Autocorrelation in Sequential Medical Decisions

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Grading a set of student work...

Literature: Autocorrelation in Sequential Decisions

Researchers find autocorrelation in decision making among:

- professional essay raters (Attali, 2011; Zhao et al., 2017)
- gymnastics judges (Damisch et al., 2006)
- juries (Bindler and Hjalmarsson, JEEA 2018)

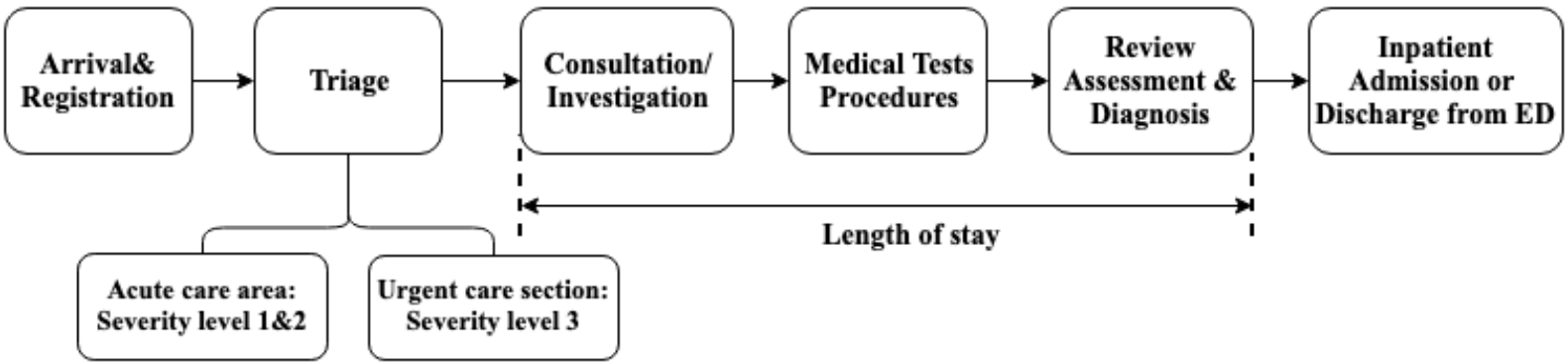
- speed dating participants (Bhargava and Fisman, REStat 2014)
- asylum judges, loan officers, and baseball umpires (Chen et al., QJE 2016)

Research Questions

1. Are medical decisions sequentially autocorrelated?

2. What is the mechanism underlying the autocorrelation?

Setting of Emergency Department



- Quasi-random pairing between patient and physician unexpected ED visits and pre-determined shift schedules
- The order in which patients are treated by the physician is conditionally random
- No financial incentives
- Frequent medical decisions

