, there would not be a clear explanation for the increased admission rates observed within the study. If the contrarian viewpoint was correct, then one would expect to see a comparable admission rate on days that were defined as having poor weather versus other days.

In fact, if accessibility issues were truly the reason behind decreased ED utilization, then the case is even stronger for government/community/healthcare provider partnerships to identify strategies to improve access to care within the community.

Another opposing perspective on these research findings might be based on patients feeling that their condition could be exacerbated by the poor climate conditions and opt not to utilize the ED.

Once again, if this were the case, then one would expect to see comparable admission rates or even slightly reduced admission rates on days with poor

weather versus other days. Following this logic, only those patients whose conditions would *not* be affected by the weather would use the ED, which would seemingly be those that were not truly emergent. The data analysis identified a higher admission rate on poor weather days, indicating that emergent cases still find ways of accessing the ED.

It could be intuitively deduced that weather ultimately affects the ability of emergency medical services (EMS) to respond in a timely fashion to emergencies. Even on days with poor weather where ambulance call volume remains constant, delays in response time would be expected because of wet or icy roads, for example. Perhaps this could explain the reduced numbers of those using the ED and the increased admission rate. Although EMS serves as a key mode of arrival for metropolitan EDs, it is unlikely that this notion alone explains the findings of the aforementioned research.

Regardless of EMS delays, it is unlikely that patients with critical or life-threatening medical conditions would hesitate to contact an ambulance for transportation or arrange alternative transportation to an ED. More probable is the case that those with questionable “emergency” medical conditions make a decision to visit an ED depending on the weather.

CONCLUSION

The data analyzed showed a detectable correlation between eight poor weather

scenarios (e.g., snow, rain, cold temperatures) and ED utilization at a large academic tertiary-care hospital in New York City. Other related research has identified similar trends between weather and ED usage.

EDs and hospitals could identify strategies for improved efficiencies related to labor, supplies, and equipment by more closely monitoring weather patterns in order to predict ED patient volume. More appropriate utilization of staff and supplies can lead to improved outcomes, minimized risk of medical error, and improved overall quality of care. Given the multitude of challenges currently facing EDs, this could help to mitigate the burden placed on hospitals in acting as the community safety net.

The findings also suggest the possibility that EDs are experiencing utilization by patient whose conditions may not be truly emergent or who could be seen in an alternative setting, such as a primary care clinic or physician practice. Historical trends have shown a growing reliance on EDs for healthcare services, and this trend is expected to continue into the future, which may further strain the financial conditions of many hospitals.

Aggressive efforts must be made by community leaders, government officials, industry, and healthcare providers to identify alternative options for patients to seek care within a community, other than the ED. Resources that can be offered by the community and/or subsidized by government must be identified and provided for an extended period to meet the overwhelming demand for

medical care. Ongoing assessment and analysis should be conducted to ensure that there is a sufficient supply of healthcare services to meet the demand of the public's healthcare needs.

Contrarians may challenge the findings and implications of this research on the grounds that other factors make it difficult to conclude a direct correlation between weather and ED utilization and that the issue is more of accessibility rather than inappropriate use of the ED.

For this reason, continued research is recommended to further identify the correlation between poor weather (e.g., snow, rain, cold temperatures) and ED utilization to not only provide an additional tool for EDs and hospitals to better address the increasing volumes but also to further prove the need for stronger community resources to address the needs of the population.

REFERENCES

American College of Emergency Physicians. 1999. *Policy on Responsibilities of Acute Care Hospitals to the Community*. Irving, TX: American College of Emergency Physicians.

American Public Health Association. 2001. *Policy on Hospital Emergency Department Closures*. Washington, DC: American Public Health Association.

Attia, M. W. 1998. "The Blizzard of 1996: A Pediatric Emergency Department." *Prehospital Emergency Care* 2 (4): 285–8.

Attia, M. W., and R. Edward. 1998. "Effect of Weather on the Number and the Nature of Visits to a Pediatric ED." *American Journal of Emergency Medicine* 16 (4): 374–5.

- Baker, D. W., C. D. Stevens, and R. H. Brook. 1995. "Determinants of Emergency Department Use by Ambulatory Patients at an Urban Public Hospital." *Annals of Emergency Medicine* 25 (3): 311–16.
- Bhattacharyya, T., and D. H. Millham. 2001. "Relationship Between Weather and Seasonal Factors and Trauma Admission Volume at a Level I Trauma Center." *Journal of Trauma* 51 (1): 118–22
- Byrne, M. 2003. "Frequent Attenders to an Emergency Department: A Study of Primary Health Care Use, Medical Profile, and Psychosocial Characteristics." *Annals of Emergency Medicine* 41 (3): 309–18.
- Christoffel, K. K. 1985. "Effect of Season and Weather on Pediatric Emergency Department Use." *American Journal of Emergency Medicine* 3 (4): 327–30.
- Cooke, J., and K. Finneran. 1994. "A Clearing in the Crowd: Innovations in Emergency Services." *Paper Series (United Hospital Fund of New York)* January: 1–43.
- Diehl, A. K., M. D. Morris, and S. A. Mannis. 1981. "Use of Calendar and Weather Data to Predict Walk-in Attendance." *Southern Medical Journal* 74 (6): 709–12.
- Diesburg-Stanwood, A. 2004. "Nonemergent ED Patients Referred to Community Resources After Medical Screening Examination: Characteristics, Medical Condition After 72 hours, and Use of Follow-up Services." *Journal of Emergency Nursing* 30 (4): 312–17.
- Dowling, D., and W. Dudley. 1995. "Nurse Practitioners: Meeting the ED's Needs." *Nurse Manager* 26 (1): 48C–E, 48J.
- Dunn, M. G., R. Norby, P. Cournoyer, S. Hudec, J. O'Donnell, and M. D. Snider. 1995. "Expert Panel Method for Nurse Staffing and Resource Management." *Journal of Nursing Administration* 25 (10): 61–7.
- ED Management*. 2003. "Novel Strategies to Handle Nonemergent ED Visits." *ED Management* 15 (2): 21–2.
- . 2005. "'Predicting the Future' Helps cut LOS by 50%." *ED Management* 17 (3): 31–3.

