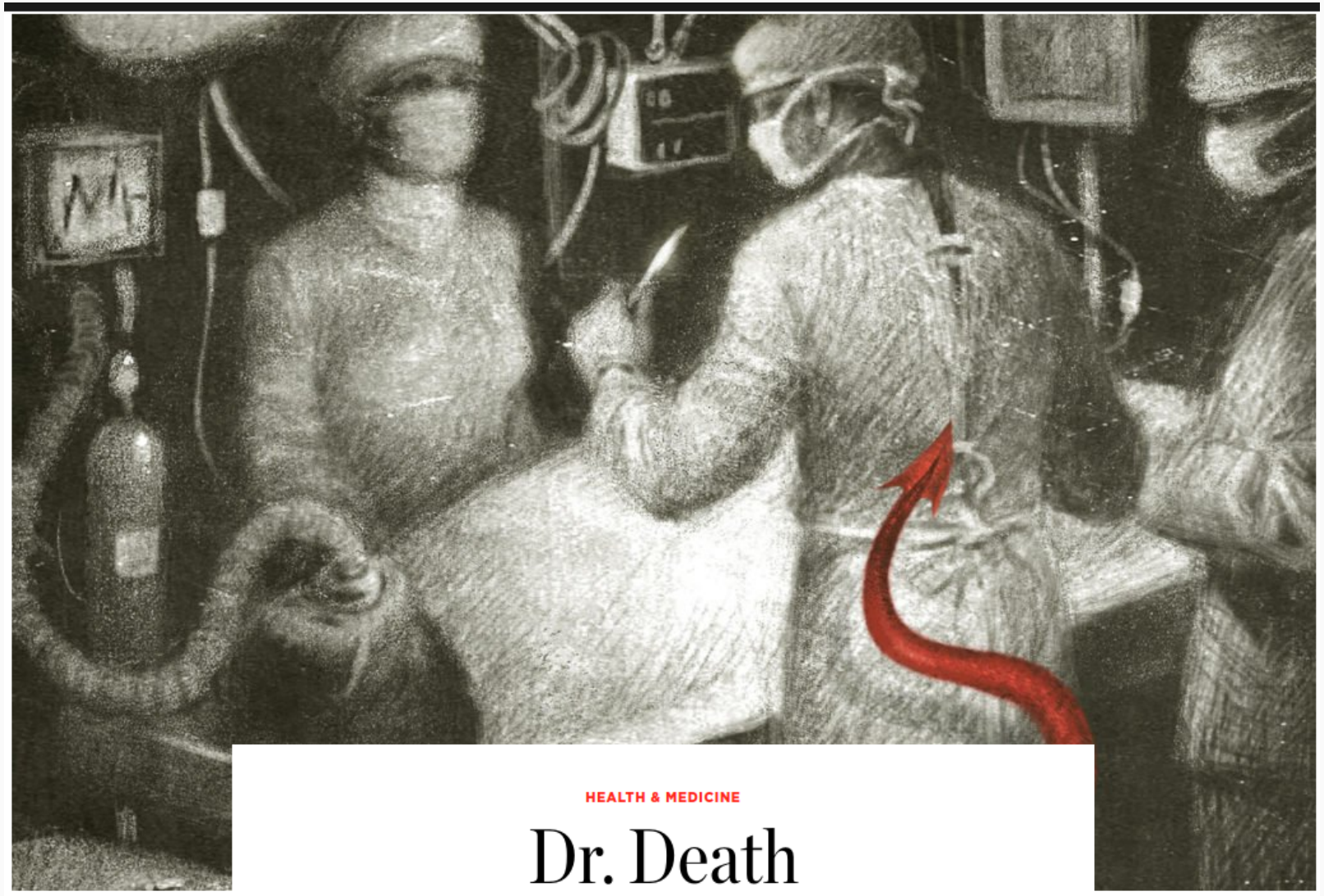
How efficient is the market for physician referrals?

...or Feeding Dr. Death

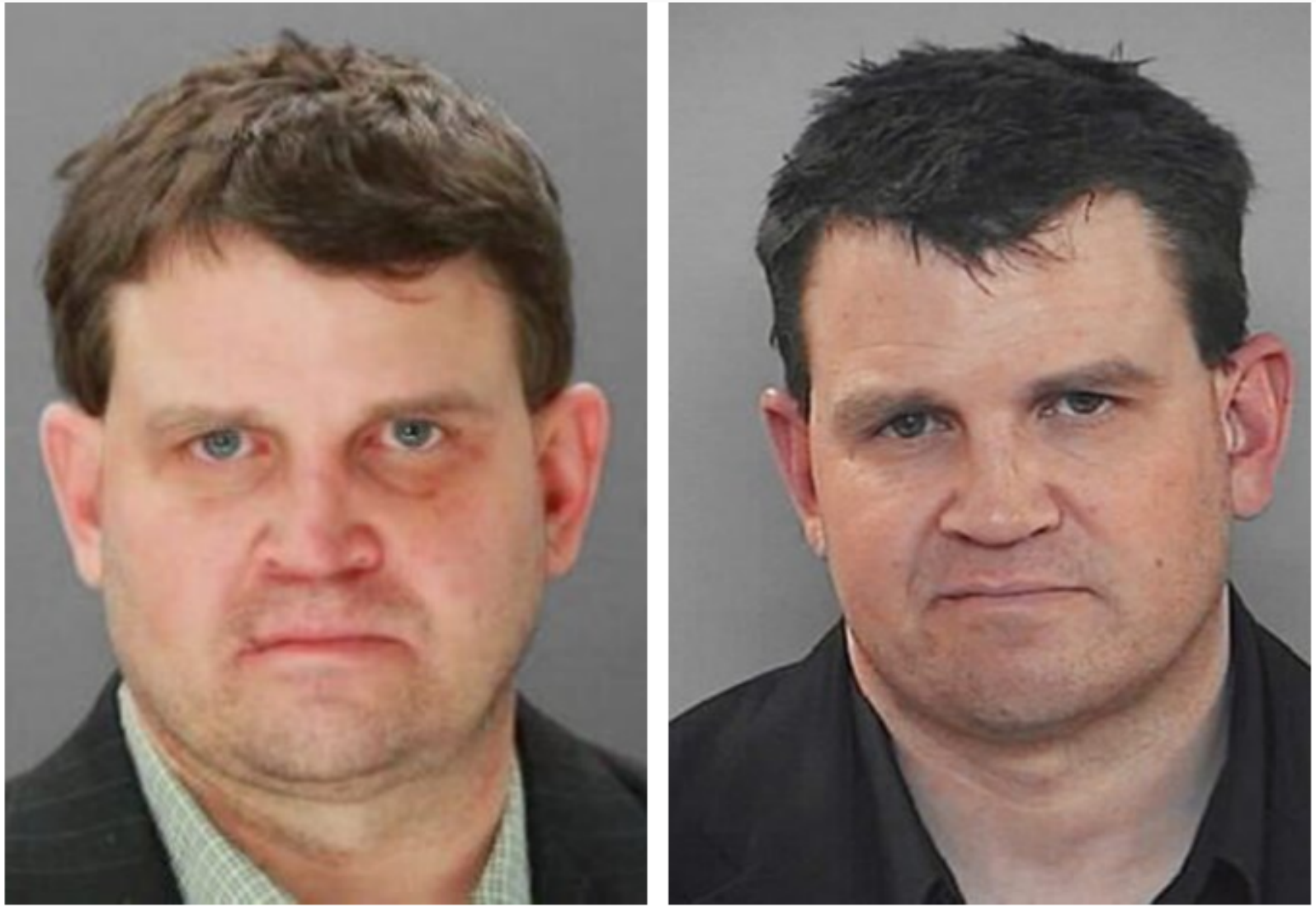
Ian McCarthy & Seth Richards-Shubik
Indiana University, February 17, 2022