Graphical Evidence

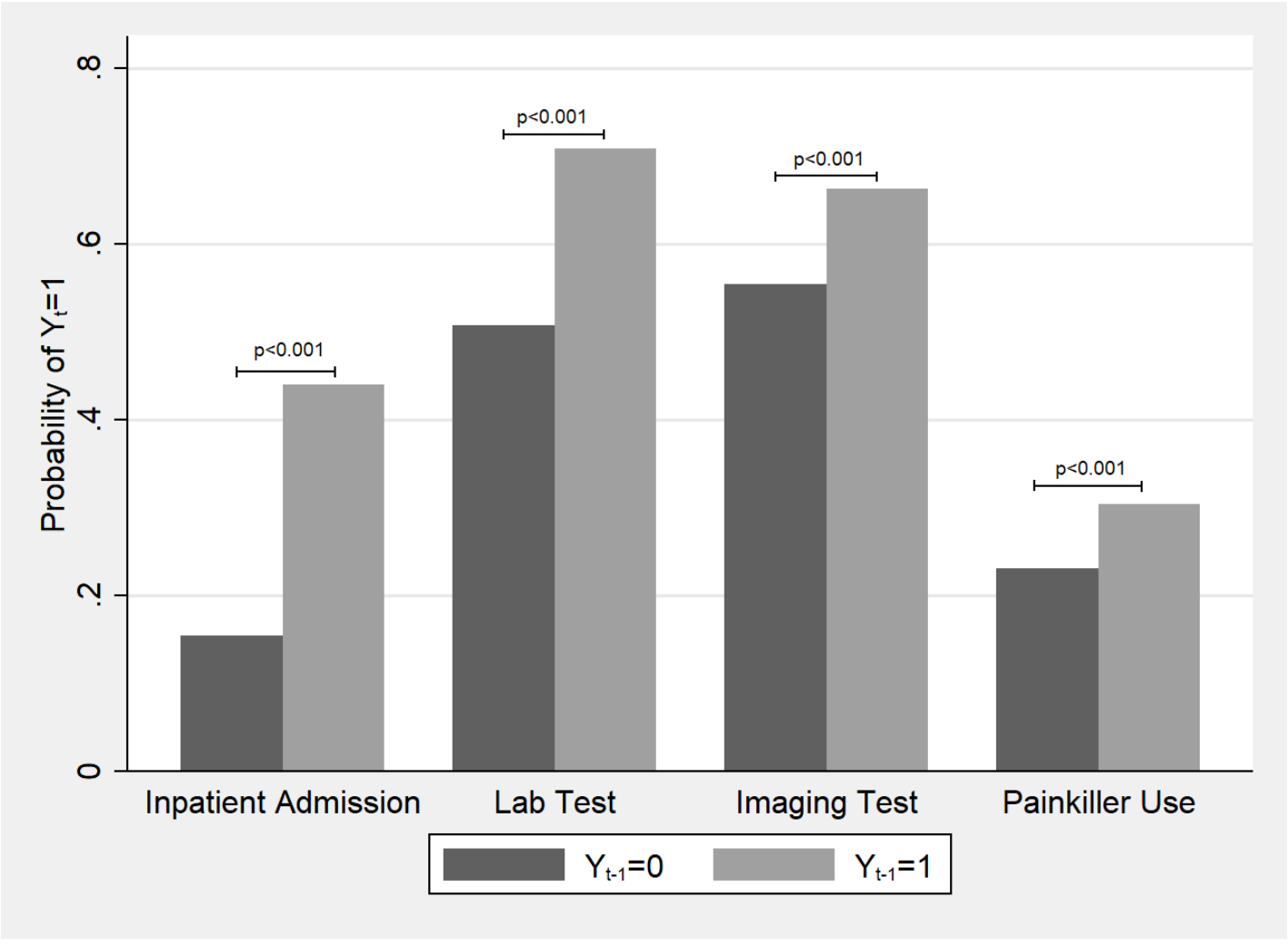


Figure: Raw gaps in decision rates

Autocorrelation in Patient Dispositions

Whether the current decision is correlated with the lagged decision, conditional on a set of control variables:

$$Admission_{it} = \alpha_0 + \alpha_1 Admission_{i,t-1} + X_t\gamma + c_i + \mu_{it}$$

- $Admission_{it}$—whether physician i admits the current case t
- $Admission_{i,t-1}$—whether physician i admits the previous case
- X_t—characteristics of the current case
  - patient demographics: gender, age, race
  - triage severity and diagnostic category
  - time fixed effects: hour of day, day of week, and month-year interactions
- c_i—physician fixed effects
- standard errors clustered at the physician level

Table: Autocorrelation in patient dispositions

	(1)	(2)	(3)
Y	Inpatient admission dummy		
Sample	Full Sample	Same-shift Cases	First Case in a Shift
Lag admission	0.0322***	**0.0378*** **	-0.0002
	(0.0026)	**(0.0030)**	(0.0072)
R-squared	0.394	**0.387**	0.461
Patient demographics	YES	YES	YES
Triage severity	YES	YES	YES
Diagnosis	YES	YES	YES
Time FE	YES	YES	YES
Physician FE	YES	YES	YES
Observations	253,472	241,279	12,193
Sample mean outcome	0.217	0.208	0.408

(1) full analysis sample—cases that follow another case within two days;
(2) cases that follow another case within the same shift;
(3) the first case in each shift.

