Association of Demographic Variables and Oral Contrast Protocol With Abdominal Computed Tomography Scan Waiting Times

Scholarly Report submitted in partial fulfillment of the MD Degree at Harvard Medical School

Date: 27 February 2016

Student Name: Jonathan Kim

Scholarly Report Title: **Association of Demographic Variables and Oral Contrast Protocol with Abdominal Computed Tomography Scan Waiting Times**

Mentor Name(s) and Affiliations: Jonathan Rogg, MD, MBA, Dept of Emergency Medicine, Massachusetts General Hospital

Collaborators: Yuchiao Chang, PhD, Statistician, Division of General Internal Medicine, Massachusetts General Hospital

Abstract

TITLE: Association of Demographic Variables and Oral Contrast Protocol with Abdominal Computed Tomography Scan Waiting Times

Jonathan Kim, Jonathan Rogg, MD.

Purpose: With the increased number of patients seeking care at emergency departments, physicians are increasingly relying on scarce imaging resources such as computed tomography (CT). This retrospective study aimed to identify any demographic variables (e.g., age, sex, race, socioeconomic status) associated with increased CT scan time intervals and to determine if a change in oral contrast protocol in November 2014 led to decreased waiting times for abdominal CT scans.

Methods: Using radiology logs at MGH, all patients who had an abdominal CT with and without IV and/or oral contrast were identified between May 17, 2014 and May 16, 2015. Using the Emergency Department Information System (EDIS), demographic variables including age, sex, race and insurance status (private or government) were obtained. Other data that was obtained included time interval from CT scan order to CT scan completion, ED length of stay (LOS), ED volume, method of patient arrival (via EMS or walk-in) and at the location in the ED where each patient was treated. ED volume was determined by the number of patients that were currently in the ED at the time of patient arrival. Wilcoxon and T-test by rank analysis was performed to assess the statistical differences in time interval between contrast groups. Linear regression and correlation was used to evaluate the effect of demographic variables on the median time interval from CT order to scan completion.

Results: Results show that no variables are associated with increased abdominal CT scan waiting times with the exception of gender. Regression analysis shows that females waited 13.45 ($p < .0001$) minutes longer than males. Regression analysis also showed that patients with private insurance waited 6.5 ($p = 0.002$) minutes less than those with government insurance. The location a patient was triaged to also had an effect on waiting times. Patients that were treated in Acute waited 17.3 (p – 0.001) minutes less than patients treated in Urgent before November 17, 2014. Not surprisingly, ED volume has a statistically significant effect on waiting times, patients who arrived with an ED volume less than 60 waited 20.3 ($p < 0.0001$) minutes less, when the ED volume was between 60 and 80 patients waited 10.5 ($p < 0.001$) minutes less, and when ED volume was between 80 and 95, patients waited 3.3 ($p = 0.2$) minutes less than patients when ED volume was greater than 95. Patients with abdominal CT scans that required contrast had waiting times that were consistently longer than waiting times for patients without contrast.

Patients that were PO+IV+ took 91.4 ($p < 0.0001$) minutes longer, patients that had PO+IV- took 84.5 ($p < 0.0001$) minutes longer and patients with PO-IV+ took 56.3 ($p < 0.0001$) minutes longer than patients without PO or IV contrast.

Conclusions: Our analysis indicates that gender and insurance type are associated with increased abdominal CT scan waiting times and that the oral contrast protocol change on November 17, 2014 led to a statistically significant reduction in waiting times for all demographic and contrast groups.

Table of Contents

Glossary of abbreviations

CT: computed tomography
ED: emergency department
EDIS: Emergency Department Information System
LOS: length of stay
LWBS: leaving without being seen
MRI: magnetic resonance imaging

Section 1: Introduction

Changes in social, economic and health policies over the last decade have resulted in an increased number of patients seeking medical care at emergency departments[1]. In response to these changes, emergency departments across the country have employed time-efficient practices to accommodate the increased patient load.[2] Numerous studies have linked these time-efficient practices to an improvement in patient care, patient satisfaction, decreased waiting times and a decreased number of patients leaving without being seen (LWBS) by a physician[3].