HEALTH & MEDICINE

Dr. Death

Plano surgeon Christopher Duntsch left a trail of bodies. The shocking story of a madman with a scalpel.



Duntsch grew accustomed to having his mug shot taken, whether for assault, DWI, or shoplifting.

Baylor Plano, 2011, Lee Passmore

This would be the first and last time Hoyle worked next to Duntsch. Hoyle's job was to cut Passmore open and sew him up, and on December 30, 2011, he made a small incision just above the 36-year-old's groin and moved the blood vessels and organs out of the way, allowing Duntsch clear access to the lower spine to remove a herniated disc. The disc was pressing on a nerve, which caused the pain.

A Surgeon on the Loose: Duntsch made surgical mistakes that one doctor called "never events," meaning they shouldn't ever happen in a career.

But as Duntsch worked, Hoyle looked over and saw blood and not much else. It was pouring out of the epidural blood vessels and pooling in the disc space. But Duntsch kept going, as if he were fishing in a pond at night, saying he was working by feel, not sight. He announced that he would be removing the ligament that separates the disc from the spinal canal. This posterior longitudinal ligament is one of the spine's two major stabilizers. It's less than a millimeter from the spinal canal. Hoyle stepped in front of Duntsch to block his way.

Baylor Plano, 2012, Barry Morguloff

Morguloff's surgery, a spinal fusion, didn't go well. Dr. Randall Kirby, a prominent Dallas surgeon who assisted Duntsch in the surgery, compared Duntsch's technique to that of a first-year medical student. Duntsch, he later wrote, didn't seem to have any understanding of spinal anatomy. Morguloff says he woke up with agonizing pain in his left leg; Duntsch prescribed him painkillers and told him the pain would go away. Six months later, a doctor at Presbyterian Hospital of Dallas found that Duntsch had installed the spinal hardware wrong and left bone fragments in the nerves of Morguloff's back, requiring another round of surgery to remove them.

Baylor Plano, 2012, Jerry Summers

Morgan was present in the operating room during Passmore's surgery. She says she didn't hear or see any altercation between Duntsch and Mark Hoyle —her view was blocked by a microscope, and the combined hum of the EKG machine and the oxygen cylinder drowned out the sound of Hoyle's pleading, if there was any. She was also present for Summers' operation. But she wasn't in the room when he woke up a quadriplegic, telling anyone with ears that Duntsch had been using cocaine the night before the procedure. Summers had come in for an elective spinal fusion to relieve the pain he'd carried for years after a car accident. According to Texas Medical Board records, Summers' vertebral artery was damaged, and he lost more than two liters of blood while intubated. When his patient woke up in the recovery room unable to move his extremities, Duntsch failed to perform a CAT scan or MRI.

Baylor Plano, 2012, Kellie Martin

After Summers' procedure, Morgan says Duntsch "was not allowed to operate" at Baylor Plano until March 2012. Martin was his first patient back, and it was the last operation he performed at that hospital. Multiple lawsuits allege that Baylor did not report Duntsch to the National Practitioner Data Bank, which was created by Congress to be a private clearinghouse of

Dallas Medical Center, 2012, Floella Brown

He performed his first operation at Dallas Medical Center on July 24, 2012; the hospital issued temporary privileges while it verified his credentials. During this time, out of three procedures, one patient died and another was partially paralyzed. Like Summers, Floella Brown's vertebral artery was damaged, causing massive bleeding. Unlike Summers, Brown, 63, suffered from hypertension and was a stroke risk. She suffered a "massive posterior circulation stroke" and was transferred to UT Southwestern Medical Center. She arrived brain-dead. "No autopsy was done (at the family's request) but it is well-documented that the stroke was due to a left vertebral artery injury due to Dr. Duntsch's horrendous surgical technique," wrote surgeon Randall Kirby in a letter to the Texas Medical Board. Kirby reported having "direct knowledge" of seven patients that "Dr. Duntsch has maimed or killed." Hoyle, the surgeon who exposed the incision in Passmore, had also filed a complaint with the board. "I agree completely with Dr. Hoyle's complaint to the board when he stated that Dr. Duntsch is the most careless, clueless, and dangerous spine surgeon either of us has ever seen," Kirby wrote.

Dallas Medical Center, 2012, Mary Efurd

Duntsch had another surgery scheduled the day that Brown suffered her stroke. It was a revision of a patient whom he originally operated on at Baylor Plano. Mary Efurd, 74, was to have two vertebrae fused, linked by a metal plate. She woke up with severe pain and couldn't stand. Henderson was brought in to operate two days later. He was shocked at the CT scan: the spinal fusion hardware sat in her soft tissue. The nerve root had been amputated. There were multiple screw holes nowhere near where they were supposed to be, and a screw had been lodged in another nerve root near the bottom of the spine. At that point, the administration revoked his privileges. Duntsch says he was so distraught by Brown's outcome that he placed a screw in Efurd 3 millimeters away from where it should've been, damaging a nerve root. But that's all.

South Hampton Medical, 2012, Jeff Cheney

surgery. Brown died four months later. Another indictment says he penetrated Jeff Cheney's spinal cord with a screw and used a peek cage that was the wrong size. On yet another indictment, Duntsch allegedly cut Jeff Glidewell's esophagus and vertebral artery, leaving a sponge inside his body after sewing him up.

Legacy Surgery Center at Frisco, 2012, Marshall Muse

"This pain was just like someone had a jack hammer with a knife on the end and they were just holding it into my spine," Muse said.

Duntsch assured him it was normal and that he was overreacting and prescribed so much pain medication that the pharmacist refused to fill the order a second time because "the doctor is going to kill the patient," Muse said.