Robustness Checks

1. Correlated patient conditions: major accidents bring in patients with similar conditions at the same time
   - exclude observations who shared the same diagnosis with the previous case
   - real-time admission rate
2. The most recent patient disposition by colleagues
3. ED crowdedness
   - physician adjusted value of system load
4. Physician multitasking
   - number of patients concurrently managed by the physician
5. Physician fatigue
   - number of patients treated and number of hours worked
6. Availability of inpatient beds
   - number of admissions issued in the ED in the previous 12 hours

result

Autocorrelation in Other Decisions

Panel A: Whether there exists autocorrelation in physician orders

$$Y_{it} = \alpha_0 + \alpha_1 Y_{i,t-1} + X_t\gamma + c_i + \mu_{it}$$

Panel B: Whether lag admission affects the current treatment decision

$$Y_{it} = \alpha_0 + \alpha_1 Y_{i,t-1} + \alpha_2 Admission_{i,t-1} + X_t\gamma + c_i + \mu_{it}$$

	Other decision measure: Y		
	(1) LabTest	(2) ImageTest	(3) PainkillerUse
Panel A			
Lag Y	0.0201***	0.0289***	0.0259***
	(0.0018)	(0.0028)	(0.0031)
R-squared	0.411	0.220	0.102
Panel B			
Lag Y	0.0199***	0.0285***	0.0259***
	(0.0019)	(0.0029)	(0.0031)
Lag admission	0.0010	0.0034	0.0037
	(0.0022)	(0.0029)	(0.0025)
R-squared	0.411	0.220	0.102
Observations	175,120	175,120	175,120
Sample mean outcome	0.628	0.620	0.248

Heterogeneous Analyses

We examine the heterogeneity in autocorrelation with respect to

- the similarity between consecutive cases result
- medical uncertainty
- physician characteristics result
- physician fatigue result

and

whether earlier decisions (two or more lagged cases) matter on the current case result

Medical Uncertainty

Sequential autocorrelation is typically triggered when "ambiguous" or moderate stimuli are judged (Herr et al, 1983).

Judgemental uncertainty regarding patient dispositions:

- condition-specific admission rates in the ED
- triage severity

  admission rates: level 1 (94%), level 2 (50%), level 3 (8%)
- the 15 most common conditions for inpatient admission

  high variations vs. low variations in admission practices
- order of advanced diagnostic imaging
- length of consultation

Heterogeneity: Admission Rates

1. Calculate ED-level admission rates for each condition (obs.>100)
2. Divide patient conditions into groups based on admission rates
3. Allow the autocorrelation to vary with groups of admission rates