With the increased number of patients seeking care at emergency departments and technological advances in imaging techniques, physicians have become more reliant on advanced imaging such as computed tomography (CT) and magnetic resonance imaging (MRI) to assist in the diagnose of life-threatening conditions that may not otherwise be appreciated through a clinical exam[4]. Advanced imaging may decrease time to treatment for life-emergent conditions, reducing morbidity and mortality. Imaging has become a vital tool in diagnosing life-emergent conditions such as a perforated bowel or non-reducible intestinal malrotation. Treatment for these emergent conditions, which may often be open abdominal surgery, requires a diagnosis that may only be possible with advanced imaging. Therefore, reducing waiting times for CT scans improves patient care and satisfaction for these emergent-cases[5]. For non-emergent cases, improving imaging workflow will enable better allocation of time and other resources to other patients. It will become more important to maximize workflow efficiency as our reliance on advanced imaging grows and resources become more strained.[3,5,6]

We performed a retrospective study of ED patients requiring abdominal CT scans over two six-month periods that differed because of a change in oral contrast protocol. We compared the time from order to scan completion and total patient length of stay (LOS) among different demographic variables, stratified by use of oral contrast. We had two specific aims of our analysis: 1) to identify any demographic variables (e.g., age, sex, race, socioeconomic status) associated with increased CT scan time intervals and 2) to determine if the change in oral protocol led to decreased waiting times for abdominal CT scans.

Section 2: Methods

The radiology logs at Massachusetts General Hospital (MGH) were used to identify a total of 5,654 patients who obtained an abdominal CT scan in the emergency department from May 17, 2014 through May 16, 2015. These identified patients were then crossed referenced with patient data in the Emergency Department Information System (EDIS) at MGH in order to link radiologic data with emergency department patient data. The resulting database was then de-identified of all patient-specific information to ensure anonymity. The study was given Institutional Review Board approval by MGH and Harvard and was exempt from review by the human subject's protection committee because our analysis involved de-identified patient data and no information was obtained through patient interviews. MGH is a large level one academic medical center with over 100,000 patient visits a year. The ED is separated into four divisions based on patient triage status. The four divisions ordered by decreasing level of acuity are acute, urgent, fast-track and evaluation. An attending physician staffs each of the divisions, with the help of emergency medicine residents and physician assistants.

Patients that required an abdominal CT scan with oral contrast from the six months spanning May 17, 2014 through November 16, 2014 were required to wait a period of 3 hours after drinking three oral contrast solutions before getting an abdominal CT scan. On November 17, 2014, MGH implemented a new oral-contrast protocol in which patients were not required to finish drinking their oral contrast solution nor were they required to wait a period of time before CT technicians could administer a scan. Because of this protocol change, we grouped patient data into two groups: a "before" group from May 17, 2014 through November 16, 2014, and an "after" group from November 17, 2014 through May 16, 2015.

Using a combination of radiology ordering codes and EDIS data, we determined which of the 5,654 patients who received an abdominal CT scan in the before and after groups also received oral and/or IV contrast. For patients with absent ordering codes, ordering comments were used to determine if IV and/or oral contrast was used. We were unable to determine the contrast status of 62 patients because of inconsistent or contradictory ordering codes, due to erroneous input of ordering codes or comments. Using the EDIS, demographic variables including age, sex, race and insurance status (private or government) were obtained. Other data that was obtained included time interval from CT scan order to CT scan completion, patient length of stay (LOS), ED volume, method of patient arrival (via EMS or walk-in) and at the location in the ED where each patient was treated. ED volume was determined by the number of patients that were currently in the ED at the time of patient arrival.

Median time intervals were chosen because the collective data of time intervals did not model a normal distribution.[7] Wilcoxon and T-test by rank analysis was performed to assess the statistical differences in time interval between contrast groups. Linear regression and correlation was used to evaluate the effect independent demographic variables had on the median time interval from CT order to scan completion.

Section 3: Results (observations, data analysis)