Muse spiraled into addiction, losing his job and splitting from his wife in the process.

"This whole thing changed my life in so many ways," he said.

Another doctor would later determine Duntsch had never installed the necessary hardware to the spine and instead had left it floating between the spine and muscle tissue.

Legacy Surgery Center at Frisco, 2012, Jacqueline Troy

By December, Duntsch wrangled privileges at Legacy Surgery Center of Frisco, and Kirby, in his letter to the Texas Medical Board, narrated another grim outcome: Jacqueline Troy's vocal cord was paralyzed, and her esophagus and trachea had become connected, "an unheard of complication." A corrective surgery happened two weeks later, after she arrived at the emergency room of Texas Health Presbyterian Dallas, where Kirby practiced.

Legacy Surgery Center at Frisco, 2013, Philip Mayfield

On April 9, 2013, Philip underwent surgery that left him in a very vulnerable position. Dr. Christopher Duntsch who is nicknamed by the media, "Dr. Death" is now serving a life sentence after performing surgeries that left at least 33 people maimed and two dead. Philip suffered a spinal cord injury, he was paralyzed from the neck down after the procedure. It is only by the grace of God he was able to walk. However, over the years he had multiple surgeries and procedures to help alleviate the severe pain he encountered.

University General at Dallas, 2013, Jeff Glidewell

"I wake up from surgery and I knew something was wrong. I couldn't feel my feet. I could not move my left arm, I couldn't talk. I was in more pain than I ever thought imaginable and my wife walked over and she was crying," he told "License to Kill."

Duntsch told Robin they had to abort the surgery because he had discovered a tumor, which he thought could be cancer.

Kirby was called in to try to fix the procedure, and after transferring Jeff to another hospital, determined that the incision was in the wrong place, Duntsch had put a "hole the size of a silver dollar" in his esophagus, taken out a nerve, cut an artery and then left a sponge inside the body.

"He was septic. He had a bad blood-borne infection. Puss was pouring out his neck along with saliva," Kirby said in the docuseries of Glidewell's condition. "Dr. Duntsch left the sponge in because if he pulled the sponge out, Mr. Glidewell would have exsanguinated, he'd bleed to death, but you know, that's not any long-term solution. That sponge has got to be removed. You've got to take care of whatever you injured."

The material Duntsch believed to be a tumor was really just muscle.

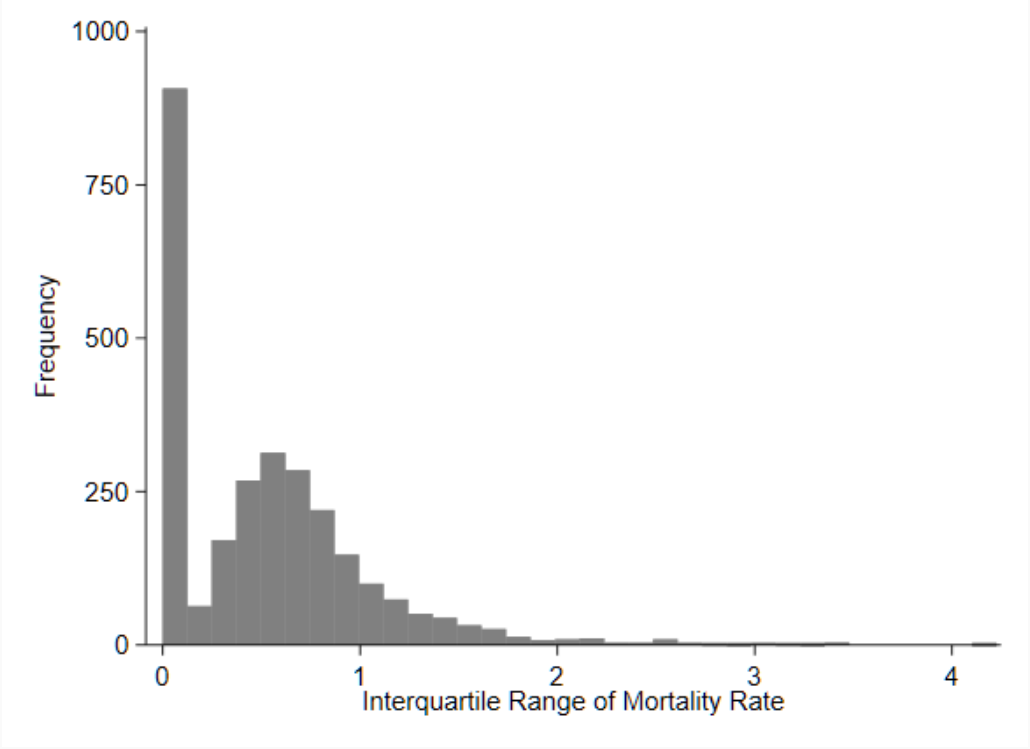
Question

- **Motivating question:** How did Dr. Death keep getting patients?
- **Research question:** Do PCPs learn about specialist quality and adjust referral patterns accordingly?