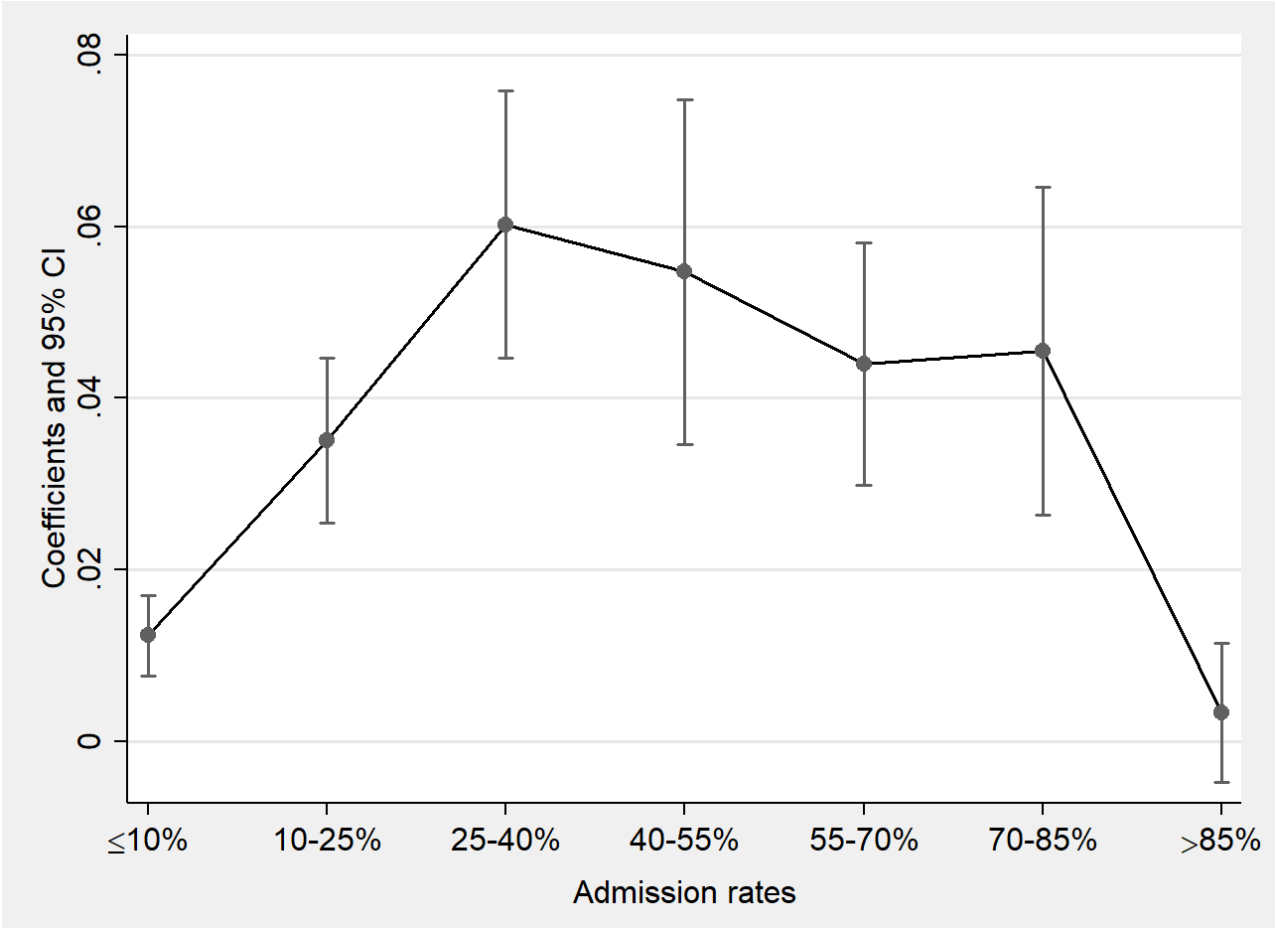


Table. Heterogeneity analysis: medical uncertainty

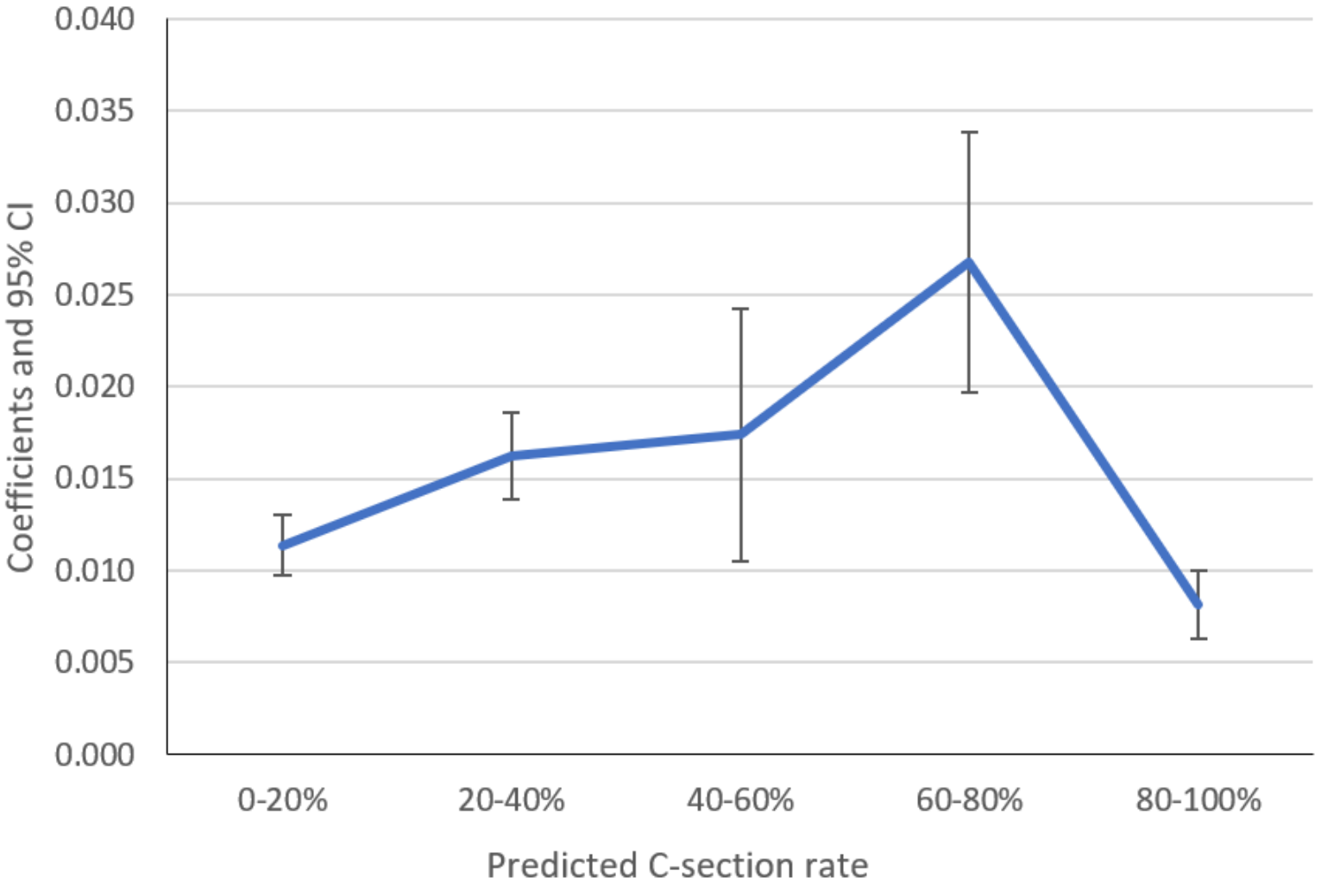
	(1)	(2)	(3)	(4)
Y	Inpatient admission dummy			
Lag admission	0.0569***	0.0234***	0.0401***	0.1273***
	(0.0044)	(0.0064)	(0.0034)	(0.0194)
Level 1	0.4181***			
	(0.0122)			
Level 3	-0.2614***			
	(0.0064)			
Lag admission * Level 1	-0.0582***			
	(0.0064)			
Lag admission * Level 3	-0.0318***			
	(0.0057)			
High variation conditions		-0.0338**		
		(0.0134)		
Lag admission * High variation conditions		0.0301**		
		(0.0117)		
Advanced diagnostic imaging (ADI)			0.3280***	
			(0.0093)	
Lag admission * ADI			-0.0260***	
			(0.0096)	
Log length of consultation				0.0016
				(0.0037)
Lag admission * Log length of consultation				-0.0233***
				(0.0043)
Observations	241,279	29,827	203,305	241,279
R-squared	0.387	0.455	0.391	0.388
Sample mean outcome	0.208	0.580	0.246	0.208