5,654 patients were included in the one-year study period. Patient census and study demographics for the two six-month periods spanning May 17, 2014 through May 16, 2015 are presented in Table 1. The demographic percentages for gender, race and insurance status remained similar across the two time periods. Of the 2,940 people who received abdominal CT scans in the first six-month period spanning May 17, 2014 – November 16, 2014 ("before"), 1404 (47.8%) were female, 1536 (52.2%) were male. Of the 2,714 people who received abdominal CT scans in the last six months of the study spanning November 17, 2014 – May 15, 2015 ("after"), 1380 (50.8%) were female and 1334 (49.2%) were male. The median age in the before group was 54.1 (SD = 19.4) and in the after group was 56.1 (SD = 19.5). The race demographic in the before group was 2118 (72%) Caucasian, 192 (6.5%) African-American, 158 (5.4%) Hispanic, 100 (3.4%) Asian, 252 (8.6%) other and 120 (4.1%) not classified. In the after group, it was 1964 (72.4%) Caucasian, 183 (6.7%) African-American, 56 (2.1%) Hispanic, 77 (2.8%) Asian, 309 (11.4%) other and 125 (4.6%) not classified. Insurance status in the before group was 1452 (49.4%) private, 1406 (47.8%) government and 82 (2.8%) undetermined. In the after group it was 1341 (49.4%) private, 1320 (48.6%) government and 53 (2%) undetermined. Table 2 contains data on the median length of stay, CT scan waiting times, volume of the ED upon patient arrival, method of arrival to the ED (ambulance or walk-in), use of PO and IV contrast and distribution of patients across the ED treatment areas. With the exception of median time interval for CT scan completion, these variables remained similar across the two time periods.

Table 3 contains additional information of time intervals for CT scan completion and length of stay stratified by the four PO and IV contrast combinations (PO+IV+, PO+IV-, PO-IV+, PO-IV-). There was a statistically significant drop in abdominal CT waiting times after the protocol change for patients with PO+IV+ scans (190.5 to 142 min, $p < 0.0001$), PO+IV- scans (189 to 134 min, $p < 0.0001$) and PO-IV- scans (69.5 to 60 min, $p = 0.0002$). However, there was not a statistically significant change in waiting times after the protocol change for patients who required only IV contrast (PO-IV+). There was no statistically significant change in patient length of stay, ED volume at patient arrival, or median patient age after the protocol change. There was no statistically significant difference in utilization of contrast CT scans based on sex, insurance status, and location of treatment in the ED across both time periods. There was a statistically significant difference in utilization of abdominal scans by race, but these percentages were consistent with the patient race demographic and did not changer after the protocol change on November 17, 2014.

Table 4 lists predictors of time from linear regression analysis based on demographic or treatment variables, stratified by time periods. The median patient who received an abdominal CT scan after the oral contrast protocol change on November 17, 2014 waited 37.3 ($p < .0001$) minutes less than patients before November 17, 2014. With respect to age, patients under the age of 40 in the before group had a statistically significant reduction in waiting time compared to patients equal to or greater than 70 by 11.57 ($p = 0.005$) minutes. This change was not seen in the after group nor was there any other statistically significant change in waiting time for patients based on age. Females consistently waited longer than males for abdominal CT scans. In the before group, females waited 10.94 ($p < 0.0001$) minutes more, and in the after group, females waited 15.5 ($p < 0.0001$) minutes more than males. African-Americans had a statistically significant increase in waiting times in the after group (11.39 minutes, $p = 0.028$) compared to Caucasians and Hispanics waited 12.69 ($p = 0.026$) minutes less compared to Caucasians in the before group. Patients with private insurance waited 7.77 ($p = 0.006$) minutes more than patients with government insurance in the after group. There was no statistically significant difference in waiting times for patients who walked-in to the ED versus patients who arrived by ambulance. Patients triaged to the Acute area of the ED in the before group waited 17.30 ($p = 0.001$) minutes less than patients who received abdominal CTs in the Urgent area. Patients who arrived when the ED volume was less than 60 patients in the before and after groups waited 22.18 ($p < 0.0001$) minutes and 16.43 ($p < 0.0001$) minutes less than when the ED volume was 95 or greater, respectively. In the after group when the ED volume was between 60 and 80, patients waited 14.21 ($p < 0.0001$) minutes less than when patients arrived with an ED volume greater than or equal to 95. Patients with abdominal CT scans that required contrast had waiting times that were consistently longer than waiting times for patients without contrast across both time periods. Using no PO and no IV contrast as the reference in waiting times comparisons between contrast groups, in the before group patients that were PO+IV+ took 106.7 ($p < 0.0001$) minutes longer, patients that had PO+IV- took 102.7 ($p < 0.001$) minutes longer and patients that were PO-IV+ took 55.2 ($p < 0.0001$) minutes longer than patients without any PO or IV contrast. Patients in the after group that were PO+IV+ took 73.7 ($p < 0.0001$) minutes longer, patients with PO+IV- took 63.3 ($p < 0.0001$) minutes longer, and patients with PO-IV+ took 54.7 ($p < 0.001$) minutes longer than patients without any oral or IV contrast.

