2019

A COMPARISON OF THE EFFECTS OF WEATHER AND CALENDAR VARIABLES ON PATIENT VOLUMES BETWEEN EMERGENCY DEPARTMENT AND URGENT CARE FACILITIES

James Davis
jmichaeldavis11@gmail.com

A COMPARISON OF THE EFFECTS OF WEATHER AND CALENDAR VARIABLES ON PATIENT VOLUMES BETWEEN EMERGENCY DEPARTMENT AND URGENT CARE FACILITIES

by

James Davis

B.A., Southern Illinois University, 2013

A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
Master of Arts

Department of Economics
in the Graduate School
Southern Illinois University Carbondale
May 2019

RESEARCH PAPER APPROVAL

A COMPARISON OF THE EFFECTS OF WEATHER AND CALENDAR VARIABLES ON PATIENT VOLUMES BETWEEN EMERGENCY DEPARTMENT AND URGENT CARE FACILITIES

by

James Davis

A Research Paper Submitted in Partial

Fulfillment of the Requirements

for the Degree of

Master of Arts

in the field of Economics

Approved by:

Dr. Kevin Sylwester, Chair

Graduate School
Southern Illinois University Carbondale
April 6, 2019

AN ABSTRACT OF THE RESEARCH PAPER OF

James Davis, for the Master of Arts degree in Economics, presented on April 6, 2019, at Southern Illinois University Carbondale.

TITLE: A COMPARISON OF THE EFFECTS OF WEATHER AND CALENDAR VARIABLES ON PATIENT VOLUMES BETWEEN EMERGENCY DEPARTMENT AND URGENT CARE FACILITIES

MAJOR PROFESSOR: Dr. Kevin Sylwester

Year after year, emergency department visits in the United States increase along with cost of healthcare. In an effort to combat this, urgent care facilities have become an increasingly common alternative to emergency departments. These urgent care facilities are meant as a low cost, easier to access substitute to emergency departments for the treatment of unexpected, non-life-threatening illnesses. As urgent care facilities become more common, the way in which patients chose between them has become a growing topic of interest. This paper aims to examine the effects weather and calendar variables have on emergency department and urgent care visits in Springfield, Illinois and to compare to similarities and differences between the effects.

TABLE OF CONTENTS

LIST OF TABLES

SECTION 1

INTRODUCTION

Throughout the last several decades there has been dramatic increase in patient volumes in emergency departments across the United States. Because emergency department needs are increasing at a greater rate than expansion of facilities can occur, hospitals and patients have suffered the consequences of overcrowding. In order to combat overcrowding while continuing to provide quality care for patients, urgent care facilities and retail clinics have become an increasingly common alternative to treat patients with sudden, non-life-threatening medical conditions. These standalone facilities are intended treat less urgent medical conditions with the hope of diverting lower acuity patients away from emergency departments in an attempt to alleviate overcrowding.

Emergency departments (ED) have traditionally been the only health care option when patients do not have immediate access to primary care providers. Because of this, they have had a broad range of medical responsibilities extending beyond what might be seen as their primary objective of emergency care. Urgent care facilities are intended to ease the strain on emergency departments by treating a subset of patients who otherwise might have presented to the emergency department. While urgent care clinics act as an alternative for patients who might otherwise present to an emergency department, they are not perfect substitutes. The staffing structure of urgent cares typically mirrors that of emergency departments, but there are several notable differences between the two. One clear difference can be seen in the hours of operation between the two. Given their role as primary treatment centers for life-threatening medical events, virtually all emergency departments in the US remain open at all hours and year-round. While some urgent care facilities are open year-round, most have limited daily hours and are often closed during certain holidays.

Another important difference between emergency departments and urgent care facilities is in the level of medical care available. Urgent care facilities are intended to provide walk-in access for treatment of illnesses and injuries that present suddenly, and require medical intervention, but are not immediately life-threatening. This could include, but not be restricted to, bone fractures and joint sprains, seasonal viral and bacterial infections such as influenza or strep throat, or non-seasonal viral infections such as bronchitis. Typically, non-urgent medical ailments refer to a condition in which a several-hour delay in care will not lead to an adverse outcome (Uscher-Pines et al, 2013). This contrasts with the mission of emergency department facilities, which are intended to act as the primary treatment center for immediately life-threatening medical conditions. A few examples of these would be heart attack, stroke, traumatic injury, allergic reaction, etc. Because emergency departments are intended to treat life-threatening illnesses, they require immediate access to specialists, equipment, and facilities needed to treat these conditions. Conversely, urgent care facilities do not have the same access to specialists, equipment, and facilities, as they are intended to treat non-urgent conditions.

