Expertise Overlap and Team Productivity: Evidence from the Hospital Industry

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Motivation and Question

How to organize teams to achieve higher productivity?

- Why important? Many organizations use teamwork
- Our focus: should teams consist of heterogeneous specialists or members with similar expertise?

Diversity or shared expertise?

Members with different expertise $\Longrightarrow$ productive complementarities

- Adam Smith (1776)
  - The most dissimilar geniuses are of use to one another

But $\Uparrow$ coordination costs

- Becker and Murphy (1992):
  - poorer coordination of tasks in teams with more separate specialists

What we do?

Teamwork in the context of a heart procedure in Brazil

- Effects of expertise overlap on patient mortality
  - Expertise overlap: share of overlapping medical specialties between doctors
- Policy relevant context:
  - Healthcare is teamwork-intensive
- Preview:
  - expertise overlap $\Longrightarrow$ mortality $\Downarrow$

Existing Research and Contributions

What is new here?

- Theory of team composition: Groves (1973), Becker and Murphy (1992), Lazear (1999), Che and Yoo (2001), among others.
  - We empirically investigate some of these ideas

- Cultural and ethnic diversity: (Hjort, 2014; Lyons, 2017; Marx et al 2021)
  - demographic diversity $\neq$ skill or specialized knowledge diversity

- Variation in the quality and cost of care: financial incentives (Clemens and Gottlieb, 2014), medical skill (Chan, Gentzkow, and Yu, 2019), team-specific human capital (Chen, 2021)
  - **our paper:** variation in expertise among team members

Background

Brazil's unified health system —(SUS)

- Universal health system:
  - largest public health care system in the world
    - covering over 150 million people
    - more than 75% of Brazil's population (SUS, 2021)
    - annual spending is around R290 billion (or USD 58 billion)
- Hospital care through public and affiliated private health hospitals:
  - Reimbursement system
    - per procedure
    - standardized nationwide fees

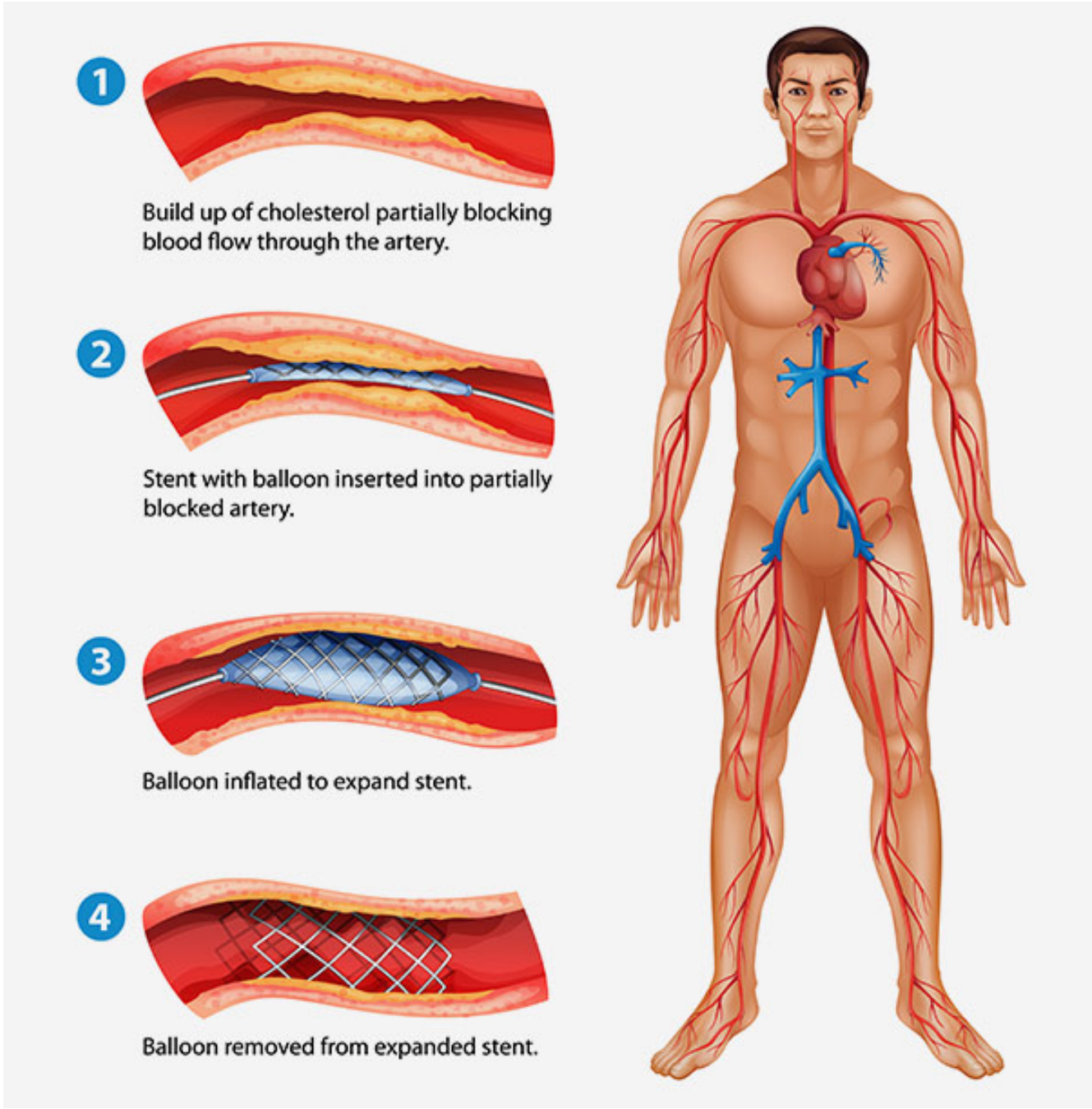
Specialties

- There are about 60 specialties in Brazil
- Doctors complete more than one specialty
  - On average, 2-3
- Some specialties are pre-requirement for others

Percuntaneous Coronary Intervention (PCI)

- Nonsurgical technique to restore the blood flow through the blocked arteries.
  - catheter with a tiny balloon and stent to widen the diseased artery
  - the most recommended procedure for patients with severe clinical conditions
    - e.g., heart attacks (≈50% of all cases)
  - length of stay is ≈ 5 days, depending on the case

Percutaneous Coronary Intervention (PCI)



PCI teams

The team consists of one proceduralist and one or more physicians:

- **Proceduralist:** a PCI-operator who executes the procedure.
- **Physicians:** provide pre/post-procedure hospital visits

Communication before/after procedure:

- before procedure $\Longrightarrow$ decision about timing and strategy
  - require inputs from physicians
- after procedure $\Longrightarrow$ managment of complications

Assigment of Physicians to Teams

- Assigment rule 1: availability
  - limited sorting
    - doctor schedules set well in advance
- Assigment rule 2: need
  - Example: heart attack patients with a history of cancer $\Longrightarrow$ oncologist
  - We observe the specialty that motivated the assigned of each physician to cases—focal specialty

Data and Identification

New Dataset on Health Care

Monthly data on doctor background:

- Universe of health professionals (with unique identifiers)
- All specialties are observed
- hospital affiliations

Hospital data on patients:

- dates of admissions and discharges
- All medical procedures
- Identity of all health professionals (with unique identifiers)
- Background information (age, gender, race, etc)
- 30-day mortality

Period: 2009-2020

Measuring Expertise Overlap

Expertise overlap between proceduralist j and physician k treating patient i:

$$z_{ijk} = \frac{\#\text{overlapping specialties}}{\#\text{specialties}} \tag{1}$$

Example:
Proceduralist: cardiology, and oncology
Physician: cardiology, and general surgery

Specialties: 3 (cardiology, oncology, general surgery)
Overlapping specialties: 1 (cardiology)

$z_{ijk} = \frac{1}{3} = 0.33$

Measuring Expertise Overlap

when multiple physicians:

$$\text{Expertise overlap}_{ij} \equiv Z_{ij} = \sum_{k \in \mathcal{K}(i)} \underbrace{\left(\frac{q_k}{\sum_{k \in \mathcal{K}(i)} q_k} \right)}_{\substack{\text{share of visits} \\ \text{by physician } k}} \times \underbrace{z_{jk}}_{\substack{\text{proceduralist-physician } (j,k) \\ \text{expertise overlap}}} \tag{2}$$

It is a weighted mean, where the number of hospital visits by physicians is used as weights

Identification

Overview - I

Within-proceduralist approach —proceduralist-time fixed effects:

- Patients treated by the same proceduralist but by different physicians
- Sample limited to emergency health conditions
- Conditioning on focal specialty fixed effects