Section 4: Discussion, Limitations, Conclusions, and Suggestions for Future Work

Our investigation into demographic variables associated with increased waiting times did not reveal statistically significant trends across both time periods, with the exception of gender. Regression analysis showed that patients under the age of 40 before November 17, 2014 had statistically significant reduced abdominal CT waiting times (11.6 minutes, $p = 0.005$) than patients aged 70 or greater. Interestingly, a statistically significant reduced waiting did not exist for patients under 40 after November 17, 2014. The reason for this reduced waiting period in only the before period is not completely clear, but any inefficient workflow that may have existed to yield faster abdominal CT scans for patients under 40 likely disappeared after the protocol change. Females had a statistically significant increased abdominal CT waiting time compared to males across both time periods (10.9 minutes before, $p < 0.0001$; 15.5 minutes after, $p < 0.0001$). This is most likely due to hospital practice of waiting for pregnancy results before administering CT scans to women of childbearing age. What is not completely clear is the reason for the increased waiting time from 10.9 minutes to 15.5 minutes after the oral contrast protocol change on November 17. What may have occurred is that the overall reduction in abdominal CT scans for patients requiring contrast after November 17 may have amplified any existing inefficiencies that may have been hidden before the protocol change due to the extended waiting time that contrast patients had to undergo. Race did not show statistically significant increased waiting time trends across both time periods.

Using the type of insurance (private vs government) as a proxy for socioeconomic status, this study examined to see if patients with different types of insurance had discrepancies in waiting times for abdominal scans. Indeed, the data shows that patients with private insurance waited 6.5 ($p = 0.002$) minutes less than patients with government insurance across both time periods. The concern here is that hospital caregivers may be subconsciously giving preferential treatment to patients of higher socioeconomic status or that patients with government insurance may have increased waiting times due to an administrative inefficiency in processing that is not present or not as severe for patients with private insurance.

As expected, location of treatment, and thus triage acuity has a large impact on CT scan waiting times. Patients treated in the Acute section of the ED waited 17.3 ($p = 0.001$) minutes less than patients treated in Urgent in the before group. This likely reflects the high acuity of patients triaged to the Acute section of the ED and the priority abdominal CT scans were given to these patients. Surprisingly, there was not a statistically significant reduction in waiting times for Acute patients in the after group compared to patients treated in Urgent. The reason for this is not clear, but it may reflect the improved efficiency of abdominal CT scans across all contrast groups following the protocol change.

Not surprisingly, our data supports that waiting times for abdominal CT scans is reduced when the ED is not busy. Waiting times for patients who arrived when the ED volume was less than 60 waited 22.2 minutes less than when the ED volume was above 95. This trend was consistent in the after group however the time reduction was not as remarkable with only a 16.4-minute reduction in waiting time after the change in PO contrast protocol.

By far the variable with the largest and most consistent association with CT scan waiting times was the use of PO and IV contrast. Patients requiring both oral and IV contrast (PO+IV+) after the protocol change waited a staggering 48.5 minutes less than patients before the protocol change (142 vs 190.5 min). This reduction was also seen in patients requiring only oral contrast (PO+IV-) after the protocol change - these patients waited 55 minutes less than patients before the protocol change (134 vs 189). These two reductions in waiting times provide supporting evidence that the oral contrast protocol change on November 17, 2014 led to decreased waiting times for patients requiring abdominal CT scans with oral contrast. As additional support, patients that only required IV contrast (PO-IV+) after the protocol change did not have a statistically significant change in waiting time compared to before the protocol change. This was not surprising given that the change in protocol only affected procedures for administering oral contrast and not IV contrast. However, a waiting time reduction of 9.5 minutes for patients requiring no contrast (PO-IV-) in the after group compared to the before group (69.5 vs 60 min) provides some evidence that the benefits of the protocol change may have indirectly reduced waiting times for non-oral contrast patients.