Non-urgent visits to emergency departments have been a concern for decades. A cross-sectional survey conducted by Young et al. (1996) found that approximately 37 percent of patients seen at one hospital emergency department in a 24-hour period were non-urgent cases. A more recent study by Weinick et al (2010) estimated that between 13.7 and 27.1 percent of emergency department visits could have been seen at urgent care facilities or retail clinics. There is little consensus on whether these non-urgent visits increase wait times and cost with evidence supporting and contracting both (Schull et al, 2006). Regardless of whether urgent care facilities help reduce cost and emergency department wait times, the introduction of urgent care facilities has been shown to effect emergency department visits (Poon et al, 2018).

Studies have shown that there are several reasons why patients might choose to present at an emergency department versus an alternative such as their primary care provider or an urgent care facility. Burnett and Grover (1996) found that, of a surveyed population, nearly 66 percent of respondents stated the emergency department was the only place they knew to go for their medical problem. Similarly, the limited hours, longer wait times, and scheduling difficulties associated with seeing a primary care physician have been shown to be associated with increased inappropriate use of emergency departments (Carret et al, 2009). Patients have also been shown to be poorly capable of self-triaging. A study done by Gill and Riley (1996) showed that within a patient population deemed non-urgent by emergency department staff, 82 percent rated their condition as urgent.

Besides patient-reported reasons for emergency department visits, a number of studies have examined effects of environmental and calendar variables on emergency department and urgent care facility volumes. Calendar variables such as specific days of the week or holidays have consistently shown to be influential factors. Volumes tend to peak on Monday, and steadily decline through the rest of the week (Batal et al, 2001). Monday, Thursday, and Friday have been shown to be the most statistically significant towards increased volumes (Holleman et al, 1196). Holidays, and the few days preceding them, have shown to be correlated with declines in emergency department volumes while days following holidays typically have higher volumes (Carret et al, 2009).

There has also be significant research on the effects of weather variables on patient volumes at emergency departments. Temperature, rainfall, and sunshine hours have been shown in some studies to influence emergency department attendance. A study done by Ou et al showed rainfall being associated with lower volume days and sunshine hours and temperature being associated with higher volume days (Ou et al, 2005). Another study showed weather was an influence in emergency department visits specifically for asthma (Kwon et al, 2016). Pediatric emergency department visits have also been shown to decrease on days with rain or snow and increase in the days following rain or snow (Lee et al, 2016).

Given the similarities between emergency departments and urgent care facilities, examination of patient flows between the two given certain factors can potentially provide insight into how view these medical “goods” relative to each other. For instance, perfect similarities in patient volume changes between urgent care and emergency departments given certain calendar or weather variables might indicate that the population views the two as perfect substitutes. Conversely, no similarities whatsoever might suggest the two are viewed as entirely separate goods, despite the fact that they are designed to perform many of the same functions. This could be a sign of imperfect information, an issue that plagues medical markets.

SECTION 2

DATA

Data was compiled and provided by Memorial Health System of Springfield, Illinois. Daily emergency department and ExpressCare (Memorial Health Systems urgent care facilities) census and admission data was included as well as daily weather data for the Springfield, Illinois area. Environmental data included average points for temperature (Fahrenheit), dew point (Fahrenheit), humidity (%), visibility (miles), barometric pressure (inches), wind speed (miles per hour), precipitation (inches), and max wind gust. Calendar data points included full date, day of the week, and month of year, as well as numerical assignments for those categorical data points. The data spanned six years, starting on 6/1/2009 and ending on 6/1/2015. Given that ExpressCare closes for certain holidays, those days and the corresponding data for emergency department visits for those days was removed. Aside from these days all days from 6/1/2009 up to and including 6/1/2015 were included. In total 2172 days of data were taken from an original sample of 2189 days.

SECTION 3

METHODS

A retrospective study using the aforementioned data was conducted using SAS Enterprise Guide 7.1 software. Initial summary statistics were taken to provide maximum, minimum, mean, median, and standard deviation values for the dependent variables of emergency department census, adjusted emergency department census, and ExpressCare census figures. Adjusted emergency department census was calculated by subtracting emergency department visits that resulted in hospital admittance from total emergency department census figures. The rational with adjusting for hospital admissions being that, while the data set does not categorically segment non-urgent emergency department visits, one can unequivocally conclude visits resulting in admission to the hospital are urgent. Similar summary statistic was then taken for the independent variables (calendar and daily weather variables). Correlations were then taken between the independent variables and dependent variables.

