Life is All About Timing:
An Examination of Differences in Treatment Quality for Trauma Patients Based on Hospital Arrival Time

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Hospital Quality

- There is significant variation in the quality of care offered by hospitals
- Most work focuses on quality variations between hospitals
- We examine how quality varies within hospitals between daytime (6 AM – 6 PM) and off-hours (6 PM – 6 AM)

Trauma

- Trauma: "sudden physical injury"
  - Car crashes
  - Traumatic brain injury
  - Gunshot wounds
- Trauma is the leading cause of death among Americans 1-44 years old (122,000 deaths a year)
- Trauma patients are treated at a wide variety of hospitals
  - Short treatment cycle
  - Clear quality metrics

Data

- National Trauma Data Bank created and maintained by the American College of Surgeons
- Data on over 1.5 million patients from 477 hospitals
- Detailed data: patient demographics, hospital characteristics, treatment characteristics, outcome, payment type, comorbidities, etc…

Quality Measures

- Mortality
- Waiting Time
- Length of ICU Stay
- Surgical Complication Rate
- Number of Surgeries Needed

Mortality

VARIABLES	Baseline Model	Fixed Effects Model
Early AM	0.111***	0.117***
	(0.0165)	(0.0168)
Night	0.111***	0.109***
	(0.0137)	(0.0139)
Age	0.0194***	0.0206***
	(0.000317)	(0.000327)
Severity	1.823***	1.858***
	(0.00933)	(0.00970)
Male	0.274***	0.257***
	(0.0136)	(0.0138)
Trauma Level II	-0.0329**	-0.799***
	(0.0130)	(0.302)
Trauma Level III	-0.213***	-1.737***
	(0.0405)	(0.422)
Trauma Level IV	-0.685***	1.297*
	(0.168)	(0.706)
Trauma Level NA	-0.305***	-0.161
	(0.0349)	(0.189)
Constant	-8.539***	-8.546***
	(0.0567)	(0.0935)
Observations	681,651	678,762

The odds of death for a patient who arrives during the early AM or at night are 11.7% higher than for a similar patient arriving during the day.

Exp(.111) = 1.117

Length of ICU Stay

VARIABLES	Baseline model	Fixed effects model
Early AM	0.0815***	0.0867***
	(0.00474)	(0.00463)
Night	0.0537***	0.0517***
	(0.00395)	(0.00384)
Age	-0.000211**	0.000768***
	(9.17e-05)	(9.15e-05)
Log(ISS)	0.569***	0.563***
	(0.00159)	(0.00161)
Male	0.159***	0.141***
	(0.00372)	(0.00363)
Trauma Level II	-0.123***	-0.526***
	(0.00369)	(0.0617)
Trauma Level III	-0.358***	-0.615***
	(0.00940)	(0.0603)
Trauma Level IV	-0.704***	-0.194
	(0.0346)	(0.160)
Trauma Level NA	-0.450***	-0.538***
	(0.00847)	(0.0471)
Constant	-2.557***	-2.547***
	(0.0140)	(0.0282)
Observations	681,651	681,651
R-squared	0.173	0.219

Patients arriving during the early AM or at night have 8.5% and 5.5% longer ICU stays, on average, than similar patients arriving during the day

Exp(.0815) = 1.085
Exp(.0537) = 1.055

Time to Surgery

- Prompt treatment is essential in trauma care
  - "Golden Hour"
- More hospital resources are available during the day
- However, hospitals are much busier during the day than at night
  - Elective surgeries are not scheduled at night, leaving operating rooms free
- Longer waits for treatment at night could explain the observed increase in mortality

Time to Surgery

VARIABLES	Baseline Model	Fixed Effects Model
Early AM	-0.117***	-0.0982***
	(0.0102)	(0.00849)
Night	-0.243***	-0.262***
	(0.00838)	(0.00698)
Age	0.0169***	0.0146***
	(0.000194)	(0.000166)
Male	-0.284***	-0.241***
	(0.00796)	(0.00665)
Severity	0.0337***	-0.0459***
	(0.00382)	(0.00332)
Trauma Level II	0.0877***	-0.923***
	(0.00779)	(0.109)
Trauma Level III	0.281***	-1.121***
	(0.0206)	(0.105)
Trauma Level IV	1.262***	-2.058***
	(0.0952)	(0.613)
Trauma Level NA	0.674***	-1.103***
	(0.0219)	(0.0913)
Constant	2.701***	4.840***
	(0.0356)	(0.0583)
Observations	371,262	371,262
R-squared	0.050	0.344