Autocorrelation in C-sections

New York obstetrics data from SPARCS (Statewide Planning and Research Cooperative System), 2005-2015

	(1)	(2)
Y	C-section dummy	
Lag C-section	0.0138***	0.0141***
	(0.0006)	(0.0006)
Patient conditions	Y	Y
Day-of-week FE	Y	Y
Month FE	Y	Y
Year FE	Y	Y
Physician FE	Y	N
# Physicians	6,584	6,584
# Observations	2,516,286	2,516,286
R squared	0.3286	0.3286
Sample mean outcome	0.3375	0.3375

Heterogeneity: Medical Uncertainty



Summary of Empirical Findings

1. Positive autocorrelation in physician decision making that is unrelated to the characteristics of cases considered
2. The effect is observed throughout the shift, regardless of whether the case is early or late in the shift
3. The autocorrelation is more pronounced
   - when physicians face larger medical uncertainty
   - for recent as compared to more distant decisions
   - when the current and previous cases share similar characteristics
   - among inexperienced physicians and non-specialists

Physicians desire to achieve "immediate" internal consistency

Theory

Thinking Aversion: Decision makers maintain their decision rules for consecutive cases to avoid thinking.

Model: Physicians have access to multiple information sources, but incur costs for contemplating the optimal one.

Our model predicts

- positively autocorrelated decisions for similar consecutive cases
- negatively autocorrelated decisions when consecutive cases are distinct

The autocorrelation can be positive in total (as in our data).

Discussion of Alternative Mechanisms

1. **learning**: Through repeated practices, physicians learn about the correlation between observed signals and real states of the world.
   - ✓ smaller autocorrelation among senior physicians
   - – the observed recency effects—the autocorrelation is confined to cases that occur within the same shift, and mostly driven by previous decisions in the most recent past

Discussion of Alternative Mechanisms

2. **emotional spillovers**: The characteristics and/or outcome of earlier cases affect an individual's mood.

   A physician who just treated a high risk case becomes more empathetic towards the current case.

   - ✓ positive autocorrelation
   - – lag admission does not predict other empathetic decisions (e.g. imaging test, painkiller use)

Discussion of Alternative Mechanisms

3. **the hot hand fallacy**: People believe in the continuation of a trend.

   A physician who just treated a high risk patient believes that the next case will be more likely to be of high risk.

   $$Admission_{it} = \alpha_0 + \alpha_2 Severity_{i,t-1} + X_t\gamma + c_i + \mu_{it}$$

   - prediction from the hot-hand fallacy: $\alpha_2 > 0$
   - empirical evidence: $\hat{\alpha_2} = 0$

Thank you for your comments!

Appendix

Table: Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Y	Inpatient admission dummy						
Lag admission	0.0334***	0.0375***	0.0378***	0.0378***	0.0372***	0.0363***	0.0378***
	(0.0032)	(0.0030)	(0.0030)	(0.0030)	(0.0029)	(0.0029)	(0.0032)
Real-time ED admission rate		0.0051					
		(0.0050)					
Lag admission (Colleague)			-0.0014				
			(0.0014)				
Adjusted system load				-0.0024***			
				(0.0007)			
Physician multitasking					-0.0020		
					(0.0012)		
# Hours worked						-0.0022***	
						(0.0005)	
# Patients treated						-0.0011***	
						(0.0002)	
# ED admissions (12 hours)							-0.00002
							(0.0004)
Observations	203,501	241,279	241,279	241,279	241,279	241,279	241,279
R-squared	0.385	0.387	0.387	0.387	0.387	0.388	0.387
Outcome mean	0.211	0.208	0.208	0.208	0.208	0.208	0.208