Three sets of regressions were then conducted alternating emergency department census, adjusted emergency department census and ExpressCare census as the dependent variables. The first regression only used the calendar variables – day of week and month of year – as independent variable. The second examined the effect of environmental factors as the independent variables. The last regression model included both calendar and environmental factors.

SECTION 4

RESULTS

Emergency department visits across all observations averaged 185.68 per day, with a high of 270, a low of 104, and a standard deviation of 18.57. Using the adjusted emergency department census these numbers dropped considerably, with average daily volumes of 149, a maximum of 221, a minimum of 77 and standard deviation of 16.16. ExpressCare daily census across the same time period averaged 205.2, with a one-day maximum of 382, minimum of 76, and standard deviation of 39.67. Emergency department census significantly correlated with ExpressCare census having a Pearson correlation coefficient of .29120 ($P < .0001$). This correlation, while still statistically significant, was reduced when correlating ExpressCare census to adjusted emergency department census (Pearson correlation coefficient .22011, $P < .0001$). Average emergency department visits, before and after adjusting for admissions, peaked in the second observation year (2010) and then decreased every year thereafter. ExpressCare visits also peaked in 2010 and decreased year after year until the last observation year, 2015, when there was a slight increase.

Emergency department census positively correlated with Monday, March, May, June, July, August, September, mean temperature, mean dew and mean visibility at a 99% confidence interval as well as Tuesday, at a 95% confidence interval. Emergency department census was negatively correlated with Sunday, Friday, Saturday, February, November, December, mean barometric pressure, and mean wind speed at a 99% confidence interval as well as January, and mean humidity at a 95% confidence interval. Adjusted emergency department census was positively correlated with Monday, March, May, June, July, August, September, mean temperature, mean dew and mean visibility at a 99% confidence interval. It was negatively correlated with Friday, Saturday, January, February, November, December, mean barometric pressure, and mean wind speed at the

99% confidence interval as well as Sunday, and mean humidity at a 95% confidence interval. ExpressCare positively correlated with Monday, Tuesday, January, February, March, December, mean barometric pressure, and mean wind speed at the 99% confidence interval as well as mean visibility at the 95% confidence interval. ExpressCare was negatively correlated with Thursday, Friday, June, August, mean temperature, mean dew, and precipitation at the 99% confidence interval as well as Sunday, Saturday and mean humidity at a 95% confidence interval.

The regression of emergency department census on calendar variables showed that all week days had positive coefficients at a 99% confidence interval. January, March, April, May, June, July, August, September, and October had positive coefficients at a 99% confidence interval. February had a positive coefficient that was significant at the 95% confidence level while November had a negative coefficient but was only statistically significant at a 90% confidence interval. The model was significant with (Pr > F) <.0001 and had an R^2 of .2271 and an adjusted R^2 of .2211. The same regression but with adjusted emergency department census as the independent variable had similar directional results for variable coefficients with some exceptions; January was only significant at a 95% confidence interval and November, while still having a negative coefficient, was not statistically significant. The model was also significant with (Pr > F) <.0001, had an R^2 of .1772 and an adjusted R^2 of .1707. Regression of ExpressCare census showed that Monday, Tuesday, April, May, June, July, August, September, and October were statistically significant at a 99% confidence interval with Monday and Tuesday having positive coefficients and the other variables having negative coefficients. Friday and January also had negative coefficients but were significant only at a 90% confidence interval. This model was also significant with (Pr > F) <.0001, had an R^2 of .1786 and an adjusted R^2 of .1721. These results can be seen in table 1.

