The Impact of Emergency Department Census on the Decision to Admit

Jillian K. Gorski, Robert J. Batt, PhD, MBA, Erkin Otles, MS, Manish N. Shah, MD, MPH, Azita G. Hamedani, MD, MPH, MBA, and Brian W. Patterson, MD, MPH

ABSTRACT

Objective: We evaluated the effect of emergency department (ED) census on disposition decisions made by ED physicians.

Methods: We performed a retrospective analysis using 18 months of all adult patient encounters seen in the main ED at an academic tertiary care center. Patient census information was calculated at the time of physician assignment for each individual patient and included the number of patients in the waiting room (waiting room census) and number of patients being managed by the patient's attending (physician load census). A multiple logistic regression model was created to assess the association between these census variables and the disposition decision, controlling for potential confounders including Emergency Severity Index acuity, patient demographics, arrival hour, arrival mode, and chief complaint.

Results: A total of 49,487 patient visits were included in this analysis, of whom 37% were admitted to the hospital. Both census measures were significantly associated with increased chance of admission; the odds ratio (OR) per patient increase for waiting room census was 1.011 (95% confidence interval [CI] = 1.001 to 1.020), and the OR for physician load census was 1.010 (95% CI = 1.002 to 1.019). To put this in practical terms, this translated to a modeled rise from 35.3% to 40.1% when shifting from an empty waiting room and zero patient load to a 12-patient wait and 16-patient load for a given physician.

Conclusion: Waiting room census and physician load census at time of physician assignment were positively associated with the likelihood that a patient would be admitted, controlling for potential confounders. Our data suggest that disposition decisions in the ED are influenced not only by objective measures of a patient's disease state, but also by workflow-related concerns.

Emergency care is receiving increasing scrutiny as a potential area for cost reductions.[1–3] Management of emergency department (ED) costs begins with examining how ED operational characteristics contribute to both patient-level and system-level outcomes. One such characteristic under scrutiny is ED crowding, a phenomenon that can be partially attributed to rising practice intensity[4,5] and inpatient boarding.[6–8] As ED utilization rises, research on the effects of crowding has primarily focused on its influence on patient outcomes, including treatment delays[9–11] and patient mortality.[12–15] Less well characterized are organizational responses to increasing operational pressure, such as changes to rates of admission.

Highly relevant to the discussion of the cost of emergency care is the growing role of the ED as a "gatekeeper" for inpatient services.[1,16,17] In a 2013 RAND report, hospital admissions rose 4% from 34.7

From the BerbeeWalsh Department of Emergency Medicine (JKG, EO, MNS, AGH, BWP), University of Wisconsin–Madison School of Medicine and Public Health; and the Wisconsin School of Business, University of Wisconsin–Madison (RJB), Madison, WI.
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Address for correspondence and reprints: Jillian K. Gorski; e-mail: jkgorski@wisc.edu.
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million in 2003 to 36.1 million in 2009, and EDs were responsible for almost all of the rise in admissions.[16] Recently, it has been recognized that ED physicians initiate significant expenditures when deciding to admit patients, as opposed to discharging them home,[17] and two thirds of overall national health expenditures related to ED episodes of care are due to ED admissions.[18] Admissions to the hospital are not only costly, but also result in increased length of stays for patients in the ED, contributing to crowding.[6,17,19,20]

As disposition decisions are ultimately made by the emergency physicians on duty, understanding variability in admission rates requires exploring system-level influences on organizational behavior. While clinical factors provide the expected basis for physicians' disposition decisions, it has been shown that factors unrelated to patients' healthcare needs such as triage factors,[21] patient home environment,[22] use of diagnostic testing,[23] patient ethnicity,[24] and hospital size[24] also play a role in this process.