Identification

Overview - II

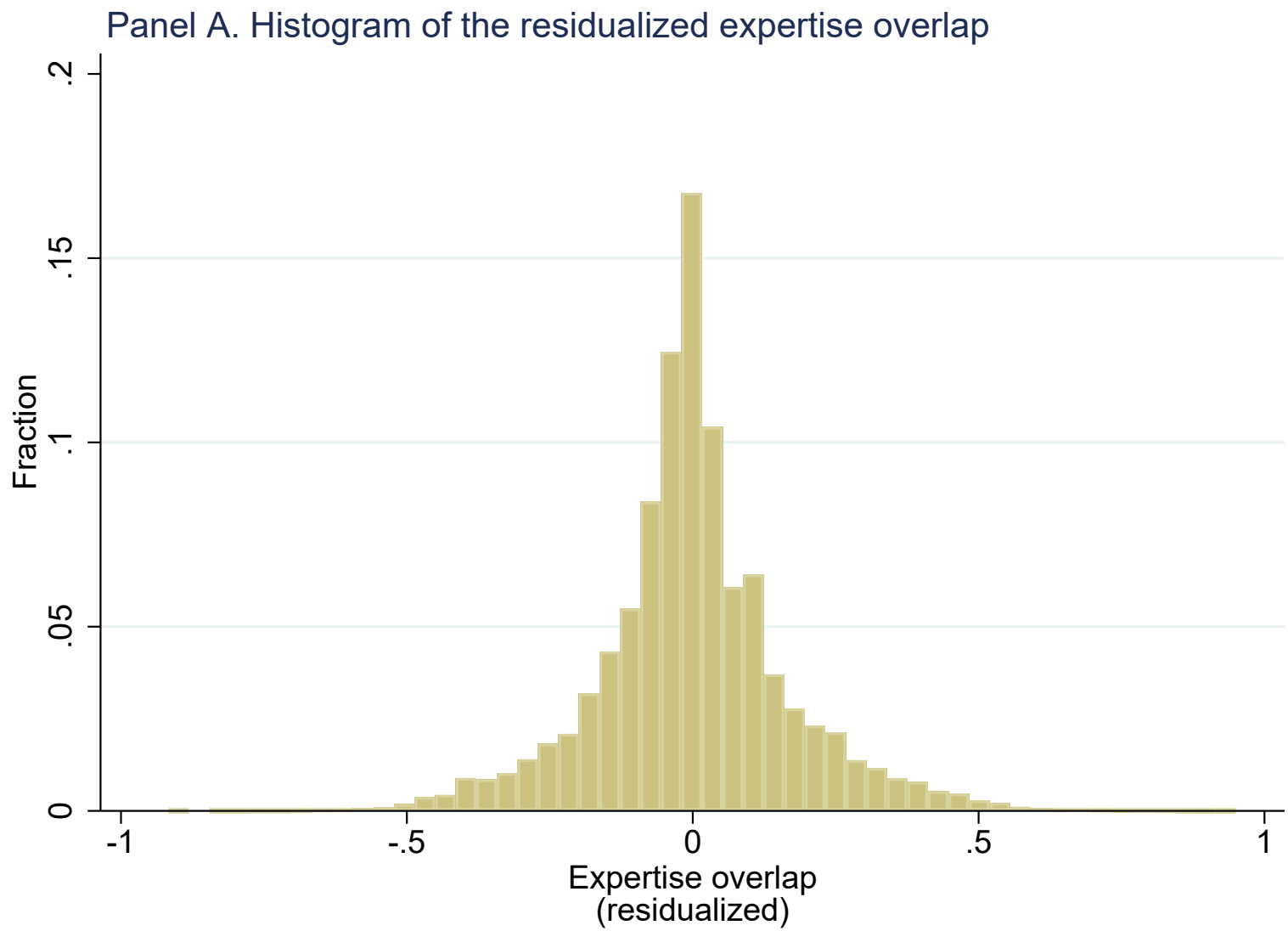
Variation caused by institutional features:

- Residency programs: limited supply
- Multiple paths to specialize in a given area. Example:
  - Pediatrics $\Longrightarrow$ intensive care medicine; or
  - general surgery $\Longrightarrow$ intensive care medicine; or
  - Anesthesiology $\Longrightarrow$ intensive care medicine; or
  - Among others $\Longrightarrow$ intensive care medicine; or
- Pre-requisites can differ across institutions (and regions)
  - Some institutions could have zero pre-requirements for some specialties

What does this mean?

- Idiosyncratic variation in expertise overlap
  - Identical individulas could follow different paths for a same specialty

Identifying Variation



Estimating Equation

$$Y_{ijt} = \alpha + \beta \,\text{Expertise overlap}_{ijt} + \overbrace{\vec{X}'_{ijt}\Psi}^{\substack{\textbf{physician,}\\ \textbf{and patient}\\ \textbf{characteristics}}} + \underbrace{\vec{\mathscr{S}}'_{ijt}}_{\substack{\textbf{focal}\\ \textbf{specialty FE}}} + \underbrace{\xi_{jt}}_{\substack{\textbf{proced.-year}\\ \textbf{FE}}} + \eta_{ijt} \tag{3}$$

i indexes patient, j proceduralist, and t year

parameter of interest is β

OBS: standard errors clustered by hospital

Identifying Assumptions

Condition 1. (Independence)

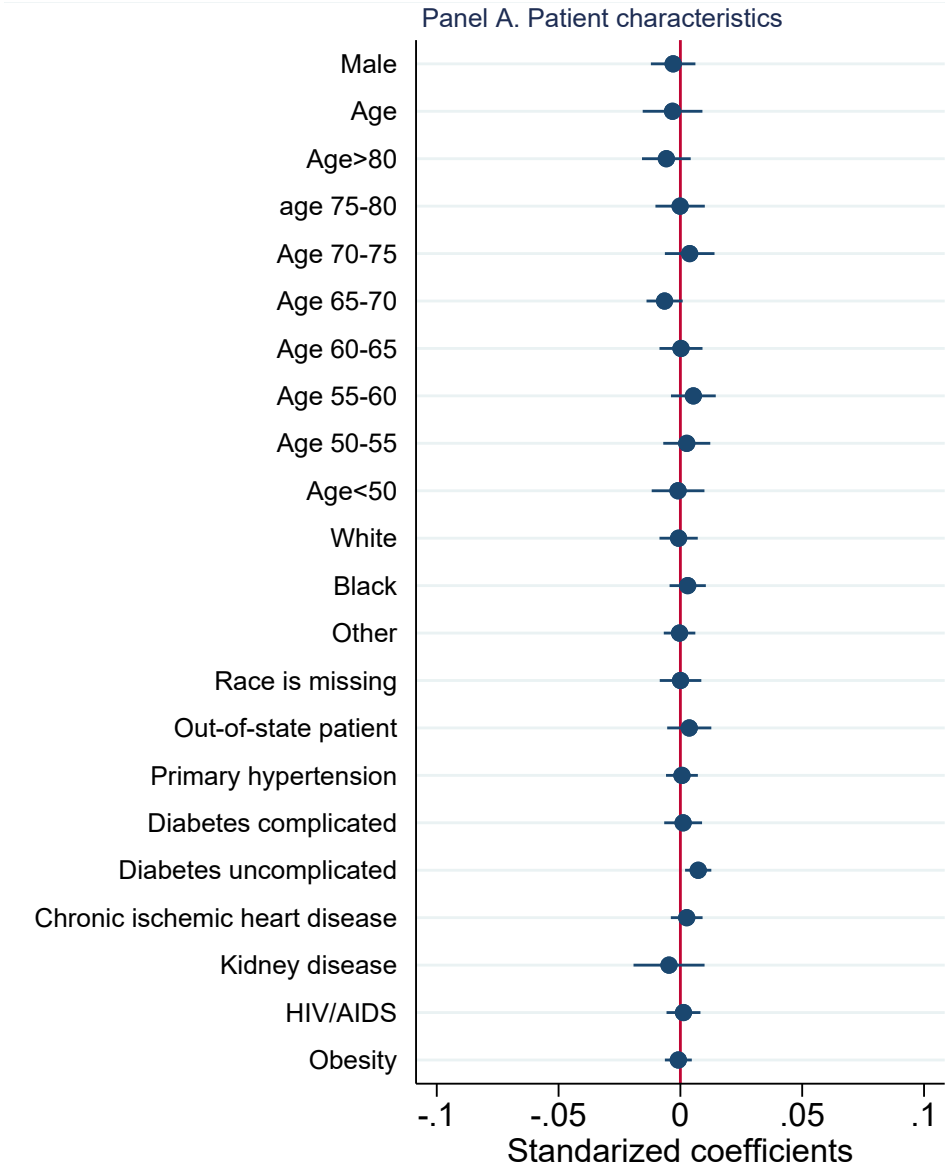
Conditional on proceduralist-time and focal specialty fixed effects, patient potential outcomes are independent of the expertise overlap

Condition 2. (Exclusion)

Conditional on proceduralist-time and focal specialty fixed effects, unobserved doctor characteristics are independent of the expertise overlap