Table 1. Regression on Calendar Variables

	ED				Adjusted ED				Express			
	Estimate	Standar Error	t Value	Pr > |t|	Estimate	Standar Error	t Value	Pr > |t|	Estimate	Standar Error	t Value	Pr > |t|
Intercept	168.00335	1.49918	112.06	<.0001	135.70395	1.34313	101.04	<.0001	214.3239	3.56394	60.14	<.0001
Sunday	5.57667	1.32867	4.2	<.0001	3.60966	1.19037	3.03	0.0025	0.06031	3.15858	0.02	0.9848
Monday	25.14571	1.32869	18.93	<.0001	16.19066	1.19039	13.6	<.0001	29.53273	3.15864	9.35	<.0001
Tuesday	11.92323	1.32977	8.97	<.0001	6.68338	1.19136	5.61	<.0001	11.90477	3.16121	3.77	0.0002
Wednesday	9.63704	1.32978	7.25	<.0001	5.07064	1.19137	4.26	<.0001	4.99883	3.16124	1.58	0.114
Thursday	8.30751	1.3287	6.25	<.0001	3.97302	1.1904	3.34	0.0009	-3.81202	3.15867	-1.21	0.2276
Friday	6.23146	1.32868	4.69	<.0001	3.32448	1.19038	2.79	0.0053	-5.64111	3.15861	-1.79	0.0742
Saturday	0	.	.	.	0	.	.	.	0	.	.	.
January	5.07472	1.72361	2.94	0.0033	3.60758	1.5442	2.34	0.0196	-7.30636	4.09747	-1.78	0.0747
February	3.58625	1.76639	2.03	0.0425	3.19241	1.58253	2.02	0.0438	1.39183	4.19917	0.33	0.7403
March	11.88907	1.72359	6.9	<.0001	10.94857	1.54419	7.09	<.0001	4.81251	4.09743	1.17	0.2403
April	9.98117	1.73787	5.74	<.0001	9.12084	1.55698	5.86	<.0001	-15.00207	4.13138	-3.63	0.0003
May	13.01558	1.72361	7.55	<.0001	12.36565	1.5442	8.01	<.0001	-11.82786	4.09747	-2.89	0.0039
June	12.68371	1.74286	7.27	<.0001	12.85169	1.56145	8.23	<.0001	-39.55244	4.14323	-9.55	<.0001
July	12.12319	1.72358	7.03	<.0001	12.11756	1.54417	7.85	<.0001	-43.06896	4.09739	-10.51	<.0001
August	11.89817	1.72361	6.9	<.0001	12.10104	1.5442	7.84	<.0001	-26.29746	4.09747	-6.42	<.0001
September	11.99036	1.73787	6.9	<.0001	13.1637	1.55698	8.45	<.0001	-14.80041	4.13138	-3.58	0.0003
October	5.48837	1.72359	3.18	0.0015	6.98683	1.54419	4.52	<.0001	-19.92431	4.09743	-4.86	<.0001
November	-3.10568	1.7379	-1.79	0.0741	-0.94342	1.55701	-0.61	0.5446	-19.99581	4.13145	-4.84	<.0001
December	0	.	.	.	0	.	.	.	0	.	.	.
	Sum of Squares	Mean Square	F Value	Pr > F	Sum of Squares	Mean Square	F Value	Pr > F	Sum of Squares	Mean Square	F Value	Pr > F
Model	176260	10368	37.53	<.0001	103673	6098.40071	27.5	<.0001	736768	43339	27.76	<.0001
Error	599788	276.27272			481424	221.75207			3389619	1561.31711		
Corrected Total	776048				585097				4126387			
	Values				Values				Values			
Root MSE	16.62145				14.89134				39.51351			
Dependent Mean	185.46094				149.23938				203.6053			
Coeff Var	8.96224				9.97816				19.40691			
R-Square	0.2271				0.1772				0.1786			
Adj R-Sq	0.2211				0.1707				0.1721			

Regression using environmental factors and with emergency department census as the dependent variable showed that only mean temperature was statistically significant. It was significant at a 99% confidence interval and had a positive coefficient. This was also true with adjusted emergency department census as the dependent variable. Both were statistically significant with (Pr > F) <.0001 while the R^2 and adjusted R^2 for the emergency department census model were .0789 and .0755, respectively, and the R^2 and adjusted R^2 for adjusted emergency department census model were .1053 and .102, respectively. With ExpressCare census as the dependent variable, mean visibility and mean wind speed were significant at the 99% level – both having positive coefficients – while mean dew was significant at the 90% level and had a negative coefficient. This model was significant with (Pr > F) <.0001, had an R^2 of .0604 and an adjusted R^2 of .057. A table of these regression results can be seen in table 2.