back

Table. Heterogeneity analysis: patient similarity

	(1)	(2)	(3)	(4)	(5)
Y	Inpatient admission dummy				
Lag admission	0.0337***	0.0339***	0.0366***	0.0364***	0.0161*
	(0.0031)	(0.0031)	(0.0034)	(0.0034)	(0.0083)
Same diagnosis	-0.0050***				
	(0.0016)				
Lag admission * Same diagnosis	**0.0293*** **				
	(0.0053)				
Same age group		0.0034**			
		(0.0017)			
Lag admission * Same age group		**0.0277*** **			
		(0.0062)			
Same race			-0.0013		
			(0.0014)		
Lag admission * Same race			0.0023		
			(0.0036)		
Same gender				0.0005	
				(0.0014)	
Lag admission * Same gender				0.0027	
				(0.0035)	
Same severity					-0.0359***
					(0.0074)
Lag admission * Same severity					**0.0239** **
					(0.0105)
Observations	241,279	241,279	239,001	241,279	241,279
R-squared	0.387	0.387	0.387	0.387	0.387
Sample mean outcome	0.208	0.208	0.208	0.208	0.208

back

Table. Heterogeneity analysis: physician characteristics

Y	(1)	(2)
Lag admission	0.0525***	0.0389***
	(0.0049)	(0.0032)
Experienced physician	0.0171***	
	(0.0051)	
Lag admission * Experienced physician	-0.0173***	
	(0.0063)	
Specialist		-0.0368***
		(0.0046)
Lag admission *Specialist		-0.0218*
		(0.0112)
Observations	241,279	241,279
R-squared	0.387	0.387
Sample mean outcome	0.208	0.208

back

Table. Heterogeneity analysis: physician fatigue and multitasking

	(1)	(2)	(3)	(4)	(5)
Y	Inpatient admission dummy				
Lag admission	0.0452***	0.0480***	0.0538***	0.0616***	0.0670***
	(0.0052)	(0.0069)	(0.0112)	(0.0195)	(0.0048)
#Hours worked	-0.0033***				
	(0.0005)				
Lag admission * #Hours worked	-0.0013				
	(0.0009)				
#Patients treated		-0.0013***			
		(0.0002)			
Lag admission * #Patients treated		-0.0012			
		(0.0008)			
Log ShiftGap			0.0004		
			(0.0011)		
Lag admission * Log ShiftGap			-0.0049		
			(0.0030)		
Log DecisionGap				0.0102***	
				(0.0011)	
Lag admission * Log DecisionGap				-0.0079	
				(0.0056)	
Multitasking					-0.0003
					(0.0011)
Lag admission * Multitasking					**-0.0083*** **
					(0.0013)
Observations	241,279	241,279	240,054	241,279	241,279
R-squared	0.388	0.388	0.387	0.387	0.388
Sample mean outcome	0.208	0.208	0.207	0.208	0.208

back

Table. Earlier cases: more lags

	(1)	(2)	(3)
Y	Inpatient admission dummy		
b1: Lag admission	0.0311***	0.0278***	0.0254***
	(0.0032)	(0.0036)	(0.0040)
b2: Lag2 admission	0.0160***	0.0125***	0.0102***
	(0.0027)	(0.0030)	(0.0029)
b3: Lag3 admission		0.0100***	0.0079***
		(0.0019)	(0.0019)
b4: Lag4 admission			0.0074**
			(0.0034)
p-value: b1=b2	0.0020	0.0060	0.0108
p-value: b1=b3		0.0000	0.0001
p-value: b2=b3		0.4554	0.4863
p-value: b1=b4			0.0082
p-value: b2=b4			0.3845
p-value: b3=b4			0.8943
Observations	224,935	209,006	193,538
R-squared	0.375	0.364	0.353
Sample mean outcome	0.197	0.188	0.179

back