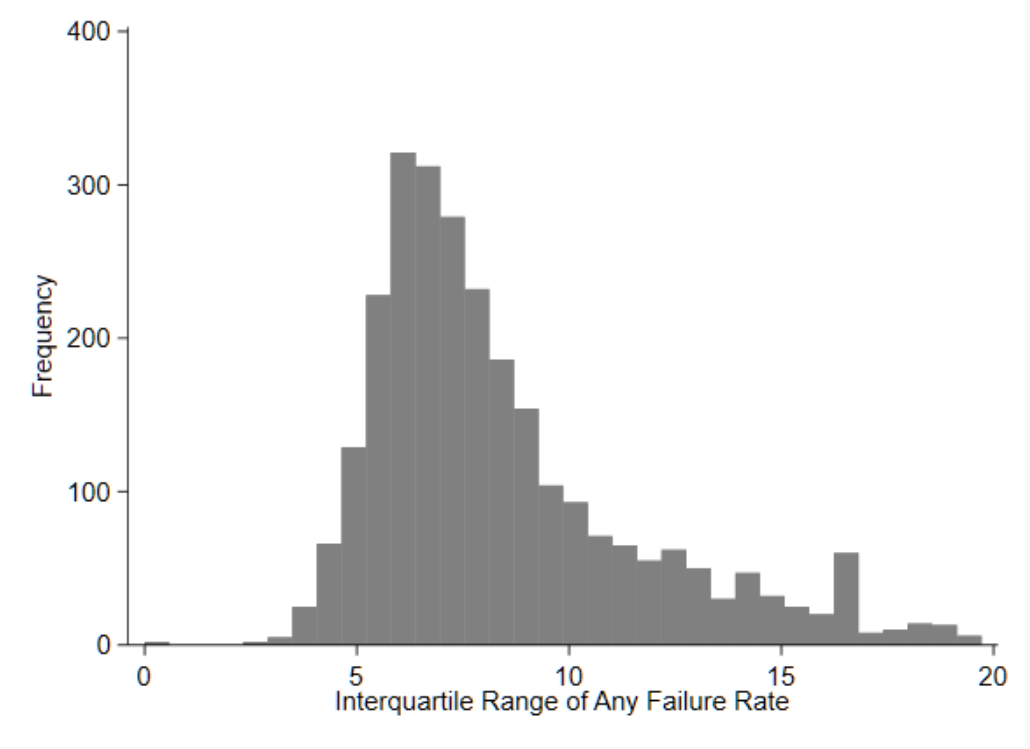
Contribution

1. Policy and "variation":
    - Significant focus on changing physician treatment decisions
    - We consider changing who does the procedure rather than how it's done
2. Referrals and learning:
    - Consider and estimate physician learning directly
    - Much more complete data

Policy and "variation"



Potential lives saved: 30 per year



Potential events saved: 550 per year

Referrals and learning

- Almost no work on physician learning in referrals
- **Johnson (2011) "Ability, Learning, and the Career Path of Cardiac Specialists."**
  - Frequency of exits or practice movements as function of negative outcomes
  - Low quality surgeons more likely to exit market or move practice
  - Data for specialists only, assumed to reflect learning after ruling out other mechanisms

Referrals and learning

- Almost no work on physician learning in referrals
- Johnson (2011) "Ability, Learning, and the Career Path of Cardiac Specialists."
- **Sarsons (2017), "Interpreting Signals in the Labor Market: Evidence from Medical Referrals"**
  - Considers learning framework as motivation
  - Estimates relationship between negative outcomes and quarterly referrals among PCP/specialist pairs
  - PCPs interpret negative outcomes differentially by gender

Learning Framework

Setup

- PCP i sends a patient to specialist j at time t, $D_{ijt} \in 0, 1$
- Outcome is binary $Y_{ijt} \in 0, 1$, with 1 being success (e.g., no complication or readmission)
- Probability of success for specialist j: $p_j \equiv \Pr(Y_{ijt} = 1)$, assumed constant over time and across patients

PCPs do not know p_j but use Bayesian inference to learn about it from their patients' outcomes

Beliefs

- Beliefs about p_j follow a beta distribution, with parameters:
  - (a_0, b_0) in the initial period (common prior beliefs)
  - (a_{ijt}, b_{ijt}) in period t
- Beliefs updated based on the numbers of successes and failures experienced with specialist j, as follows:

$$a_{ijt} = a_0 + \sum_{s=1}^{t} Y_{ijs}$$

$$b_{ijt} = b_0 + \sum_{s=1}^{t} (D_{ijs} - Y_{ijs})$$

Beliefs

Mean and variance of the beliefs about p_j in period t:

$$m_{ijt} \equiv \frac{a_{ij,t-1}}{a_{ij,t-1} + b_{ij,t-1}}$$

$$v_{ijt} \equiv \frac{a_{ij,t-1} b_{ij,t-1}}{(a_{ij,t-1} + b_{ij,t-1})^2 (a_{ij,t-1} + b_{ij,t-1} + 1)}$$

Patient Utility

- PCPs perfect agents of patients
- Patient (and PCP) utility: $U_{ijt} = \alpha Y_{ijt} + \epsilon_{ijt}$
- PCP chooses specialist with highest expected utility

$$\max_j \mathbf{E}\left[U_{ijt} | a_{ij,t-1}, b_{ij,t-1}\right] = \max_j \left\{\alpha \mathbf{E}\left[Y_{ijt} | a_{ij,t-1}, b_{ij,t-1}\right] + \epsilon_{ijt}\right\}$$

Data and Restrictions

Data Sources

- 100% Medicare claims data (Inpatient, Outpatient, Carrier Claims) from 2008 through 2018
- MD-PPAS (physician information)
- AHA Annual Surveys (hospital characteristics)
- American Community Survey (market level demographics)

Sample Construction

- Planned and elective inpatient stays
- Age 65 or above
- Major joint surgery
  - DRG 470 (major joint replacement, lower, w/o cc): 87%
  - DRG 483 (major joint replacement, upper, with cc): 5%
  - DRG 469 (major joint replacement, lower, with cc): 3%
  - DRG 462 (multiple joint procedures, lower, w/o cc): 2%

What is a referral?

- Assign a PCP to each surgery based on:

    1. Referring physician listed "in the data"
    2. Most frequently visited physician in last year
        - Tiebreaker to most recently visited

- Specialist is operating physician listed on the claim, limited to orthopedic surgeons

What is the referring "physician"?

- PCP is "primary care" as per MD-PPAS
- Limit to established or will-be-established practices
  - At least 3 consecutive years having non-zero referrals
  - At least 20 patients total across all years

What is a failure?

Any of the following:

- 90-day mortality
- 90-day readmission
- 90-day complication (SSI or sepsis)