Patients who arrive in the early AM (midnight – 6 AM) and night (6 PM – midnight) have, on average, 7 and 15 minute shorter waiting times for surgery than patients who arrive during the day

60 (-0.117) = -7 minutes
60 (-0.243) = -15 minutes

Surgery Quality

- Staffing levels differ between daytime and off-hours
- There tend to be more generalists on duty overnight
- Fewer specialized resources are available off-hours than during the daytime
- Therefore, we expect to observe a higher surgical complication rate off-hours
- We also expect patients arriving off-hours to be more likely to require multiple surgeries

Complications

VARIABLES	Baseline Model	Fixed Effects Model
Early AM	0.0906***	0.0984***
	(0.0173)	(0.0178)
Night	0.0492***	0.0359**
	(0.0143)	(0.0148)
Age	0.0128***	0.0146***
	(0.000329)	(0.000348)
Male	0.114***	0.111***
	(0.0139)	(0.0143)
Severity	1.304***	1.308***
	(0.00922)	(0.00979)
Trauma Level II	-0.275***	-2.110***
	(0.0138)	(0.461)
Trauma Level III	-0.191***	-0.721***
	(0.0411)	(0.260)
Trauma Level IV	0.0414	-0.00626
	(0.171)	(0.193)
Trauma Level NA	-0.0447	0.117
	(0.0378)	(0.168)
Constant	-6.286***	-6.217***
	(0.0645)	(0.108)
Observations	371,262	348,598

The odds of a patient arriving at night or early AM having a complication during surgery are 9% and 5% higher than for similar patients arriving during the day

Exp(.0906) = 1.09
Exp(.0492) = 1.05

Multiple Surgeries

VARIABLES	MULTIPLE
Early AM	0.124***
	(0.0131)
Night	-0.00579
	(0.0101)
Age	-0.0121***
	(0.000232)
Severity	0.427***
	(0.00458)
Male	0.259***
	(0.00942)
Trauma Level II	-0.290***
	(0.00941)
Trauma Level III	-1.031***
	(0.0204)
Trauma Level IV	-0.569***
	(0.0965)
Trauma Level NA	-0.740***
	(0.0229)
Constant	1.299***
	(0.0445)
Observations	371,262

Patients arriving in the early AM have 13% higher odds of requiring multiple surgeries than similar patients arriving during the daytime

Exp(.124) = 1.13

Differences Between Hospitals

- The difference in resource availability between night and day at small hospitals is greater than at larger hospitals
- Level I trauma centers are required to have certain surgical specialty staff available at all times
- Therefore, we expect to see larger differences between daytime and the off-hours at lower level trauma centers, and smaller, more resource-constrained hospitals

Differences by Hospital Type

	Level I	Level 2	Level 3-4
Early AM	11.0%	14.3%	30.6%
Night	10.1%	13.1%	18.9%

Increase in mortality rate at different level trauma centers compared to daytime

	Level I	Level 2	Level 3-4
Early AM	9.2%	10.8%	31.9%
Night	4.6%	4.7%	8.2%

Increase in surgical complication rate at different level trauma centers compared to daytime

We see bigger differences in quality of care at lower level trauma centers

Differences by Hospital Type

Time	Bottom Quartile	2nd Quartile	3rd Quartile	Top Quartile
Early AM	18.8%	17.1%	6.5%	10.6%
Night	11.3%	10.0%	14.7%	9.1%

Increase in mortality rate compared to daytime by number of beds

	Bottom Quartile	2nd Quartile	3rd Quartile	Top Quartile
Early AM	4.7%	14.0%	8.4%	11.5%
Night	4.7%	7.4%	9.7%	11.6%

Increase in mortality rate compared to daytime by number of visits per surgeon

We see larger differences in quality of care at hospitals that are smaller and more resource constrained

Discussion

- Patients who arrive at night or the early morning to trauma centers receive lower quality care than patients who arrive during the day
- The decrease in quality of care is largest at small, resource constrained hospitals, and at lower level trauma centers
- We believe that resource constraints are the cause of the observed quality variation
- There are fewer specialized doctors available overnight, which leads to lower quality care