Many patients evaluated in the ED fall into a "gray area" with regard to need for admission, and these patients may require expenditure of significant physician and staff time and resources to arrange a safe and therapeutic discharge plan as opposed to admission. Crowding may place physicians under information overload,[25] a state in which they are more likely to both commit errors and attempt escape from difficult tasks,[26] suggesting the potential for an increase in potentially avoidable admissions as ED physicians choose admission as a safe alternative for these gray area patients. One previous study has examined this association and found an association between crowding and increased likelihood of admission for transient ischemic attack patients in Canada;[27] to our knowledge this association has not been in investigated among all patients or in the United States. We chose to use occupancy rates of the ED to estimate crowding for the purpose of this study: while there are other metrics to estimate crowding, many of these are focused on hospital-level characteristics and may not be as useful to estimate crowding as perceived in real time by providers working in the ED. Occupancy rate is a continuous measure that both captures the minute-to-minute environment of the ED and has been shown to be a simple and valid estimate of crowding.[6,28,29]

The aim of this study was to evaluate whether probability of admission varies based on the occupancy rate of the ED, which we measured using two census metrics corresponding to phases of patient care. We aimed to measure the change in likelihood of admission as a function of waiting room census and physician load census (number of patients an attending physician was managing), while controlling for relevant patient and system factors. We hypothesized that physicians are more likely to admit patients as both of these census measures increase.

METHODS

Study Design and Setting

The study was designed in accordance with the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) statement and was institutional review board approved. We performed a retrospective observational study using patient electronic health record data at a single academic ED with a Level I trauma center. At the time of the study the main ED had 34 beds and operated on an 8-hour overlapping attending physician shift schedule with single coverage from 0100–0900 and double coverage for the remaining hours. Additional physicians serviced the pediatric ED from 1200–2400 as well as our flexible care area (FCA), where physicians based in our triage area select and care for patients with clearly defined workflows in a vertical patient care model. Patients seen through the FCA workflow were occasionally admitted but generally discharged. Patient electronic health record and physician shift schedule information were abstracted for an 18-month time period, from July 1, 2012, through December 31, 2013. Patients with incomplete health records with regards to demographic information, chief complaint, and Emergency Severity Index (ESI) acuity were excluded. Patients cared for in the FCA as well as pediatric patients (17 years and younger) were also excluded from the analysis. The final patients excluded from the analysis were those who were transferred, left without being seen, eloped, left against medical advice, or expired in the ED.

Data Analysis

Patient electronic health records were extracted from Epic (Epic Systems). For each patient encounter, extracted measures included disposition decision, chief complaint, ESI acuity, mode of arrival, sex, race, use of an interpreter, vital signs, and time stamps of

encounter events. Control variables were chosen a priori by author consensus, consistency previous literature referenced above, and availability for analysis. Vital signs included intake diastolic and systolic blood pressures, respiration rate, pulse, and temperature. Encounter events conformed to definitions described in the Emergency Department Benchmarking Alliance Second Performance Measures and Benchmarking Summit[30] and were used to calculate census information, hour of arrival (military time), and boarding time.

Patient age was modeled as a continuous variable, while race of patients, ESI triage level, interpreter use, arrival hour, and arrival mode were categorized (please see Data Supplement S1 [available as supporting information in the online version of this paper] for categories). Chief complaint (as entered into the electronic health record at triage) was available as categorical data; however, there were >250 potential options for chief complaint. The top 25 chief complaints were treated categorically, with less common chief complaints grouped in the category of "other." Blood pressure, temperature, respiratory rate, and pulse were categorized as high, normal, and low, and additionally a category for missing data was included. This was done so as not to eliminate patients with missing vital signs values, who often present differently than patients with complete vital reports.[31] Hour of arrival was defined as the hour of day when the patient was registered in the ED and was included as a categorical variable to control for both variation in system resources and staffing intensity by time of day.

Census information, our primary explanatory variable, was computed at the "time of provider contact" (time of attending physician assignment). Census information included number of patients in the waiting room ("waiting room census") and number of patients an attending was managing ("physician load census"). While FCA patients were not used as subjects for the analysis, they were included in the census measure for waiting room patients to provide a comprehensive measure of occupancy rate. Patients in the waiting room were not separately labeled as FCA status, so these patients were included as they would be seen by the physicians in the main ED as potential patients to be seen.