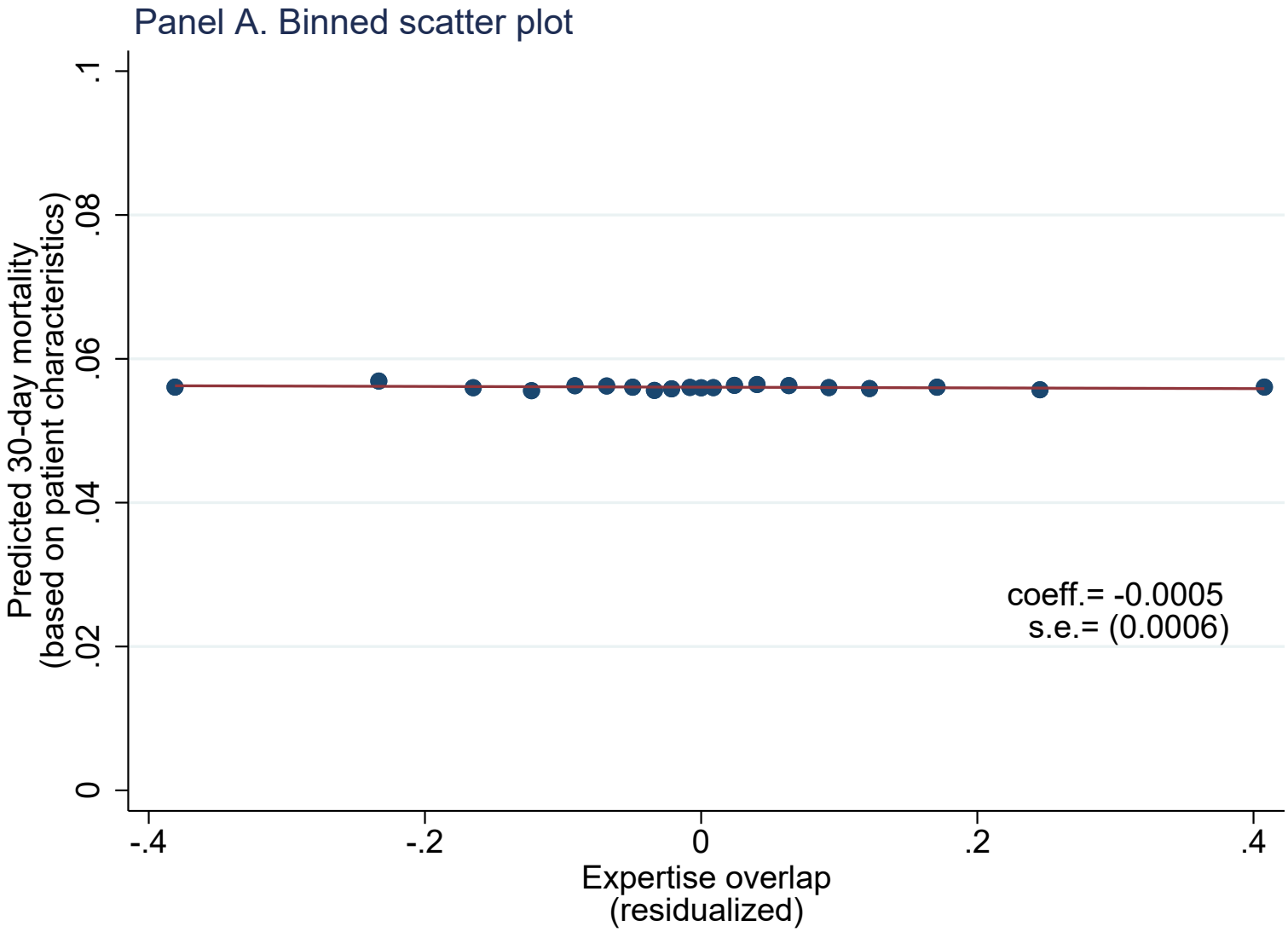
Condition 1. Covariate Balance

(patient characteristics)



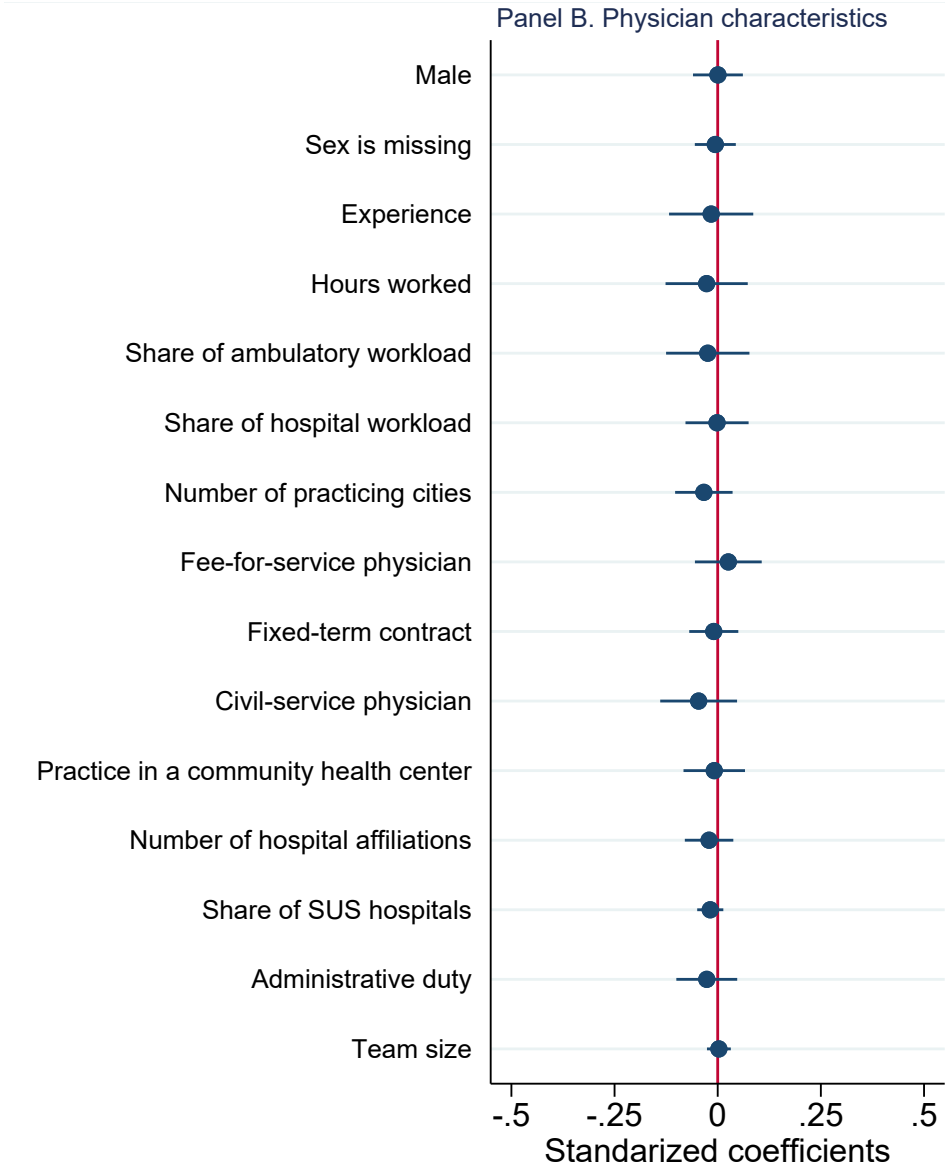
Condition 1. Predicted Mortality

(based on patient characteristics)