ED Nursing, 2005. "Save \$37,000 a month by creating a 'float pool.'" *ED Nursing*, February 1.

Ginn, G. O. 2004. "Community Health Orientation, Community-based Quality Improvement, and Health Promotion Services in Hospitals." *Journal of Healthcare Management* 49 (5): 293–306.

Graber, M. A., J. W. Dly, and J. D. Dawson. 2004. "The Nonrandom Occurrence of Visits to the Emergency Department." *Annals of Emergency Medicine* 44 (4; supplement): S115.

Huang, C. L. 2002. "Health Promotion and Partnerships: Collaboration of a Community Health Management Center, County Health Bureau, and University Nursing Program." *Journal of Nursing Research* 10 (2): 93–104.

Hospital Practice. 2000. "Doctor-Patient Relationship and ED Use." *Hospital Practice* 24 (3): 17–21.

Irvin, C. B., J. M. Fox, and K. Pothoven. 2003. "Financial Impact on Emergency Physicians for Nonreimbursed Care for the Uninsured." *Annals of Emergency Medicine* 42 (4): 571–6.

Lage Ferron, M. B., J. Diaz Jimenez, J. J. Gestal Otero, M. de la Sierra Pajares Ortiz, and J. C. Alberdi Odriozola. 1999. "Effects of Environmental Factors on the Number of Emergency Admissions to the Hospital Complex Juan Canalejo in La Coruna: Creation of a Prediction Model." [In Spanish.] *Revista Espanola de Salud Publica* 73 (1): 45–60.

MacGregor, D. M. 2003. "Effect of Weather on Attendance with Injury at a Paediatric Emergency Department." *Emergency Medicine Journal* 20 (2): 204–5.

Makie T., M. Harada, N. Kinukawa, H. Toyoshiba, T. Yamanaka, T. Nakamura, M. Sakamoto, and Y. Nose. 2002. "Association of Meteorological and Day-of-the-Week Factors with Emergency Hospital Admissions in Fukuoka, Japan." *International Journal of Biometeorology* 46 (1): 38–41.

Marx, J. A., R. S. Hockberger, and R. M. Walls. 2002. *Rosen's Emergency Medicine: Concepts and Clinical Practice*, 5th ed. Philadelphia, PA: Mosby, 2722.

National Center for Health Statistics, Centers for Disease Control and Prevention. 1998. Hospital Survey Data, 1998.

Ness, K. K. 2003. "Screening, Education, and Associated Behavioral Responses to Reduce Risk for Falls Among People Over Age 65 Years Attending a Community Health Fair." *Physical Therapy* 83 (7): 631–7.

Odato, J. 2005. "Hospital Closure Agreement Emerges." *The Times Union*, April 13.

Panagiotakos, D. B., C. Chrysohoou, C. Pitsavos, P. Nastos, A. Anadiotis, C. Tentolouris, C. Stefanadis, P. Toutouzas, and A. Paliatsos. 2004. "Climatological Variations in Daily Hospital Admissions for Acute Coronary Syndromes." *International Journal of Cardiology* 94 (2–3): 229–33.

Pear, R. 2005. "Payments to Help Hospitals Care for Illegal Immigrants." *New York Times*, May 11, A1.

Perez-Pena, R. 2005. "Hospital Business in New York, Once Prized, Braces for a Crisis." *New York Times*, section A, April 11, 1

Richardson, S. 1999. "Emergency Departments and the Inappropriate Attender—Is it Time for a Reconceptualisation of the Role of Primary Care in Emergency Facilities?" *Nursing Praxis in New Zealand*. 14 (2): 13–20.

Rogers A. E., W. T. Hwang, L. D. Scott, L. H. Aiken, and D. F. Dinges. 2004. "The Working Hours of Hospital Staff Nurses and Patient Safety." *Health Affairs (Millwood)* 23 (4): 202–12.

Rusticucci, M., M. L. Bettolli, and M. de los Angeles Harris. 2002. "Association Between Weather Conditions and the Number of Patients at the Emergency Room in an Argentine Hospital." *International Journal of Biometeorology* 46 (1): 42–51.

Tollefsen, N. H., and K. Dickstein. 2000. "Are Emergency Admissions to Medical Departments Dependent on Weather?" [In Norwegian.] *Tidsskrift for den Norske Laegeforening* 120 (30): 3678–9.

Vogt, K. 2004. "ED Closures Spur Worries of Care Crisis in L.A." *amnews.com*, Sept. 20. [Online article; retrieved 1/16/07.] <http://www.ama-assn.org/amednews/2004/09/20/gvsb0920.htm>.

Weber, E. J. 2005. "Does Lack of a Usual Source of Care or Health Insurance Increase the Likelihood of an Emergency Department Visit? Results of a National Population-based Study." *Annals of Emergency Medicine* 45 (1): 4–12.

Weitbrecht W. U., and F. Simon F. 1990. "Effect of the Weather on Acute Hospital Admissions. Observations at a Neurologic Clinic. [In German.] *Fortschritte der Medizin*. 108 (15): 287–91.

Williams, M. 2004. "Materials Management and Logistics in the Emergency Department." *Emergency Medicine Clinics of North America* 22 (1): 195–215.