While the main outcome studied was the effect of ED census on disposition decisions, we considered that crowding effects downstream of ED care could also have an effect on the decision to admit. Although evidence is conflicting,[32] hospital crowding has been shown to result in a reduced chance of admission.[33] Furthermore, it is well established in the literature that hospital crowding is a major limiting factor of ED throughput, leading to increasing inpatient boarding.[20,34–36] Therefore, while we did not have access to hospital crowding data, we provided an estimate of hospital crowding by examining the boarding times of patients entering the ED. For each patient in our analysis, an estimation of inpatient backlog was made by computing the mean boarding time (time elapsed from when patient was ready to admit to time that patient was actually admitted to the hospital) of the five patients admitted from the ED prior to the attending sign on time. This mean boarding time was used in the analysis as a control for hospital crowding, as this represented a reasonable expected wait for bed for the next patient admitted.

Data analysis was performed using Stata 14.0 (StataCorp). Prior to multivariate analysis, control variables were assessed for uncontrolled association with the outcome and all control variables were found to have significant univariate odds ratios (ORs). A multiple logistic regression model was generated to examine the effect of both census measures on disposition, including all control variables discussed above. ORs were reported with 95% confidence intervals (CIs). STATA's margins command was utilized to generate predictive probabilities reported in Table 3 and Figure 2 and associated CIs.[37]

RESULTS

A total of 72,745 patients presented to the ED during our study period, of whom 49,487 met the inclusion criteria for our analysis. A patient attribute flowsheet is illustrated below in Figure 1. In the final patient group, 37% were admitted to the hospital. Admission rates for all adult patients at the ED during our study period were lower (35%), as the least acutely ill patients were directed to the FCA; these patients and providers were not included in our analysis. Table 1 illustrates the breakdown of characteristics of all patients seen in the ED with complete records, those who met the final study criteria, and those in the study stratified by decision to admit.

In the multivariate model regression, waiting room census and physician load census were significantly associated with admission. The OR for admission per patient increase in waiting room census was 1.011

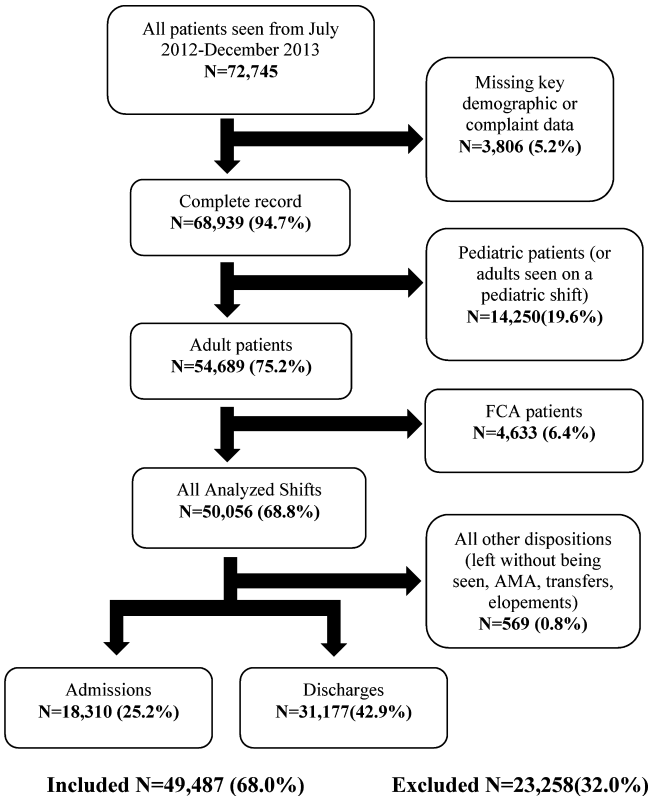

Figure 1. Patient attribute flowsheet. AMA = against medical advice; FCA = flexible care area.

(95% CI = 1.001 to 1.020), and the OR for physician load census was 1.010 (95% CI = 1.002 to 1.019). ORs for admission from the multivariable analysis are reported in Table 2, with full multivariate results available in Data Supplement S1. To place the results of the multivariable logistic regression model into a practical context, marginal probabilities of admission were generated at several plausible combinations of waiting room census and physician load census values, without modifying the distribution of control variables. These results are shown below in Table 3. Figure 2 shows similarly predicted model probabilities of admission plotted against census measures.