Table 2. Regression on Weather Variables

	ED				Adjusted ED				Express			
	Estimate	Standar Error	t Value	Pr > |t|	Estimate	Standar Error	t Value	Pr > |t|	Estimate	Standar Error	t Value	Pr > |t|
Intercept	91.02643	80.9424	1.12	0.2609	49.56717	69.30951	0.72	0.4746	-96.90186	188.49166	-0.51	0.6072
Meantemp	0.51843	0.19024	2.73	0.0065	0.51298	0.16289	3.15	0.0017	0.44794	0.443	1.01	0.3121
Meandew	-0.26811	0.20243	-1.32	0.1855	-0.26258	0.17334	-1.51	0.13	-0.87619	0.47141	-1.86	0.0632
Meanhumid	0.10472	0.10095	1.04	0.2997	0.10469	0.08644	1.21	0.226	0.36999	0.23508	1.57	0.1157
Meanbarom	2.30963	2.62999	0.88	0.3799	2.53392	2.25201	1.13	0.2606	8.8822	6.12449	1.45	0.1471
Meanvis	0.15411	0.28864	0.53	0.5934	0.06075	0.24715	0.25	0.8059	1.82543	0.67215	2.72	0.0067
Meanwind	-0.00144	0.15294	-0.01	0.9925	-0.07663	0.13096	-0.59	0.5585	1.28381	0.35616	3.6	0.0003
Precip	-0.55482	1.47695	-0.38	0.7072	-0.85182	1.26469	-0.67	0.5007	-2.40258	3.4394	-0.7	0.4849
Maxgust	0.00655	0.06539	0.1	0.9203	0.00977	0.056	0.17	0.8615	-0.20752	0.15228	-1.36	0.1731
	Sum of Squares	Mean Square	F Value	Pr > F	Sum of Squares	Mean Square	F Value	Pr > F	Sum of Squares	Mean Square	F Value	Pr > F
Model	60936	7616.9907	23.22	<.0001	61349	7668.64437	31.88	<.0001	248099	31012	17.43	<.0001
Error	711151	328.02191			521430	240.5118			3856508	1778.83222		
Corrected Total	772087				582779				4104607			
	Values				Values				Values			
Root MSE	18.11138				15.50844				42.1762			
Dependent Mean	185.45292				149.23794				203.7152			
Coeff Var	9.76602				10.39176				20.70351			
R-Square	0.0789				0.1053				0.0604			
Adj R-Sq	0.0755				0.102				0.057			

Regression using both calendar and environmental factors can be seen in table 3. With emergency department census as the dependent variable showed that all days of the week, January, February, March, June, July, August, October, November, and mean temperature were significant at the 99% level. All days of the week, January, February, March and mean temperature had positive coefficients while June, July, August, October and November coefficients were negative. September and mean wind speed coefficients were negative and significant at the 95% level while mean barometric pressure and mean visibility coefficients were positive and significant at the 95% level. This model was significant with (Pr > F) <.0001, had an R^2 of .279and an adjusted R^2 of .2706. Results were similar for adjusted emergency department census. All days of the week as well as January, February, March, and mean temperature were significant at the 99% level and had positive coefficients. July, August, and November coefficients were negative and significant at a

99% confidence interval. June and mean wind speed coefficients were negative and mean barometric pressure coefficients were positive at the 95% level, was mean visibility was positive but only significant at a 90% interval. This model was also significant with (Pr > F) <.0001, had an R^2 of .2305 and an adjusted R^2 of .2215. With ExpressCare as the dependent variable, of days of the week only Monday and Tuesday were statistically significant, both having positive coefficients and being significant at a 99% confidence interval. April through November were all significant at the 99% level and had negative coefficients. Mean barometric pressure and visibility were also significant at the 99% level and had positive coefficients. Friday had a negative coefficient but was only significant at a 90% interval. The model was significant with (Pr > F) <.0001 and had an R^2 of .2 and an adjusted R^2 of .1907.