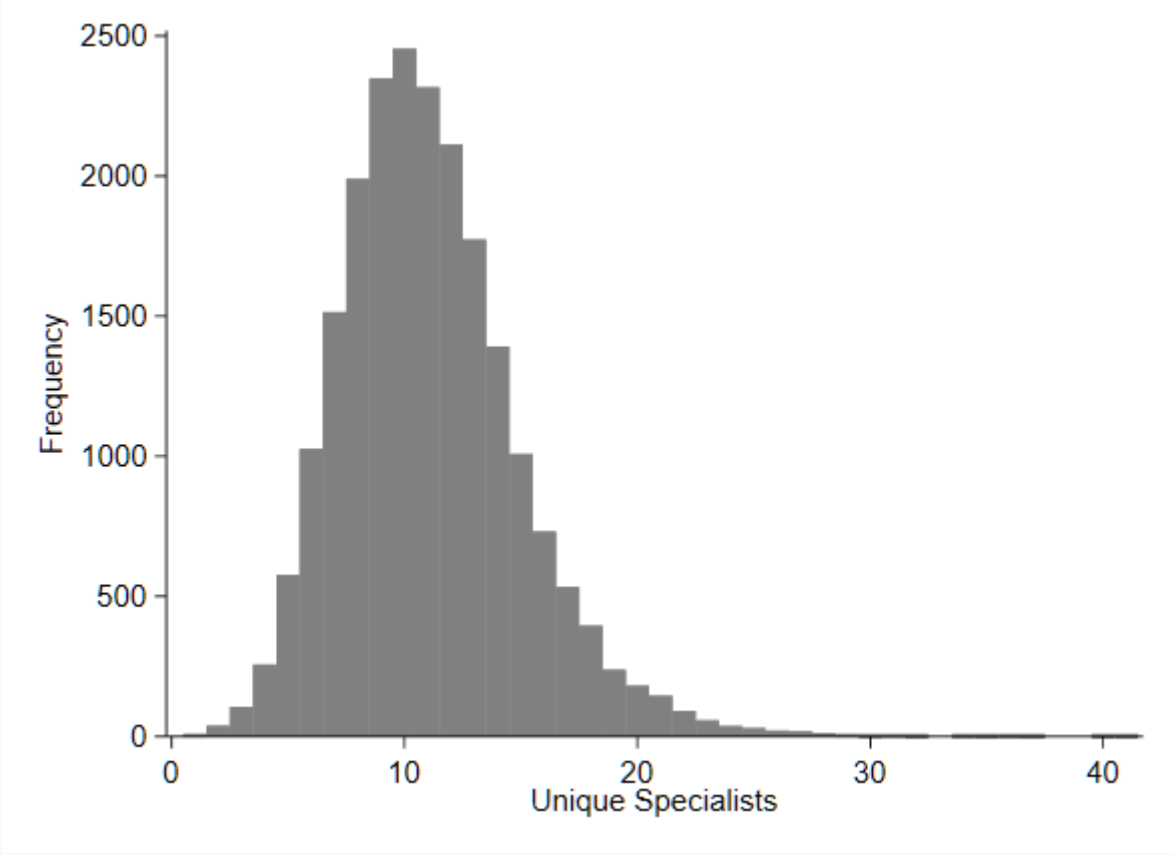
A note on information...

For now:

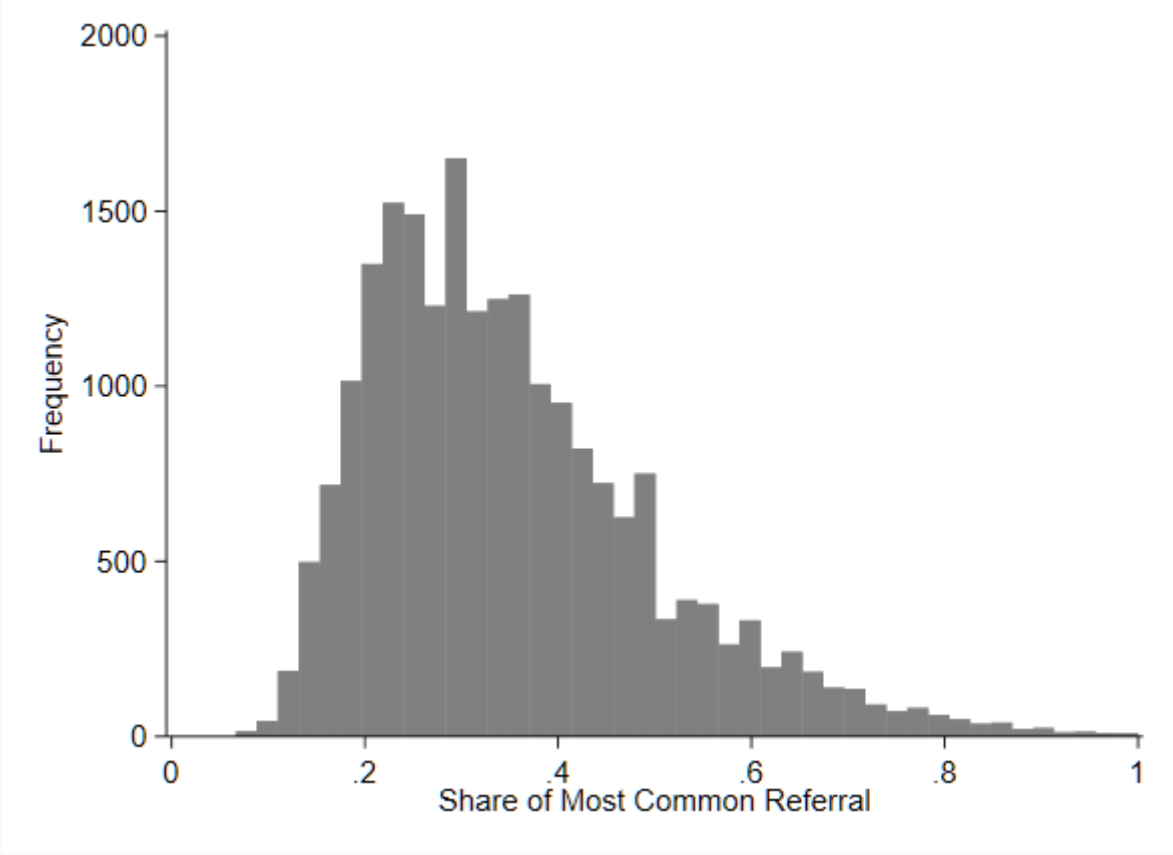
- Information flows to a single PCP
- PCP "sees" all failure events for their own patients and is unaware of failures from other patients
- Failures/successes only inform about quality of specialist j