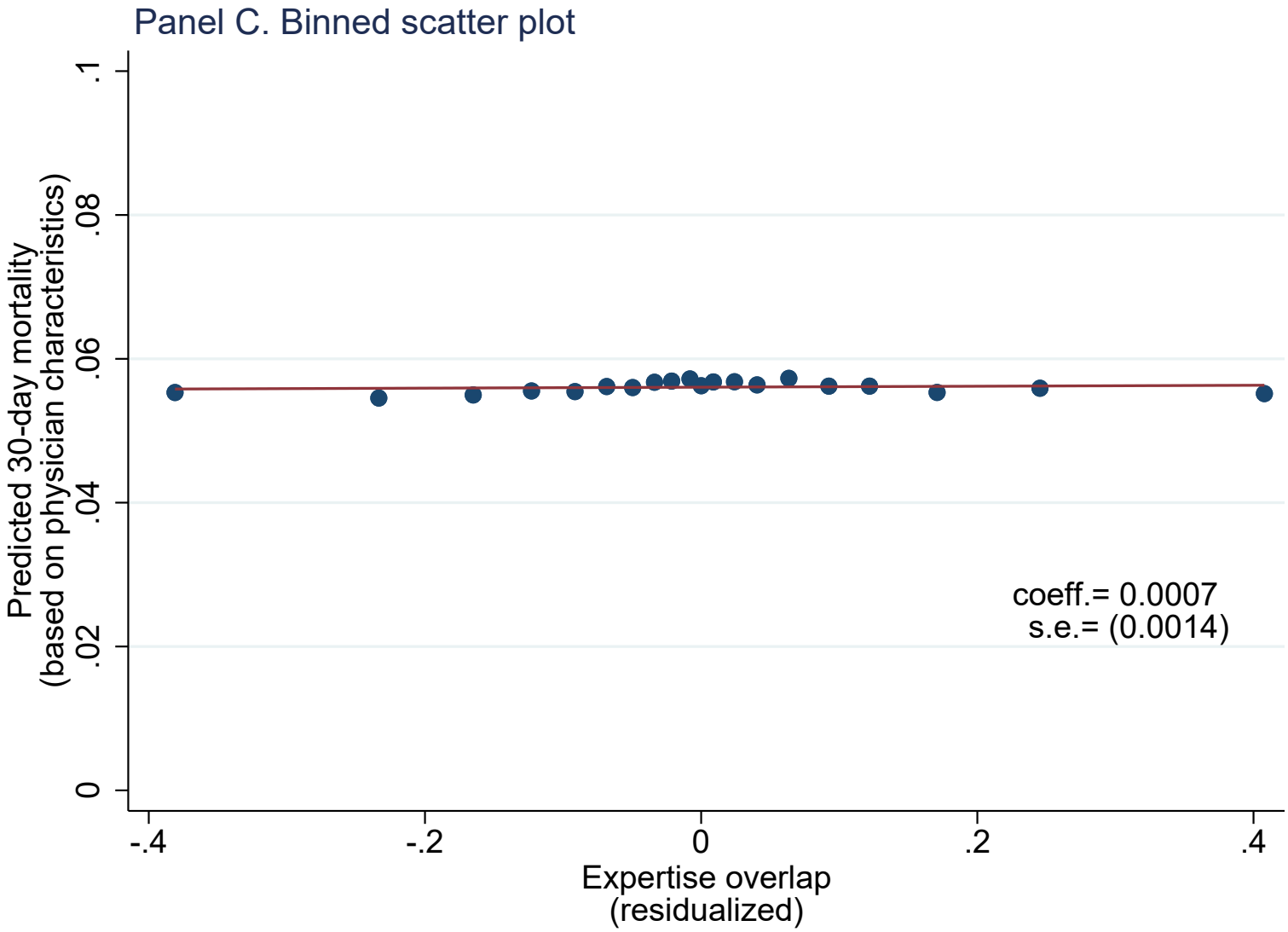
Condition 2. Covariate Balance

(physician characteristics)



Condition 2. Predicted Mortality

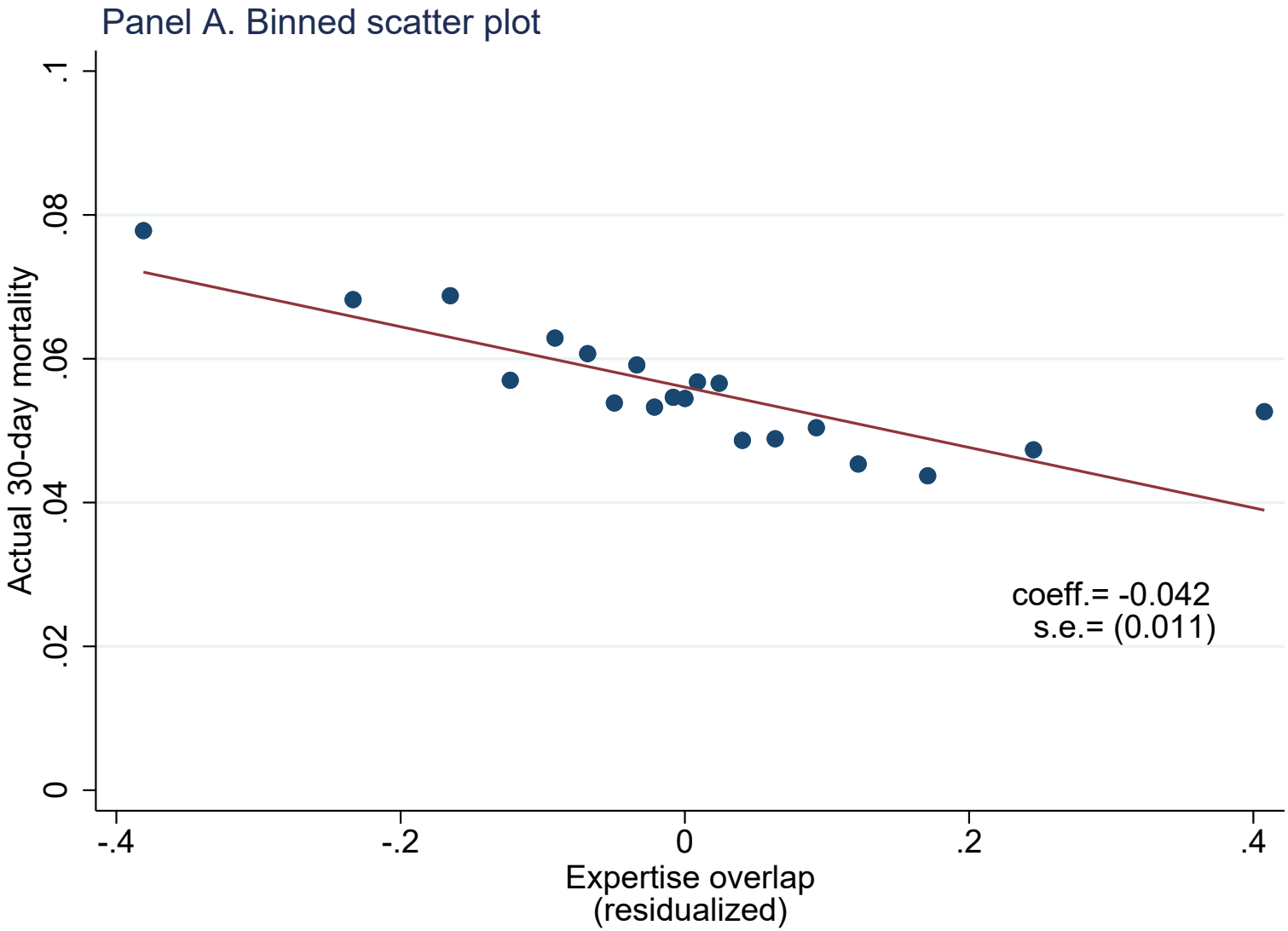
(based on physician characteristics)



Results

Main Finding

actual 30-day mortality



Effects on Mortality

	Dependent variable is 30-day mortality				
	(1)	(2)	(3)	(4)	(5)
Expertise overlap	-0.0419	-0.041	-0.0415	-0.0425	-0.041
	[0.0107]***	[0.0107]***	[0.0107]***	[0.0107]***	[0.0106]***
Mean of dep. variable	0.056	0.056	0.056	0.056	0.056
Observations	176108	176108	176108	176108	176108
Proceduralist × year FE	✓	✓	✓	✓	✓
Focal specialty FE	✓	✓	✓	✓	✓
Hospital × time FE		✓			✓
Patient characteristics			✓		✓
Physician characteristics				✓	✓

Notes: standard errors clustered at the hospital level.
* $p < 0.1$;** $p < 0.05$;*** $p < 0.01$.

10 p.p increase in expertise overlap $\implies$ 0.41 p.p (or $\approx 7.3\%$) $\Downarrow$ in mortality

Major Concerns

Two obvious concerns:

- Similarity in other individual characteristics
- Correlation with number of specialties

Concern 1: Similarity in other characteristics

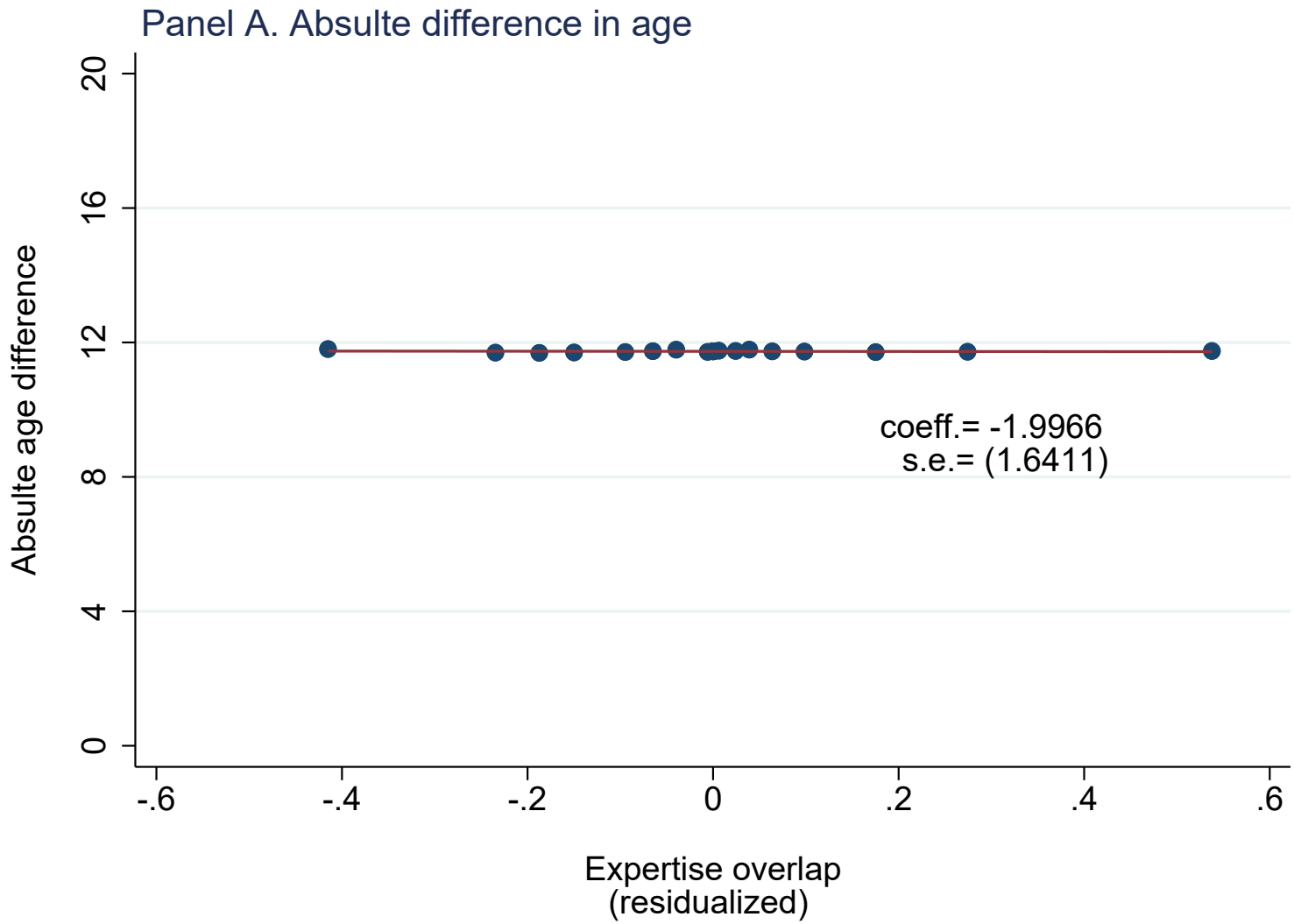
Specialty overlap could be correlated with similarities in other characteristics between proceduralists and physicians:

- doctors of the same gender or of adjacent birth cohorts could be more likely to choose the same specialties
- doctors with the same specialties could come from the same training institution
- teammates with the same gender or similar ages or from the same training institution may be able to work together more efficiently

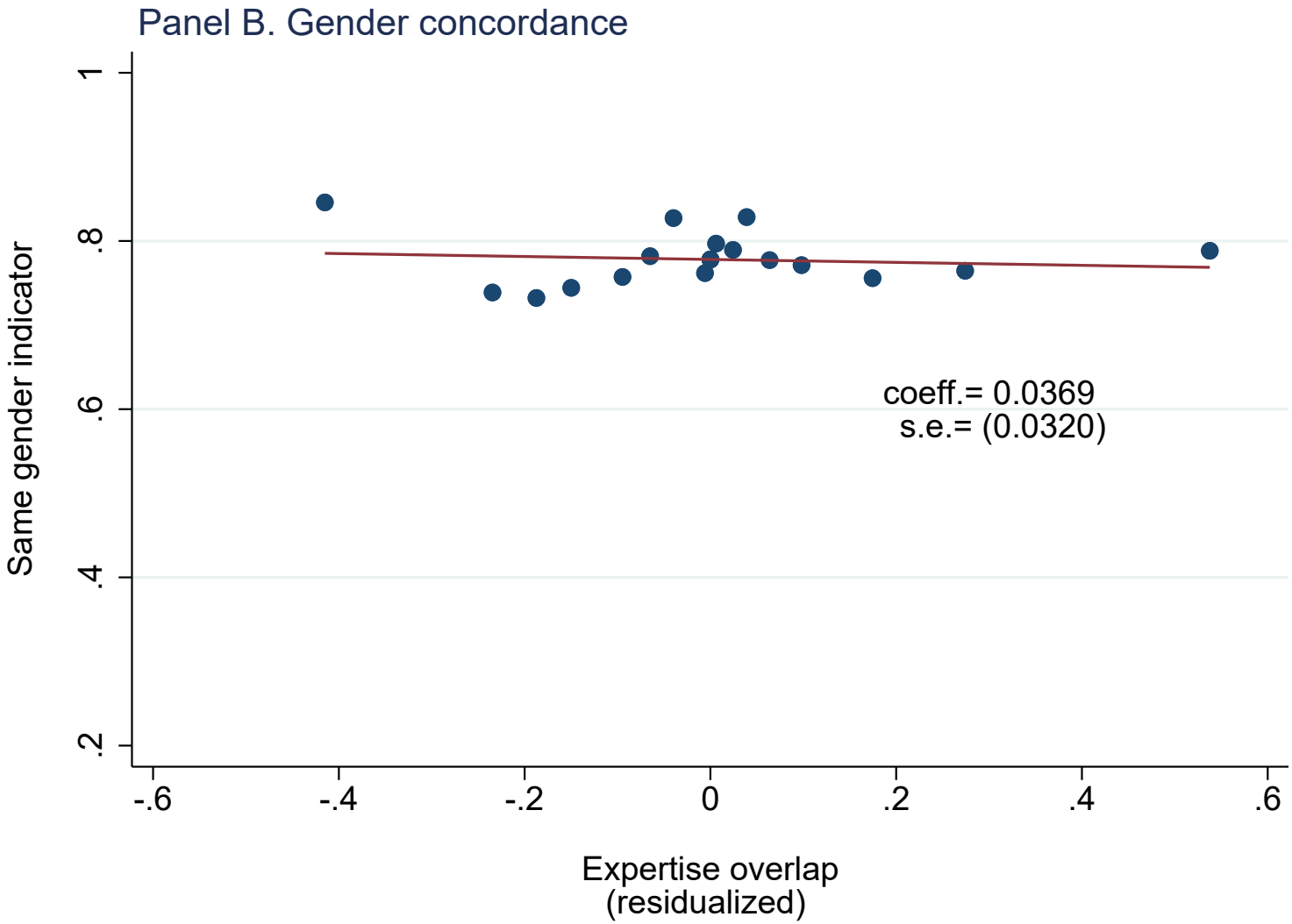
Institutional characteristics make these stories less likely:

- multiple paths to specialize; hard to get in residency programs; variation in pre-required specialties across training institutions
- individuals with identical preferences may end up with different specialties

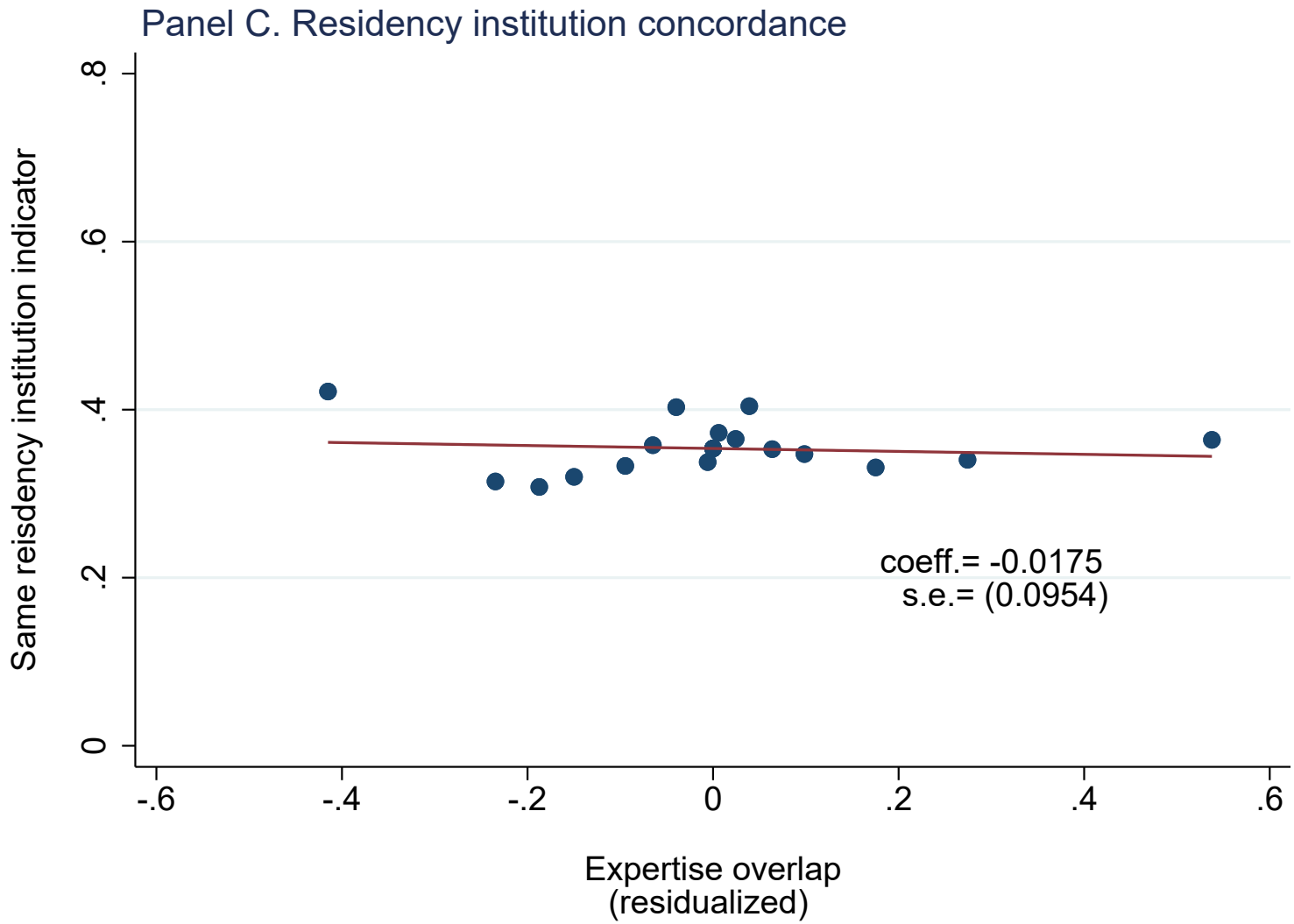
No correlation between expertise overlap and ...