The multiple regression model had a satisfactory fit, with an area under the curve of 0.82 for predicting admission. Multicollinearity was initially a concern given the likelihood that there was some relation between waiting room census and physician workload census. Were this the case, we would expect to see large CIs for the ORs in our model, which did not occur. To further evaluate for potential unexpected interaction, we additionally created multivariable regression models identical to our main multivariable model but including only one of our two census metrics. Results of these models did not vary significantly from the overall model: the OR per patient increase for waiting room census was 1.013 (95% CI = 1.003 to 1.022), and the OR for physician load census was 1.012 (95% CI = 1.004 to 1.020). Furthermore, an interaction term between the two census measures was investigated and was not significant.

DISCUSSION

In this study we sought to determine if physicians' decisions to admit are influenced by ED crowding. We examined two separate census measures individually and in combination to assess their relative affect, controlling for potential confounders. Both the number of patients concurrently being seen by a physician at time of new patient assignment (physician load census) and the number of patients in the waiting room (waiting room census) were found to be associated with increased rates of admission, controlling for potential confounders. While per-patient ORs appear modest, our model describes significant variance in admission rates across a range of normal ED operational conditions. Although our study was not able to assess the appropriateness of individual admission decisions, an increase in admission frequency based on patient census alone suggests the potential for an increase in avoidable admissions among patients seen in times of operational stress.

Emergency physicians process multiple patients in parallel, with the goal of providing appropriate diagnostic and therapeutic ED-based interventions for each individual patient while maintaining overall departmental throughput and safe care. Balancing these priorities becomes more difficult while dividing time among a large number of patients.[38] While many patients clearly medically require admission, or are safe for discharge, a number of cases are equivocal; patients have some risk of deterioration and require further testing which may be reasonably accomplished via either admission or further ED workup and well-coordinated follow-up. While admission in general increases the overall amount of healthcare resources used for an individual patient, from the standpoint of the emergency physician, admission saves the time and resources necessary to arrange for safe discharge and follow-up; these duties are handed off to the inpatient team. Physicians with high workload are unable to devote the resources necessary for an extended ED workup and discharge planning. Thus, we postulate that the observed increase in admission rates for patients presenting to a provider

Table 1
Study Sample Information Stratified by Disposition

Variable	All ED Patients	All Study Patients	Admitted Patients	Discharged Patients
Patients (no.)	68,939	49,487	18,310	31,177
Waiting room census (no.)*†	—	2.13	2.37	1.98
Physician load census (no.)*†	—	7.88	8.00	7.81
Mean boarding time of five previous admits (min)*†	—	80.0	80.5	79.7
Age of patient (y)†	40.3	49.6	56.0	45.8
Female sex	51.9%	54.0%	48.7%	56.9%
Race				
White	77.7%	80.9%	84.3%	78.8%
African American	10.2%	9.7%	8.0%	10.6%
Hispanic	5.2%	3.7%	2.8%	4.3%
Asian	2.6%	2.3%	1.8%	2.5%
Native American/Alaskan Native	0.4%	0.5%	0.4%	0.5%
Other	3.9%	3.0%	2.7%	3.2%
Interpreter used	2.8%	2.3%	2.3%	2.3%
Acuity				
1 (high)	1.0%	1.0%	2.7%	0.1%
2	23.7%	27.1%	45.6%	16.4%
3	58.3%	61.0%	50.1%	67.1%
4	16.1%	10.3%	1.14%	15.6%
5 (low)	1.0%	0.6%	0.03%	0.9%
Arrival mode				
Self	72.3%	67.1%	49.3%	77.6%
Police	0.8%	0.8%	1.0%	0.7%
Ambulance	25.8%	30.8%	46.4%	21.6%
Medical flight	1.0%	1.2%	3.2%	0.03%
Blood pressure (mm Hg)‡				
>180/80	8.8%	9.0%	10.7%	8.1%
Normal	90.7%	90.5%	88.3%	91.8%
Systolic < 80	0.4%	0.4%	1.0%	0.1%
Missing	0.1%	0.1%	0.1%	0.1%
Temperature ([degrees sign] F)‡				
>100.4	2.7%	2.9%	5.4%	1.4%
Normal	95.8%	95.6%	90.7%	98.5%
<95	0.1%	0.1%	0.2%	0.1%
Missing	1.4%	1.4%	3.7%	0.1%
Respiratory rate (breaths/min)‡				
>24	3.2%	3.4%	6.7%	1.5%
Normal	94.5%	94.2%	90.2%	96.7%
<12	1.0%	1.1%	1.7%	0.7%
Missing	1.2%	1.2%	1.5%	1.1%
Pulse (beats/min)‡				
>100	17.7%	17.8%	25.0%	13.5%
Normal	81.4%	81.3%	73.7%	85.8%
<50	0.8%	0.8%	1.1%	0.7%
Missing	0.1%	0.1%	0.1%	0.1%

*Computed metric at time of attending sign on.
†Patient totals expressed as means across subgroup.
‡"All ED patients" column includes adult patients only.

with a high workload reflects physicians choosing admission for borderline cases.