In addition to reducing the median waiting time for CT scans, the protocol changes also led to decreased waiting time discrepancies between contrast groups. Before the protocol change, patients requiring only IV contrast took 55.2 minutes longer than patients without any type of contrast. Patients that required only PO contrast took 102.7 minutes longer than those without contrast, and patients that required both PO and IV contrast took 106.6 minutes longer than those without contrast. The protocol for PO contrast takes a longer time to complete than IV contrast and can occur simultaneously, suggesting that use of PO and IV contrast together should not add any time to the waiting time for an abdominal CT when compared with PO contrast only. After the protocol change, all contrast groups had statistically significant reductions in abdominal CT waiting times resulting in a smaller range of waiting times across all four contrast groups. Patients requiring PO and IV contrast only waited 73.7 minutes more than non-contrast patients in the after group, compared to PO+IV+ patients in the before group waiting 106.7 minutes more than non-contrast patients. Patients that required only PO contrast waited 63.3 minutes longer than non-contrast patients, and patients that only required IV contrast waited 54.7 minutes longer than non-contrast patients. These drastic reductions in waiting times are consistent with the streamlined change in PO protocol that took place on November 17, 2014. Not surprisingly, there was not a significant difference between PO-IV- and PO-IV+ waiting times in the before and after groups since the protocol change only affected oral contrast procedures. While the PO contrast protocol change on November 17 most obviously reduced waiting time for patients with contrast, the benefits of this streamlined approach have spread to patients without a need for contrast, demonstrated in the reduced waiting time for non-contrast scans in the after group compared to the before. This may be due to the additive benefits of an improved workflow efficiency, allowing staff to divert their time to other processes.

Massachusetts General Hospital's implemented oral contrast protocol change with the radiology department has drastically reduced median waiting times across the board, even for patients who do not require oral contrast. Regression analysis estimates this protocol change reduced a patient's waiting time by 37 minutes across all demographic groups. Despite the reduced waiting time for CT scans, the protocol change did not result in a statistically significant reduction in a patient's length of stay. This suggests that bottlenecks may exist in the other phases of a patient's evaluation and treatment, preventing reduced CT scan waiting times to affect total length of stay. Previous studies have demonstrated that eliminating the use of oral contrast altogether in the emergency department can lead to reduced CT scan waiting times and patient length of stay without compromising acute patient diagnosis.[8,9]

The major limitation to this project is that certain demographic variables may be difficult to measure with the available data. For example, there is no obvious way to measure the socioeconomic status of patients who visit the emergency room. Also, this is at a single urban academic medical center and the patient population or processes may be different than other facilities.

In conclusion, our analysis indicates that gender and insurance type are associated with increased abdominal CT scan waiting times and that the oral contrast protocol change on November 17, 2014 led to a statistically significant reduction in waiting times for all demographic and contrast groups. Future research in the role of socioeconomic factors with increased abdominal CT scans may elucidate bottlenecks in administrative processing or show an underlying bias of treatment towards people of lower socioeconomic standing.

Section 5: Acknowledgements

A special acknowledgement and appreciation goes to Dr. Jonathan Rogg. His patience and teachings were instrumental in helping me perform my first research project with clinical data. A special acknowledgment and thanks goes to Dr. Yuchaio Chang, the statistician who made the analysis of our clinical data set possible, and for patiently answering my questions regarding statistical methods.

Section 6: Student role

My role was to prepare data that was collected by the MGH EDIS by correctly classifying patient data with incomplete radiology codes by searching into the order comments. Once statistical analysis was performed by Dr. Yuchaio Chang, I wrote the analysis of the data with the help of Dr. Jonathan Rogg.

References

1. Smulowitz PB, O'Malley J, Yang X, Landon BE. Increased use of the emergency department after health care reform in Massachusetts. *Ann Emerg Med*. 2014;64(2). doi:10.1016/j.annemergmed.2014.02.011.

2. Olshaker JS. Managing Emergency Department Overcrowding. *Emerg Med Clin North Am*. 2009;27(4):593-603. doi:10.1016/j.emc.2009.07.004.

3. Kyriacou DN, Ricketts V, Dyne PL, McCollough MD, Talan D a. A 5-year time study analysis of emergency department patient care efficiency. *Ann Emerg Med*. 1999;34(3):326-335. doi:10.1016/S0196-0644(99)70126-5.

4. Davis C a. Computed tomography for the diagnosis and management of abdominal aortic aneurysms. *Surg Clin North Am*. 2011;91(1):185-193. doi:10.1016/j.suc.2010.10.007.

5. Thompson D a, Yarnold PR, Williams DR, Adams SL. Effects of actual waiting time, perceived waiting time, information delivery, and expressive quality on patient satisfaction in the emergency department. *Ann Emerg Med*. 1996;28(6):657-665. doi:10.1016/S0196-0644(96)70090-2.