No correlation between expertise overlap and ...



No correlation between expertise overlap and ...



Concern 2: Expertise overlap or more specialties?

Expertise overlap and number of specialties are correlated by construction

Number of specialties could have an independent effect on patient outcomes

- More cardiologists in the team could actually be good for patients with heart issues

In practice, correlation is weak, negative, and only marginally significant

- correlation coefficient= -0.12

Results robust to controlling for number of specialties

	Dependent variable is 30-day mortality			
	(1)	(2)	(3)	(4)
Expertise overlap	-0.041	-0.0414	-0.0421	-0.0392
	[0.0106]***	[0.0106]***	[0.0108]***	[0.0109]***
Mean of dep. variable	0.056	0.056	0.056	0.056
Observations	176108	176108	176108	176108
Number of specialties		✓	✓	✓
Number of cardiovascular-related specialties			✓	✓
Basic controls	✓	✓	✓	✓

Notes. Standard errors are clustered at the hospital level.
* $p < 0.1$;** $p < 0.05$;*** $p < 0.01$.

Other concerns

Selection into procedure

- What if patients select into procedure depending on teams?
  - No evidence that is is the case

Case severity

- What if case severity $\Longrightarrow$ team composition?
  - Control for diagnosis FE

Expertise overlap or shared work experience?

- what if repeated team experience $\Longrightarrow$ team composition?
  - No evidence and control for team-specific experience

Physician Availability Design

Intent-to-Treat Framework

Idea. Simulate team composition based on the physicians available at patient arrival

- Simulted overlap as instrument for actual overlap

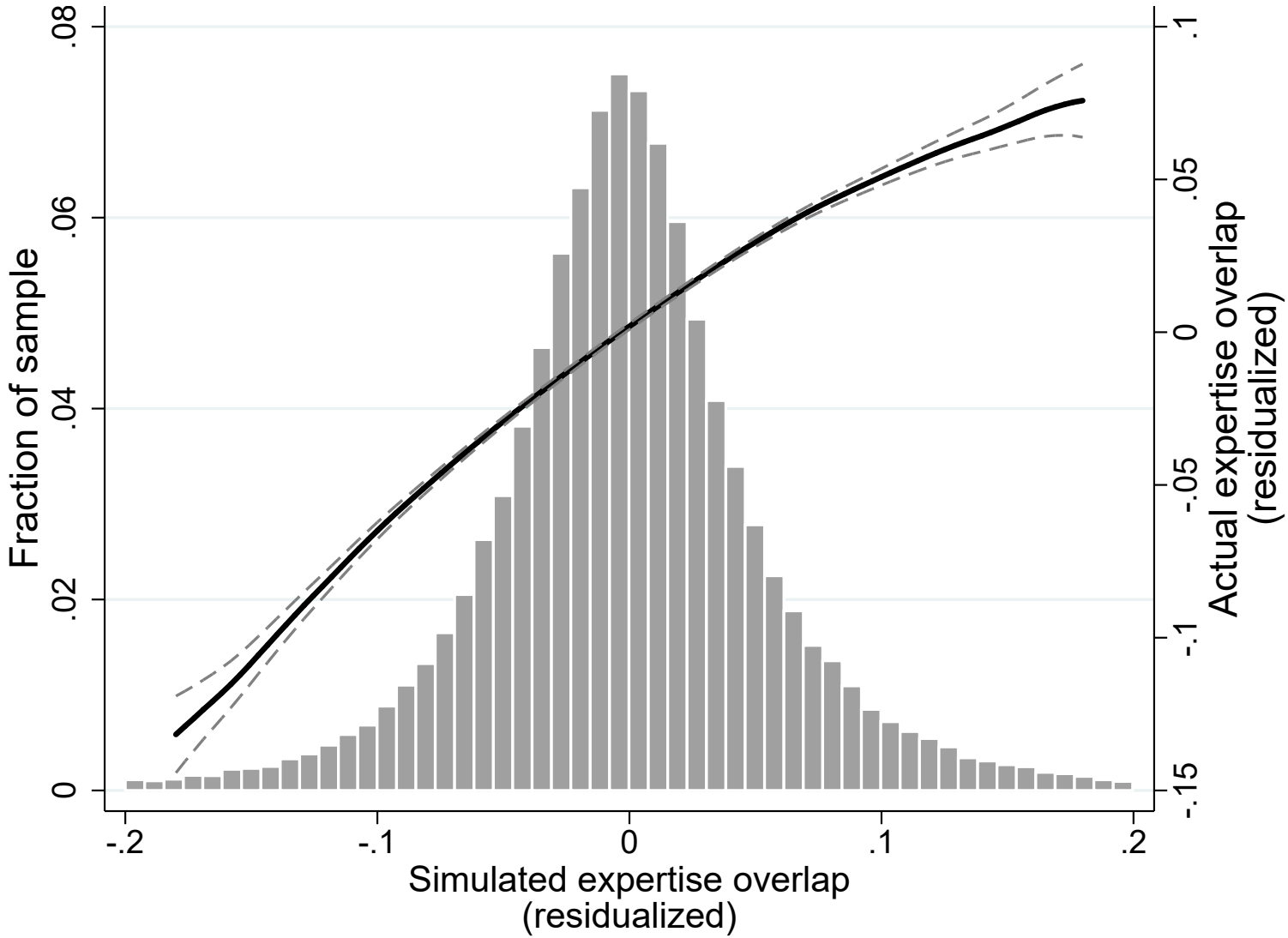
Available physicians: Based on whether they provided any care on that date.

Simulated overlap:

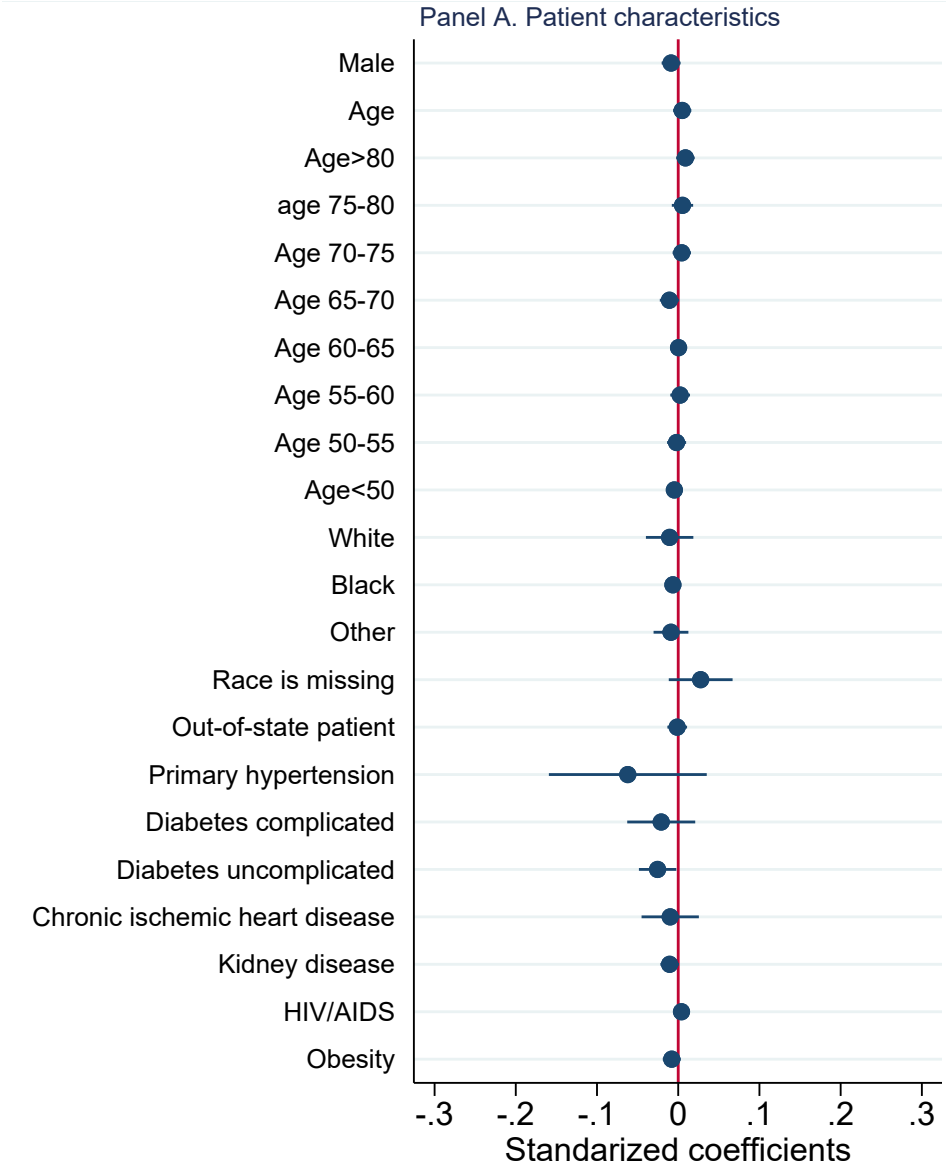
$$= \sum_{k \in \mathcal{K}(d)} w_{kd} \times z_{jkd} \quad \text{with} \quad w_{kd} = \frac{h_{kd}}{\sum_{k \in \mathcal{K}(d)} h_{kd}} \tag{4}$$