Description of Referrals and Referral Networks

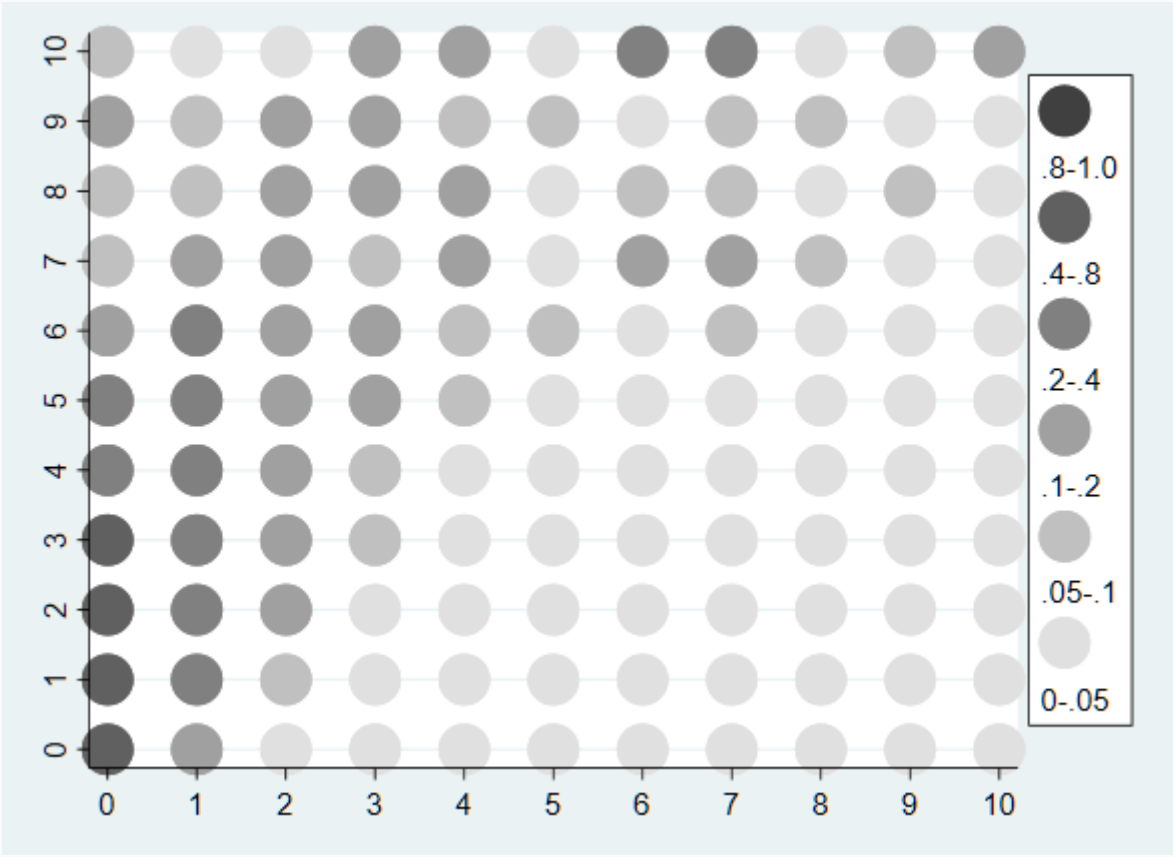
Size of Referral Networks



Attachment to Specialists



Pairwise referrals over time



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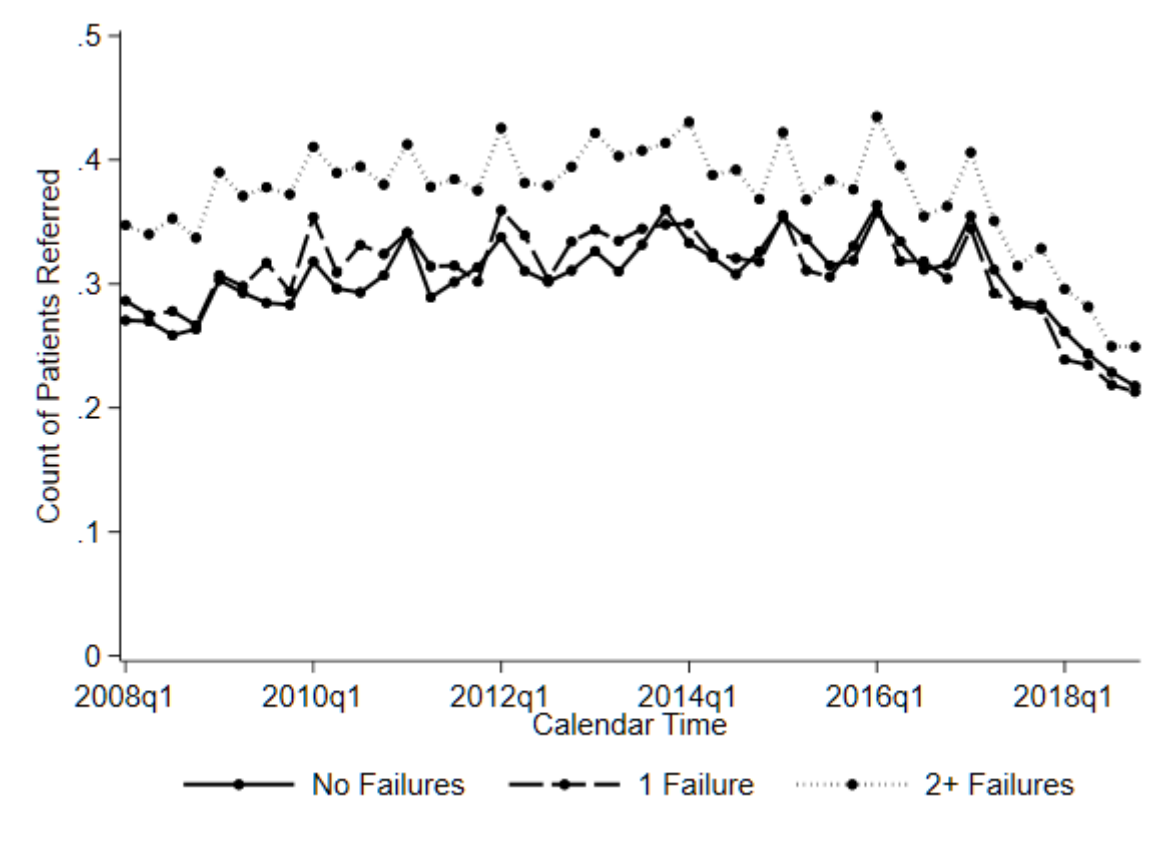
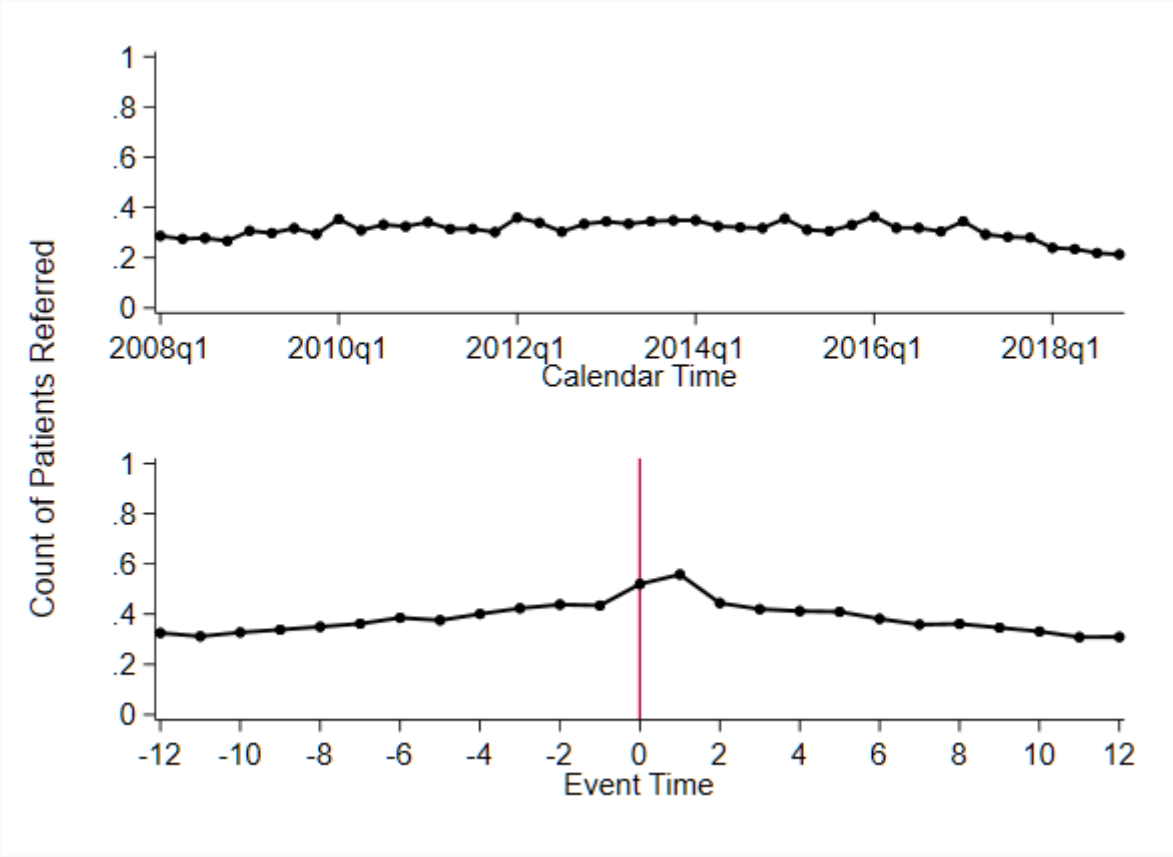