We cannot assume that waiting room census impacts physicians in the same way, as these patients are not managed by the physician directly until later in the shift. Rather, waiting room quantity is a sign of the physician's future work environment. When patients build up in the waiting room, it is often because there are neither sufficient beds nor sufficient providers to provide adequate care at that moment in time.[11] Therefore, we suggest that physicians perceive waiting room numbers as a reminder that throughput of their current patients impacts their ability to treat future patients.

This study was structured to examine system-level variation in admission probabilities based on the measured census variables and did not examine providers individually. Variability between providers in admission rates, while not examined in our data set, was likely present,[39] and it is likely that individual providers respond differentially to operational stressors. Further work is necessary to determine the interactions between intra- and interprovider variability in admission behavior.

Table 2
Model Results: Selected ORs for Admission

Variable	OR for Admission (95% CI)
Waiting room census (no.)	1.011 (1.001–1.020)
Physician load census (no.)	1.010 (1.002–1.019)
Mean boarding time of five previous admits (min)*	1.000 (0.999–1.000)
Age of patient (y)	1.024 (1.022–1.025)
Female sex	0.741 (0.715–0.781)
Race	
White	Base category
African American	0.850 (0.786–0.919)
Hispanic	0.771 (0.671–0.886)
Asian	0.820 (0.698–0.963)
Native American/Alaskan Native	0.959 (0.689–1.336)
Other	0.901 (0.789–1.030)
Interpreter used	
No	Base category
Yes	1.286 (1.084–1.525)
Missing	1.067 (0.922–1.234)
Acuity	
1 (high)	20.4 (12.4–33.6)
2	2.90 (2.75–3.06)
3	Base category
4	0.170 (0.147–0.197)
5 (low)	0.064 (0.025–0.165)
Arrival mode	
Self	Base category
Police	1.127 (0.886–1.434)
Ambulance	2.41 (2.30–2.54)
Medical flight	63 (32–124)
Blood pressure (mm Hg)	
>180/80	1.030 (0.956–1.110)
Normal	Base category
Systolic < 80	3.56 (2.31–5.48)
Missing	1.478 (0.627–3.48)
Temperature (°C)	
>38	2.26 (1.95–2.61)
Normal	Base category
<35	0.696 (0.327–1.482)
Missing	37.5 (23.5–60.1)
Respiratory rate (breaths/min)	
>24	1.736 (1.525–1.976)
Normal	Base category
<12	1.138 (0.923–1.402)
Missing	1.167 (0.955–1.427)
Pulse (beats/min)	
>100	1.823 (1.719–1.933)
Normal	Base category
<50	1.390 (1.099–1.759)
Missing	1.160 (0.566–2.376)

For full results please see Data Supplement S1.