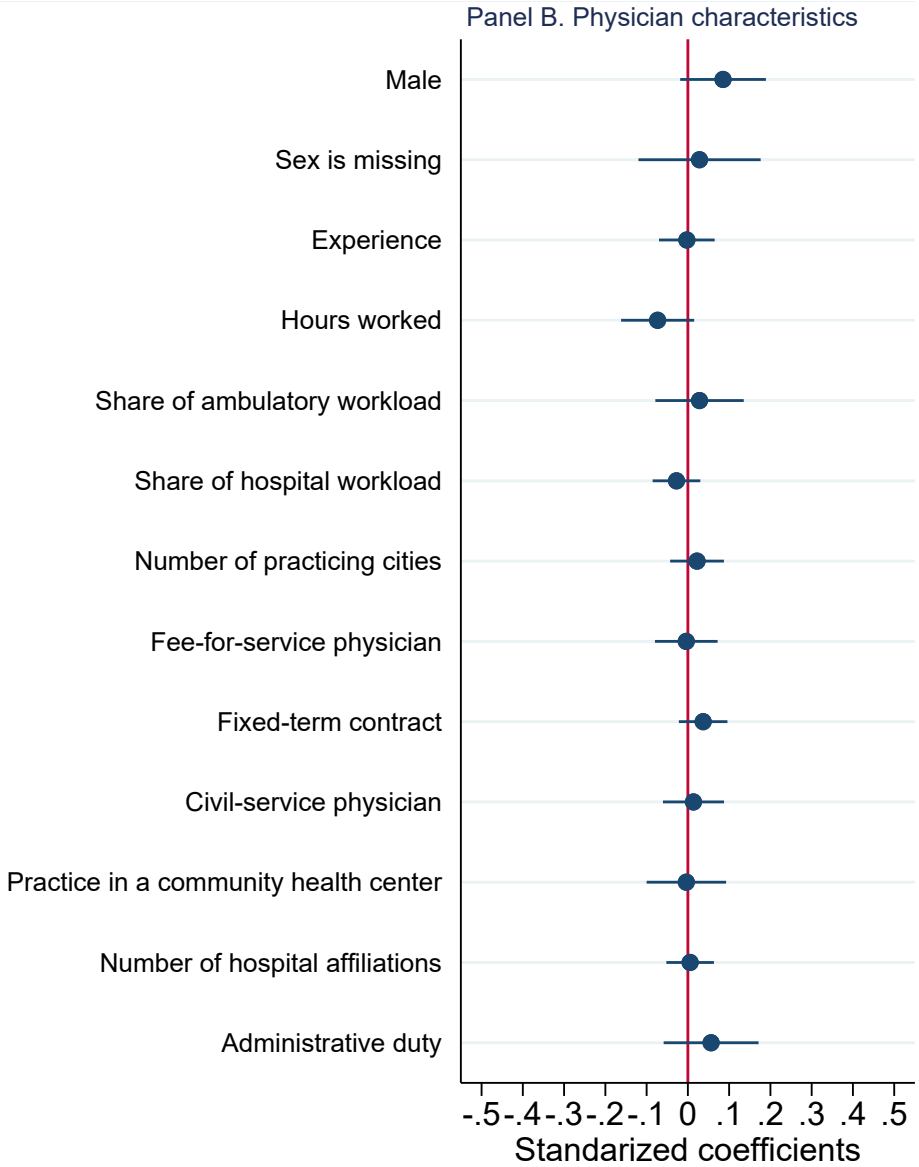
where h is the number of hours worked per week.

First Stage


Fraction of sample
0
.02
.04
.06
.08
Actual expertise overlap (residualized)
-.15
-.1
-.05
0
.05
.1
-.2
-.1
0
.1
.2
Simulated expertise overlap (residualized)

Covariate Balance





Results

	Dependent variable is:		
	Expertise overlap	30-day mortality	
	(First Stage)	(Reduced-Form)	(2SLS)
	(1)	(2)	(3)
Expertise overlap			-0.0447
			[0.0199]**
Simulated expertise overlap	0.5399	-0.0241	
	[0.0588]***	[0.0113]**	
kleibergen2006generalized F statistics			84.1518
Mean of dep. variable	0.4288	0.056	0.056
Observations	175349	175349	175349
Patient characteristics	✓	✓	✓
Physician characteristics	✓	✓	✓
Hospital × month FE	✓	✓	✓
Hospital × day-of-week FE	✓	✓	✓
Date-of-admission FE	✓	✓	✓
Proceduralist FE	✓	✓	✓

Notes. Standard errors are clustered at the hospital level.
* p < 0.1;** p < 0.05;*** p < 0.01.

Mechanisms

Two classes of mechanisms:

- Increased effort
  - more motiviated when working with similar "co-workers"
  - costs of engaging in moral hazard are higher
- Improved team coordination
  - better communication
  - doctors familiar with each other practice's style

No Evidence of Increased Effort

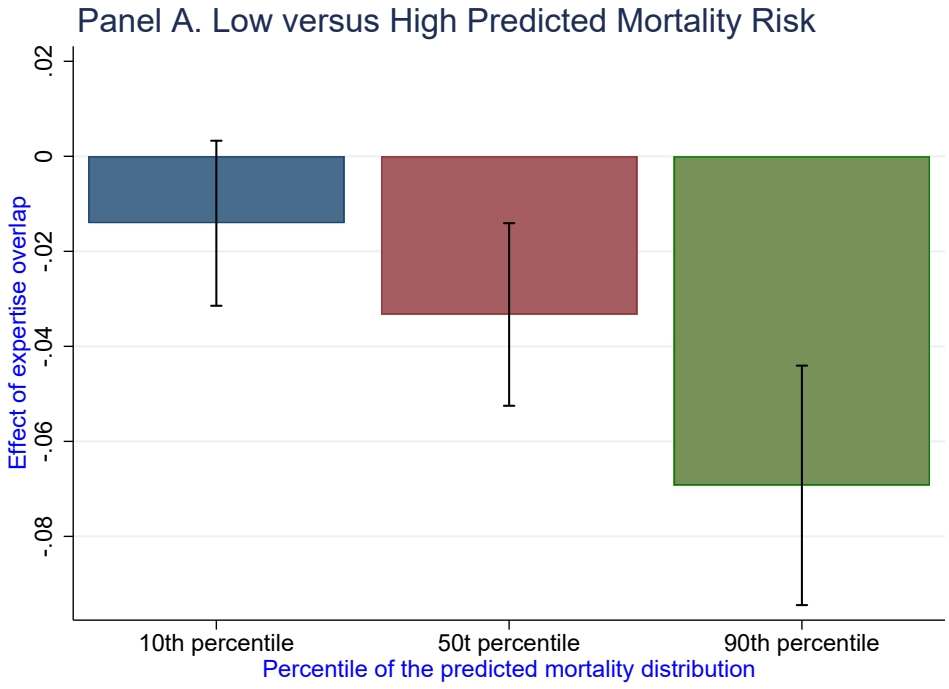
	Dependent variable is							
		Number of exam tests						
	length of stay	biochemical tests exams	hematology tests exams	laboratory tests exams	radiology exams	electro-cardiogramas	Medical input index	Hospital spending (in R$)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Expertise overlap	-0.5847	-5.4217	-1.2111	-0.5671	-0.5422	-0.3499	-0.1341	-651.8722
	[0.2551]**	[1.3773]***	[0.3720]***	[0.1732]***	[0.1729]***	[0.1594]**	[0.0367]***	[258.9633]**
Mean of dep. variable	5.7428	18.8877	5.0055	1.5795	1.1702	2.5858	1.40e-09	10619.0879
Observations	176108	176108	176108	176108	176108	176108	176108	176108
Proceduralist × year FE	✓	✓	✓	✓	✓	✓	✓	✓
Focal specialty FE	✓	✓	✓	✓	✓	✓	✓	✓
Hospital times time FE	✓	✓	✓	✓	✓	✓	✓	✓
Patient characteristics	✓	✓	✓	✓	✓	✓	✓	✓
Physician characteristics	✓	✓	✓	✓	✓	✓	✓	✓

Notes. Standard errors are clustered at the hospital level.
* $p < 0.1$;** $p < 0.05$;*** $p < 0.01$.