Referrals and failure events



Evidence of Response to Failures

Estimand of interest

- Want to identify the Average Treatment Effect on the Treated (ATT) of observed failures
- **Intuition:** Use unobserved failure events (from PCP) as counterfactual for pairs with observed failures

Estimand of interest

- Denote by $Pr[Y_{ij}^1]$ the probability of PCP i referring to specialist j after observing a failure (or sequence of failures) from specialist j, $F_{ij} > 0$
- Denote by $Pr[Y_{ij}^0]$ the probability of PCP i referring to specialist j without observing a failure from specialist j, $F_{ij} = 0$

$$ATT = Pr[Y_{ij}^1 | F_{ij} > 0] - Pr[Y_{ij}^0 | F_{ij} > 0]$$

Estimation

- Estimate panel multinomial logit model:
  - all pairs, including failures, $\hat{\theta}^1$
  - pairs without failures, $\hat{\theta}^0$
- Form (conditional) expected probability of referrals:

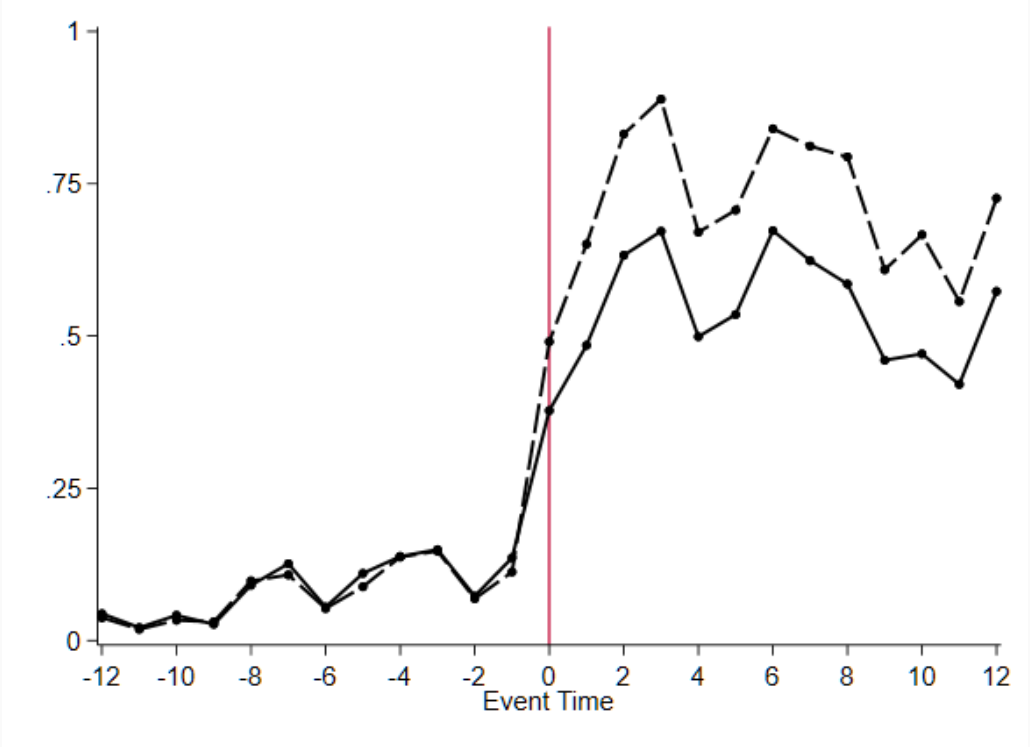
$$\widehat{Pr[Y_{ij}^1|X_{ij}]} = \Lambda(X_{ij}\hat{\theta}^1)$$
$$\widehat{Pr[Y_{ij}^0|\tilde{X}_{ij}]} = \Lambda(\tilde{X}_{ij}\hat{\theta}^0)$$