Table 3. Regression on All Variables

	ED				Adjusted ED				Express			
	Estimate	Standar Error	t Value	Pr > |t|	Estimate	Standar Error	t Value	Pr > |t|	Estimate	Standar Error	t Value	Pr > |t|
Intercept	-22.4476	74.67021	-0.3	0.7637	-38.08672	67.02214	-0.57	0.5699	-322.84252	181.35186	-1.78	0.0752
Sunday	5.6482	1.28829	4.38	<.0001	3.63315	1.15634	3.14	0.0017	0.1326	3.12868	0.04	0.9662
Monday	25.23013	1.29166	19.53	<.0001	16.23082	1.15936	14	<.0001	29.9998	3.13705	9.56	<.0001
Tuesday	11.99052	1.29249	9.28	<.0001	6.75658	1.16011	5.82	<.0001	12.3161	3.13907	3.92	<.0001
Wednesday	9.83499	1.29336	7.6	<.0001	5.17389	1.16089	4.46	<.0001	4.9906	3.1412	1.59	0.1123
Thursday	8.25765	1.2887	6.41	<.0001	3.91304	1.15671	3.38	0.0007	-4.19636	3.12988	-1.34	0.1801
Friday	6.24895	1.28946	4.85	<.0001	3.37392	1.15739	2.92	0.0036	-5.7212	3.13173	-1.83	0.0679
Saturday	0	.	.	.	0	.	.	.	0	.	.	.
January	8.3527	1.70339	4.9	<.0001	6.58416	1.52892	4.31	<.0001	-5.26193	4.13703	-1.27	0.2035
February	6.37965	1.7462	3.65	0.0003	5.75198	1.56735	3.67	0.0002	4.40073	4.241	1.04	0.2995
March	7.10955	1.74567	4.07	<.0001	6.88815	1.56687	4.4	<.0001	0.89024	4.2397	0.21	0.8337
April	-0.21936	1.96457	-0.11	0.9111	0.32157	1.76335	0.18	0.8553	-22.18116	4.77136	-4.65	<.0001
May	-2.65108	2.14249	-1.24	0.2161	-1.31646	1.92305	-0.68	0.4937	-23.30681	5.20349	-4.48	<.0001
June	-7.30358	2.39881	-3.04	0.0024	-4.60895	2.15311	-2.14	0.0324	-52.87408	5.826	-9.08	<.0001
July	-10.09626	2.4997	-4.04	<.0001	-7.44276	2.24367	-3.32	0.0009	-59.05267	6.07102	-9.73	<.0001
August	-9.42368	2.45309	-3.84	0.0001	-6.70298	2.20183	-3.04	0.0024	-40.49645	5.95783	-6.8	<.0001
September	-5.34647	2.24133	-2.39	0.0171	-2.16632	2.01176	-1.08	0.2817	-26.35191	5.44352	-4.84	<.0001
October	-5.68516	1.93702	-2.93	0.0034	-2.71813	1.73863	-1.56	0.1181	-28.07743	4.70446	-5.97	<.0001
November	-8.52476	1.76821	-4.82	<.0001	-5.56213	1.5871	-3.5	0.0005	-25.94741	4.29445	-6.04	<.0001
December	0	.	.	.	0	.	.	.	0	.	.	.
Meantemp	0.48146	0.17194	2.8	0.0052	0.48978	0.15433	3.17	0.0015	0.41121	0.41758	0.98	0.3249
Meandew	-0.00134	0.18469	-0.01	0.9942	-0.06647	0.16577	-0.4	0.6885	-0.05526	0.44855	-0.12	0.9019
Meanhumid	0.02446	0.09093	0.27	0.788	0.05757	0.08162	0.71	0.4806	0.13572	0.22085	0.61	0.5389
Meanbarom	5.64565	2.42611	2.33	0.0201	5.11239	2.17762	2.35	0.019	16.17525	5.8923	2.75	0.0061
Meanvis	0.61877	0.26021	2.38	0.0175	0.41764	0.23355	1.79	0.0739	3.26786	0.63196	5.17	<.0001
Meanwind	-0.31267	0.1431	-2.18	0.029	-0.28772	0.12845	-2.24	0.0252	0.31678	0.34756	0.91	0.3622
Maxgust	0.02574	0.05853	0.44	0.6602	0.01764	0.05253	0.34	0.737	-0.09763	0.14215	-0.69	0.4923
Precip	0.1775	1.32851	0.13	0.8937	-0.41686	1.19244	-0.35	0.7268	-0.26584	3.22655	-0.08	0.9343
	Analysis of Variance				Analysis of Variance				Analysis of Variance			
	Sum of Squares	Mean Square	F Value	Pr > F	Sum of Squares	Mean Square	F Value	Pr > F	Sum of Squares	Mean Square	F Value	Pr > F
Model	215420	8616.78067	33.3	<.0001	134304	5372.16037	25.77	<.0001	821044	32842	21.51	<.0001
Error	556668	258.79494			448475	208.49593			3282563	1526.52882		
Corrected Total	772087				582779				4104607			
	Values				Values				Values			
Root MSE	16.0871				14.43939				39.07082			
Dependent Mean	185.45292				149.23794				203.7152			
Coeff Var	8.6745				9.67541				19.17914			
R-Square	0.279				0.2305				0.2			
Adj R-Sq	0.2706				0.2215				0.1907			

Saturday =	1 * Intercept - Sunday - Monday - Tuesday - Wednesday - Thursday - Friday
December =	1 * Intercept - January - February - March - April - May - June - July - August - September - October - November

SECTION 5

CONCLUSIONS

Correlations between the independent and each dependent variable were generally similar both in terms of direction and statistically significant with some notable exceptions. January, February, December, barometric pressure and mean wind were negatively correlated with increases in emergency department and adjusted emergency department census but positively correlated with ExpressCare census. Similarly, June, July, August, mean temperature, and dew point were positively correlated with emergency department and adjusted emergency department census but negatively correlated with ExpressCare census. Tuesday was significant to emergency department and ExpressCare census but not adjusted emergency department census while May, September, and November were significant to ED and adjusted ED census but not Express census.