Teams with shared expertise become more productive

- Consistent with improved team coordination

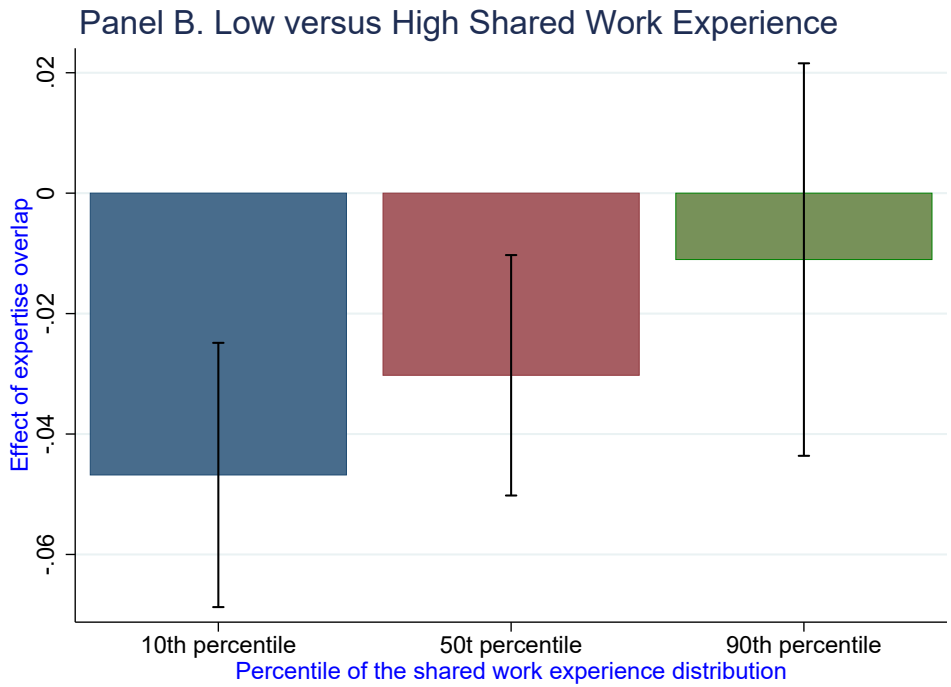
Case Complexity and Expertise Overlap



more complex cases require better coordination

- higher returns to expertise overlap

Previous Team Experience and Expertise Overlap



less shared experience, higher returns to learning each other style

- higher returns to expertise overlap

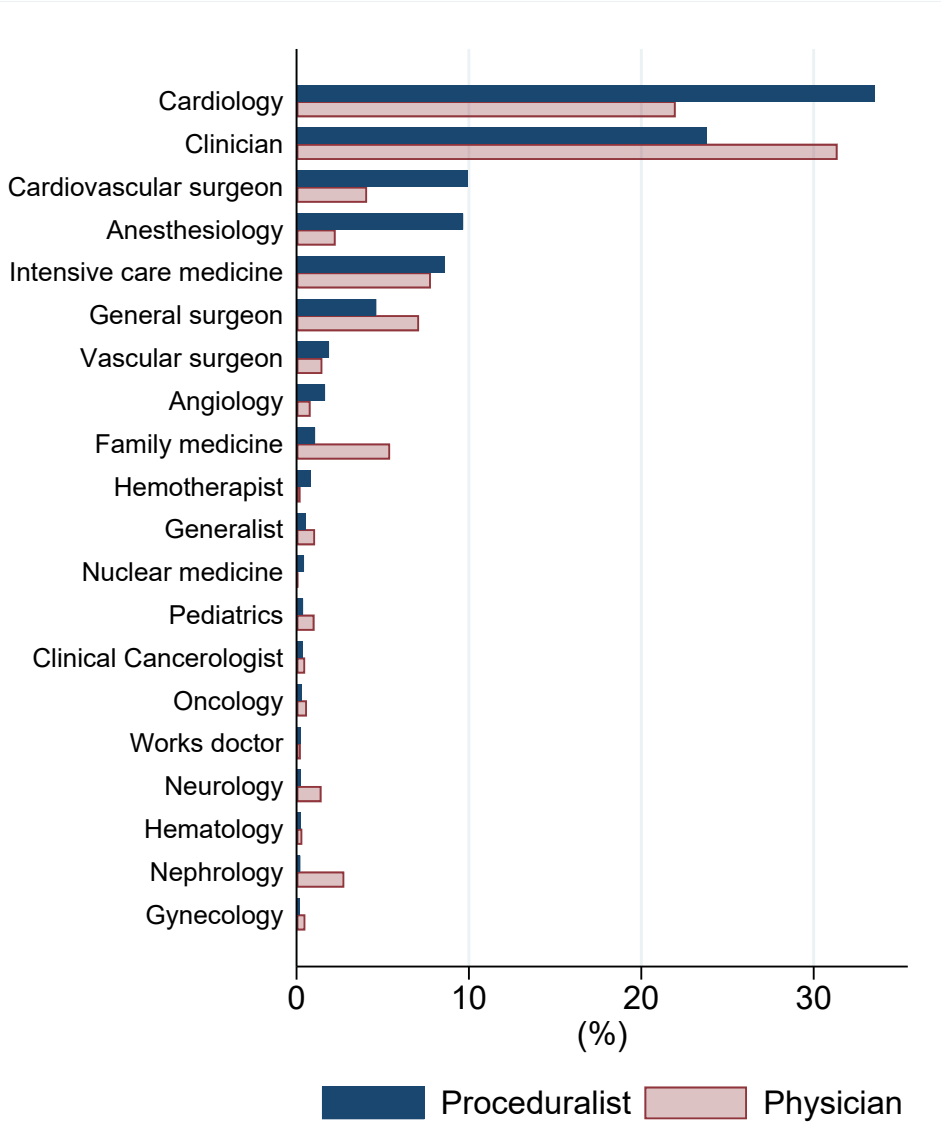
Next step

Considering other medical procedures.

- Other heart procedures:
  - Pacemaker implantation
  - Coronary Artery Bypass Graft Surgery
- Non-heart procedures:
  - Treatments for intracerebral hemoerragies
  - Emergency surgeries

Thank You!

Top 20 specialties



Potential Expertise Overlap and PCI probability

	Dependent variable is PCI treatment			
	(1)	(2)	(3)	(4)
Simulated expertise overlap	0.0338	0.0587	0.0304	0.0302
	[0.0986]	[0.0969]	[0.0386]	[0.0385]
Mean of dep. variable	0.4507	0.4507	0.4507	0.4507
Observations	1847482	1847482	1847463	1847463
Day-of-admission FE		✓	✓	✓
Hospital × (day-of-week, month, and year) FE			✓	✓
Patient characteristics				✓

Notes. Standard errors are clustered at the hospital level. * $p < 0.1$;** $p < 0.05$;*** $p < 0.01$.

Actual Expertise Overlap and Predicted PCI Probability

	Dependent variable is predicted PCI treatment				
	(1)	(2)	(3)	(4)	(5)
Expertise overlap	-0.000185	0.000005	-0.0002	-1.3E-05	0.000028
	[0.000587]	[0.000598]	[0.000140]	[0.000607]	[0.000081]
Mean of dep. variable	0.4529	0.4530	0.4529	0.4529	0.4530
Observations	174934	173893	174934	174934	173893
Proceduralist × year FE	✓	✓	✓	✓	✓
Physician's case-related specialty FE	✓	✓	✓	✓	✓
Hospital × time FE		✓			✓
Patient characteristics			✓		✓
Physician characteristics				✓	✓

Notes. Standard errors are clustered at the hospital level.
* $p < 0.1$;** $p < 0.05$;*** $p < 0.01$.

Accounting for Selection into PCI

	Dependent variable is 30-day mortality						
		Control for predicted PCI treatment				Control for inverse	Sample limited to high PCI
	Baseline	Linearly	Quadraticly	Cubicly	Quarticly	Mills ratio	prob. patients
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Expertise overlap	-0.041	-0.0409	-0.0409	-0.0409	-0.0409	-0.0408	-0.0407
	[0.0106]***	[0.0106]***	[0.0106]***	[0.0106]***	[0.0106]***	[0.0106]***	[0.0258]
Mean of dep. variable	0.056	0.0555	0.0555	0.0555	0.0555	0.0555	0.0573
Observations	176108	174934	174934	174934	174934	174934	36103
Sample	All	Common diagnosis for PCI					
Basic controls	✓	✓	✓	✓	✓	✓	✓

Notes. Standard errors are clustered at the hospital level.
* $p < 0.1$;** $p < 0.05$;*** $p < 0.01$.

Controlling for Diagnosis Fixed Effects

	Dependent variable is 30-day mortality	
	Baseline	Controlling for patient primary diagnosis
	(1)	(2)
Expertise overlap	-0.041	-0.0384
	[0.0106]***	[0.0098]***
Mean of dep. variable	0.056	0.056
Observations	176108	176108
Primary diagnosis FE		✓
Basic controls	✓	✓

Notes. Standard errors are clustered at the hospital level.
* p < 0.1;** p < 0.05;*** p < 0.01.

Team-Specific Experience

	Dependent variable is:		
	Shared work experience (in days)	30-day mortality	
	(1)	(2)	(3)
Expertise overlap	8.8064	-0.041	-0.0364
	[6.3490]	[0.0106]***	[0.0097]***
Mean of dep. variable	51.44	0.056	0.0526
Observations	168238	176108	168238
Shared work experience			✓
Basic controls	✓	✓	✓

Notes.
* p < 0.1;** p < 0.05;*** p < 0.01.