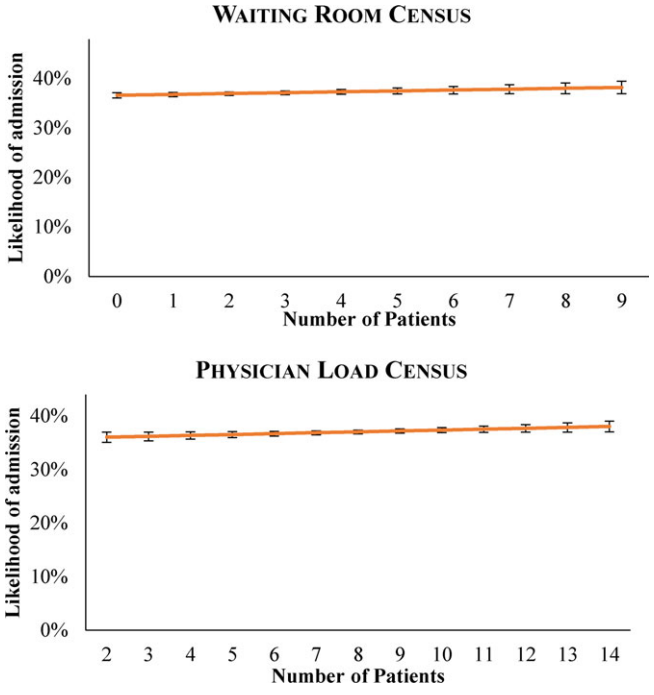

Figure 2. Similarly predicted model probabilities of admission plotted against census measures. [Color figure can be viewed at wileyonlinelibrary.com]

These findings add to the literature suggesting that operational factors have a direct impact on clinical decision-making. There is great potential to reduce the cost and morbidity associated with potentially avoidable hospitalization in settings where the pressures of workload or crowding provide a disincentive to "doing more" in the ED. Efforts aimed at improving efficiency based on patients per physician metrics may paradoxically increase resource utilization overall if workload is shifted to inpatient providers. Further work is necessary to characterize the relationship between workload, clinical safety, and efficiency to define an optimal balance between ED and systemwide efficiency.

LIMITATIONS

We analyzed the association between census measures and disposition at the time of sign-up. Attending sign on time can be variable among providers at a teaching hospital where residents often begin patient care and

Table 3
Predicted Likelihood of Admission at Given Census Measures

	Waiting Room Census		
Physician Load, No. of Patients	0	6	12
0	35.3% (34.2%–36.4%)	36.4% (35.0%–37.7%)	37.4% (35.3%–39.5%)
8	36.6% (36.1%–37.1%)	37.7% (37.0%–38.4%)	38.7% (37.1%–40.3%)
16	37.9% (36.6%–39.2%)	39.0% (37.8%–40.2%)	40.1% (38.3%–41.9%)

Table depicts model predicted values varying census measures while leaving control variables at observed values. Error bars represent calculated error for the overall model, not individual census measures.

provide information to the attending before the attending physician signs into the patient record. However, measures such as the waiting room census are typically made available to the provider via the electronic health record and when the attending is actively signing onto the patients the census numbers displayed at this point in time act as a tangible connection to the attending's interpretation in the context of patient care. Furthermore, we used the best available controls at our disposal to adjust for patient specific characteristics that could influence admission.

Another potential limitation is generalizability. Our overall admission rate during the study time period (35%, a metric including omitted adult patients) was higher than the national average (22%) of age-weighted adult patients admitted.[40] Likely these were due to a number of factors associated with our status as an academic referral center: patients are often transferred from regional hospitals through the ED, and patients receiving tertiary care at our center likely self-refer for emergent conditions. Furthermore, our ED is integrated with a robust urgent care system that sees >80,000 visits per year, which likely reduces our low-acuity volume.

We found an effect of relatively low increases in waiting room census on admission; however, this finding must be interpreted in light of the fact that our center did not suffer from significant boarding or crowding issues compared to other EDs. Further investigation at more crowded centers would elucidate whether the effect on admission rate is dependent on absolute number of patients in a given waiting room or more likely dependent on the relative shift towards crowding for an individual center. Furthermore, during our analysis our hospital did not suffer from major boarding issues. At centers in which boarding prevents patients from physically leaving once admitted, providers may face a different set of incentives when balancing the goals of safe patient disposition with maintenance of operational efficiency. The relationship between boarding and admission rates bears further study in light of our findings.

Our analysis does not prove that the association noted between census measures and admission rates is necessarily causal. It is possible that more complex patients, with a higher incidence of admission, slow down the throughput of an ED, leading to increased census. While this phenomenon may occur, it is unlikely to have had a significant effect on our results, as individual crowding measures were assessed at the time of physician assignment to individual patients, prior to the time when patient workup would begin to divert any department resources from other patients' workup.

CONCLUSION

In this single-center study, increases in physician load census and waiting room census were both independently associated with higher admission rates, controlling for patient presentation factors. This finding raises the possibility that increasing operational stress in the ED may result in potentially avoidable ED admissions.

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Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. Full Logistic Regression Results (all model variables and Odds Ratios Included).