When regressing only using calendar variables, Monday was the greatest contributing variable for all three dependent variables. Weekday variables were much more significant towards ED and adjusted ED census compared to ExpressCare census. November was not significant to ED or adjusted ED census but was significant to ExpressCare census while the reverse was true for February and March. Also, while month of the year all had a positive effect on ED and adjusted ED census there was a negative effect on the month and express census volumes. Even though all models were statistically significant the model best predicted ED census, followed by Express and then adjusted ED.

When modeling for environmental factors, only mean temperature was significant with higher temperatures being associated with higher census volumes. More of the environmental factors were significant for Express census. Increase visibility and wind speeds both led to higher census figures in ExpressCare. Increased dew point led to lower volumes but was less significant of a variable (Pr > |t| .0632). While each regression was statistically significant, none was very predictive. The most predictive of the three was adjusted ED which had an adjusted R^2 of .102.

When looking at calendar and environmental variables together, the variables that significantly affected ED census also significantly affected adjusted ED census, except for September and October. For both, January, February, and March led to increases in census volumes while later months led to decreased volumes. For all three dependent variables July was the month with the greatest impact and for all three the effect was decreased volumes. Months had a greater impact on ExpressCare census volumes than they did on ED or adjusted ED volumes. Day of the week was more significant towards ED and adjusted ED census volumes. All days of the week were significant to a 99% confidence interval and contributed to increased volumes. Only Monday and Tuesday were significant at that level for Express with Friday being significant at a 90% interval. Like with ED and adjusted ED census, Monday and Tuesday contributed to increases in Express census volumes. In contrast, Friday had a negative effect on Express volumes.

Increases in mean temperature contributed to increase in ED and adjusted ED census but had no effect on ExpressCare. This was also true of increased wind speed, but the effect was decrease volumes. Increased visibility and barometric pressure led to increases in volumes for all three dependent variables, though the significance was greatest for ExpressCare. More weather variables were significant towards ED and adjusted ED census volumes than Express volumes at 90 and 95% confidence intervals, respectively, but at the 99% level more weather variables were significant to ExpressCare volumes. Overall, calendar variables contributed more to census volumes for all three dependent variables than environmental factors. In the wholistic model, calendar and environmental factors contributed more to ED and adjusted ED census than they did to ExpressCare census. None of the models were very predictive for ED, adjusted ED, or

ExpressCare census figures. With that being said, they were consistently more accurate when regressing ED census.

There were a large number of similarities across the models, especially in the final regression. While not perfectly identical, these similarities suggest that the patient population views the two facility types as similar goods. Since the number or patients changes similarly based on calendar and weather variables, it can be assumed that patients view these two goods as substitutes. This would be ideal given that ExpressCare is intended as a substitute for non-urgent emergency department care. Despite this, results were not identical between the adjusted emergency department regressions and the ExpressCare regressions. Since the adjusted emergency department variable was intended to show which patients presented to the emergency department despite being able to be treated at ExpressCare, the differences between the models could indicate that those patients view ExpressCare as an inferior substitute to the emergency department. Conversely, there might be an issue with the variable, in that it includes patients who require care only provided at the emergency department.

Several limitations exist that, if corrected, might provide more accurate insight. The most apparent issue is that the census figures for the emergency department are not identified as being urgent or not. Adjusting for admissions with the creation of the adjusted ED census variable intuitively helped remove some urgent cases from the census figure, but it likely did not remove them all. This might be the reason that there was little difference in model outcomes between ED census and adjusted ED census models. It seems obvious that not all patients that present to the ED on any given day need urgent medical attention, but it’s possible many do require immediate attention without admission to the hospital. The inclusion of a datapoint that identified non-urgent visits at the ED – as well as at the urgent care, for that matter – would ensure homogeneity in the population.

There is also the issue concerning the timeframe from when the data was retrieved. All data points showed a total for a given day and thus are less accurate than if the data was segmented into smaller timeframes. This is especially troublesome given that the emergency department is open all day while ExpressCare is only open from 8 am to 8 pm. For example, it could be the case that no ED visits were during the open hours of Express and 100 percent of the rainfall was when express was closed. If the data was segmented into smaller timeframes it would be possible to control for this and only examine times during which both facilities were open.