6. Subash F, Dunn F, McNicholl B, Marlow J. Team triage improves emergency department efficiency. *Emerg Med J*. 2004;21(5):542-544. doi:10.1136/emj.2002.003665.

7. Huynh LN, Coughlin BF, Wolfe J, Blank F, Lee SY, Smithline H a. Patient encounter time intervals in the evaluation of emergency department patients requiring abdominopelvic CT: oral contrast versus no contrast. *Emerg Radiol*. 2004;10(6):310-313. doi:10.1007/s10140-004-0348-1.

8. Levenson RB, Camacho MA, Horn E, Saghir A, Daniel McGillicuddy, Sanchez LD. Eliminating routine oral contrast use for CT in the emergency department: Impact on patient throughput and diagnosis. *Emerg Radiol*. 2012;19(6):513-517. doi:10.1007/s10140-012-1059-7.

9. Schuur JD, Chu G, Sucov A. Effect of oral contrast for abdominal computed tomography on emergency department length of stay. *Emerg Radiol*. 2010;17(4):267-273. doi:10.1007/s10140-009-0847-1.

Tables and Figures

	Before (5/17/14-11/16/14)			After (11/17/14-5/16/15)		
	Number	**SD**	**Percentage**	**Number**	**SD**	**Percentage**
Age (years)	54.1	19.4		56.1	19.5	
Sex						
Female	1404		47.8	1380		50.8
Male	1536		52.2	1334		49.2
Race						
Caucasian	2118		72	1964		72.4
African-American	192		6.5	183		6.7
Hispanic	158		5.4	56		2.1
Asian	100		3.4	77		2.8
Other	252		8.6	309		11.4
NA	120		4.1	125		4.6
Insurance						
Private	1452		49.4	1341		49.4
Government	1406		47.8	1320		48.6
Undetermined	82		2.8	53		2

Table 1 - Demographics of abdominal CT scan patients from 5/17/14-5/16/15

	Before			After		
	Number	SD	Percentage	Number	SD	Percentage
ED Volume at Arrival	79.5	21.8		80.9	22.1	
Median Time Interval from Order to CT Scan Completion (min)	164	83.5		124	71.8	
Median Length of Stay (hours)	8.9	4.6		8.5	5.7	
Mode of Arrival						
Walk-in	1910		65	1708		62.9
EMS	1024		34.8	1006		37.1
Undetermined	6		0.2	0		0
ED Area of Treatment						
Acute	462		15.7	480		17.7
Evaluation	1997		67.9	1772		65.2
Fast Track	101		3.4	80		2.9
Urgent	347		11.8	345		12.7
Use of PO Contrast						
No	1109		37.7	981		36.1
Yes	1806		61.4	1696		62.5
Undetermined	25		0.9	37		1.4
Use of IV Contrast						
No	858		29.2	733		27
Yes	2082		70.8	1981		73