Lastly, additional analysis could be conducted to better compare the models. A SUR regression could be conducted to compare the association between the residuals. More weather variables could be added to determine what, if any, effect they might have on census volumes. While this paper identifies clear similarities and notable differences in the effects of calendar and weather variables on emergency department and urgent care census volumes, additional, more detailed, data and analysis is needed to expand and validate the findings.

REFERENCES

Batal, H, et al. “Predicting patient visits to an urgent care clinic using calendar variables.” Academic emergency medicine : official journal of the Society for Academic Emergency Medicine, 2001, 8. 48-53.

Burnett, M G, et al. “Use of the Emergency Department for Nonurgent Care during Regular Business Hours.” CMAJ : Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne, U.S. National Library of Medicine, 1 May 1996, www.ncbi.nlm.nih.gov/pmc/articles/PMC1487706/.

Carret, Maria Laura Vidal, et al. “Inappropriate Use of Emergency Services: a Systematic Review of Prevalence and Associated Factors.” Cadernos De Saude Publica, U.S. National Library of Medicine, Jan. 2009, www.ncbi.nlm.nih.gov/pubmed/19180283.

Gill, J. M., et al. “Nonurgent use of hospital emergency departments: Urgency from the patient's perspective.” Journal of Family Practice, 1996, 42(5), 491-496.

Holleman, Donald R., et al. “Predicting Daily Visits to a Waik-in Clinic and Emergency Department Using Calendar and Weather Data.” SpringerLink, Springer-Verlag, Apr. 1996, link.springer.com/article/10.1007/BF02642481.

Kwon, Jae Woo, et al. “Emergency Department Visits for Asthma Exacerbation Due to Weather Conditions and Air Pollution in Chuncheon, Korea: A Case-Crossover Analysis.” Allergy, Asthma & Immunology Research, The Korean Academy of Asthma, Allergy and Clinical Immunology; The Korean Academy of Pediatric Allergy and Respiratory Disease, Nov. 2016, www.ncbi.nlm.nih.gov/pubmed/27582402.

Lee, Hae Jeong, et al. "The Association of Weather on Pediatric Emergency Department Visits in Changwon, Korea (2005–2014)." Science of The Total Environment, Elsevier, 19 Feb. 2016, www.sciencedirect.com/science/article/pii/S0048969716302261.

Ou, Daniel, et al. "Weather Patients Will Come?" Austin Health Research Online: Home, 6 Dec. 2005, ahro.austin.org.au/austinjspui/handle/1/10050.

Poon, Sabrina J, et al. "Trends in Visits to Acute Care Venues for Treatment of Low-Acuity Conditions | Critical Care News." Critical Care News | Curated News for Intensivists, CriticalCare.news, 4 Sept. 2018, criticalcare.news/story/trends-in-visits-to-acute-care-venues-for-treatment-of-low-acuity-conditions/.

Schull, Michael J, et al. "The Effect of Low-Complexity Patients on Emergency Department Waiting Times." Annals of Emergency Medicine, Mosby, 22 Aug. 2006, www.sciencedirect.com/science/article/pii/S0196064406008845.

Uscher-Pines, Lori, et al. "Emergency Department Visits for Nonurgent Conditions: Systematic Literature Review." AJMC, 22 Jan. 2013, www.ajmc.com/journals/issue/2013/2013-1-vol19-n1/emergency-department-visits-for-nonurgent-conditions-systematic-literature-review?p=3.

Weinick, Robin M, et al. "Many Emergency Department Visits Could Be Managed at Urgent Care Centers and Retail Clinics." Health Affairs (Project Hope), U.S. National Library of Medicine, Sept. 2010, www.ncbi.nlm.nih.gov/pmc/articles/PMC3412873/.

Young, Gary, et al. "Ambulatory Visits to Hospital Emergency Departments Patterns and Reasons for Use." JAMA, 1996, 276. 460-465. 10.1001/jama.1996.03540060036032.

VITA

Graduate School
Southern Illinois University

James M. Davis

Jmichaeldavis11@gmail.com

Southern Illinois University Carbondale
Bachelor of Arts, Economics, December 2013

Research Paper Title:
A Comparison of the Effects of Weather and Calendar Variables on Patient Volumes between Emergency Department and Urgent Care Facilities

Major Professor: Dr. Kevin Sylwester