Table 2 - ED data of abdominal CT scan patients

	PO+ IV+			PO+ IV-			PO- IV+			PO- IV-		
	Before	**After**	**p**	**Before**	**After**	**p**	**Before**	**After**	**p**	**Before**	**After**	**p**
Number of Patients	1560	1452		246	244		505	502		604	470	
Order to CT Scan Completion (min)	190.5	142	<0.0001	189	134	<0.0001	131	109.5	0.013	69.5	60	0.0002
Length of Stay (hours)	9.5	8.9	0.51	10.4	9.9	0.3	8.4	8.2	0.78	6.9	7	0.27
ED Volume at Arrival	80.6	81.3	0.078	79.6	82.7	0.98	77.9	80.5	0.23	75.1	79.2	0.077
Age (median)	53.2	54.8	0.23	65.6	68.8	0.059	54.2	55.2	0.65	53	53.9	0.41
Sex												
Female (number)	823 (52.8%)	813 (56%)		131 (53.3%)	121 (49.6%)		185 (36.6)	212 (42.2%)		252 (41.7%)	220 (45.9%)	
Male (number)	737 (47.2%)	639 (44%)		115 (46.7%)	123 (50.4%)		320 (63.4%)	290 (57.8%)		352 (58.3%)	259 (54.1%)	
Race												
Caucasian	1115 (71.5%)	1045 (72%)		184 (74.8%)	184 (75.4%)		361 (71.5%)	359 (71.5%)		441 (73%)	345 (72%)	
African-American	101 (6.5%)	89 (6.1%)		22 (8.9%)	29 (11.9%)		32 (6.3%)	34 (6.8%)		35 (5.8%)	30 (6.3%)	
Hispanic	89 (5.7%)	34 (2.3%)		6 (2.4%)	3 (1.2%)		25 (5%)	8 (1.6%)		38 (6.3%)	11 (2.3%)	
Asian	49 (3.1%)	45 (3.1%)		7 (2.8%)	5 (2%)		24 (4.8%)	17 (3.4%)		18 (3%)	8 (1.7%)	
Other	147 (9.4%)	179 (12.3%)		18 (7.3%)	14 (5.7%)		39 (7.7%)	53 (10.6%)		44 (7.3%)	61 (12.7%)	
NA	59 (3.8%)	60 (4.1%)		9 (3.7%)	9 (3.7%)		24 (4.8%)	31 (6.2%)		28 (4.6%)	24 (5%)	
Insurance												
Private (number)	782 (50.1%)	742 (51.1%)		82 (33.3%)	70 (28.7%)		243 (48.1%)	265 (52.8%)		337 (55.8%)	248 (51.8%)	
Government (number)	743 (47.6%)	689 (47.5%)		160 (65%)	174 (71.3%)		241 (47.7%)	220 (43.8%)		245 (40.6%)	218 (45.5%)	
Mode of Arrival												
Walk-in (number)	1126 (72.2%)	1019 (70.2%)		152 (61.8%)	131 (53.7%)		198 (39.2%)	214 (42.6%)		421 (69.7%)	325 (67.8%)	
Ambulance (number)	432 (27.7%)	433 (29.8%)		93 (37.8%)	113 (46.3%)		306 (60.6%)	288 (57.4%)		181 (30%)	154 (32.2%)	
ED Location												
Acute (number)	122 (7.8%)	131 (9%)		33 (13.4%)	40 (16.4%)		225 (44.6%)	233 (46.4%)		79 (13.1%)	67 (14%)	
Evaluation (number)	1204 (77.2%)	1107 (76.2%)		178 (72.4%)	155 (63.6%)		184 (36.5%)	174 (34.7%)		416 (68.8%)	315 (65.8%)	
Fast Track (number)	29 (1.9%)	25 (1.7%)		2 (0.8%)	2 (0.8%)		39 (7.7%)	29 (5.8%)		29 (4.8%)	21 (4.4%)	
Urgent (number)	199 (12.8%)	176 (12.1%)		30 (12.2%)	46 (18.9%)		41 (8.1%)	51 (10.2%)		72 (11.9%)	68 (14.2%)	

Table 3 - Median CT scan time intervals by contrast group

	Before Difference (min)	p	After Difference (min)	p
All Patients	0.00		-37.35	<.0001
Age				
< 40	-11.57	0.005	2.83	0.498
40-54	-4.23	0.283	-0.13	0.973
55-69	0.61	0.876	6.50	0.078
>=70	0.00		0.00	
Sex				
Female	10.94	<.0001	15.50	<.0001
Male	0.00		0.00	
Race				
Asian	-3.72	0.612	13.25	0.098
African-American	-9.20	0.084	11.39	0.028
Hispanic	-12.69	0.026	0.30	0.973
NA	-4.04	0.540	-2.01	0.743
Other	-5.00	0.305	-4.76	0.253
Caucasian	0.00		0.00	
Insurance				
Private	-5.28	0.067	-7.77	0.006
Government	0.00		0.00	
Mode of Arrival				
Walk-in	-0.96	0.750	-4.99	0.088
Ambulance	0.00		0.00	
ED Location				
Acute	-17.30	0.001	-6.79	0.171
Evaluation	4.10	0.328	6.15	0.137
Fast Track	-1.30	0.873	-0.26	0.976
Urgent	0.00		0.00	
ED Volume				
< 60	-22.18	<.0001	-16.43	<.0001
60-<80	-5.92	0.097	-14.21	<.0001
80-<95	-0.60	0.871	-5.40	0.128
>=95	0.00		0.00	
PO/IV Contrast				
PO+IV+	106.64	<.0001	73.68	<.0001
PO+IV-	102.70	<.0001	63.33	<.0001
PO-IV+	55.23	<.0001	54.70	<.0001
PO-IV-	0.00		0.00	

Table 4 - Linear regression analysis by demographics and contrast groups