Estimation

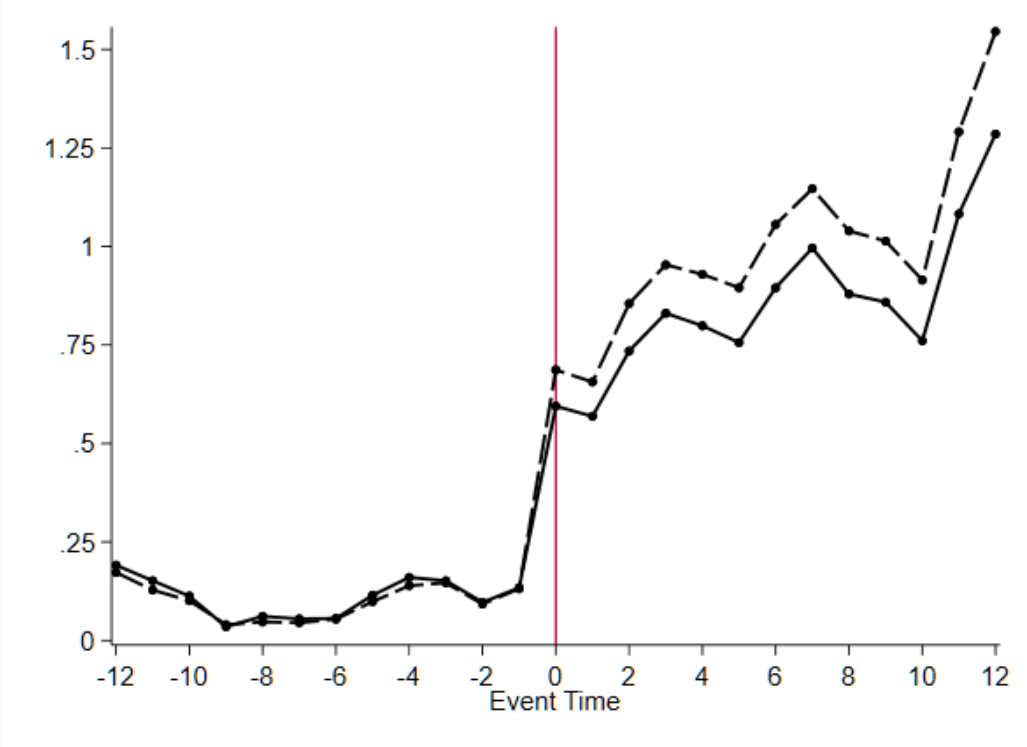
- Predictions for specific pairs:
  - specialists with failures not-yet-observed by PCP i, $\widehat{Pr[Y_{ij}^0|\tilde{X}_{ij}]}$
  - specialists with failures observed by PCP i, $\widehat{Pr[Y_{ij}^1|X_{ij}]}$
- Mean predicted referrals across specialists by quarter

Results for HRRs

HRR 391, Dallas, TX



HRR 183, Indianapolis, IN



Preliminary Learning Results

Myopic Referrals

PCP only cares about experience up to time $t-1$:

$$\begin{aligned}\max_j \mathrm{E}\left[U_{ijt}|a_{ij,t-1}, b_{ij,t-1}\right] &= \max_j \left\{\alpha \mathrm{E}\left[Y_{ijt}|a_{ij,t-1}, b_{ij,t-1}\right] + \epsilon_{ijt}\right\} \\ &= \max_j \left\{\alpha m_{ijt} + \epsilon_{ijt}\right\}\end{aligned}$$

Estimation

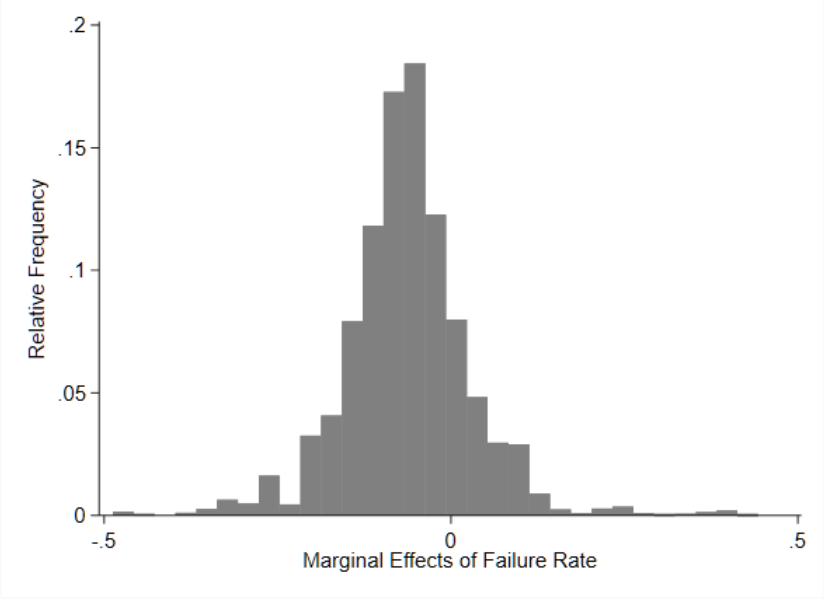
- Multinomial logit with panel
- Choice set is all specialists operating on patients in the patient's HRR in that year (within 150 miles of zip code)
- Failures and "attachment" based on cumulative failures and patients over prior 5 years (limit to 2013 to 2018)
- With and without specialist FEs

Results (HRR 391, Dallas, TX)

Variable	**(1)**	**(2)**	**(3)**
Pair Failure Rate	-0.0835**	-0.1915***	-0.1795***
	[0.0488]	**[0.0617]**	**[0.0617]**
"Attachment"	0.8248***	0.8714***	0.87098***
	[0.0305]	**[0.0403]**	**[0.0400]**
Specialist			
Fixed Effects	X		
Overall Quality			X

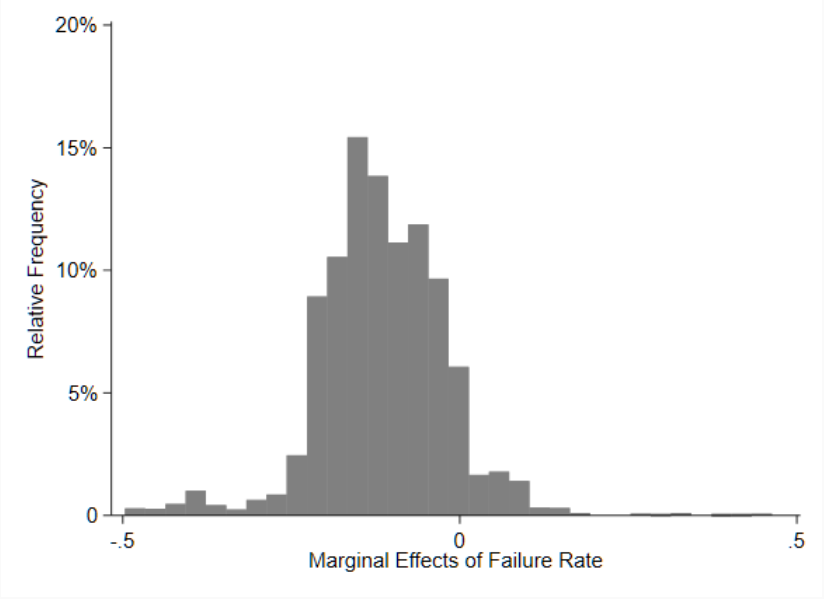
Results (all markets)

With Specialist FEs



%tile	5th	25th	50th	75th	95th
Failure	-0.21	-0.11	-0.07	-0.01	0.09

Without Specialist FEs



%tile	5th	25th	50th	75th	95th
Failure	-0.26	-0.17	-0.12	-0.06	0.03

Interpretation

- Average number of pairwise referrals, 3.35
- 1 failure reflects 30% failure rate
- Reduction in referral probability of about 3.6% (0.3 x 0.12)
- Large relative to mean "market share" of PCP referral (about 10%)

Where does "learning" occur?

Variable	Coef	St. Err.
PCP Count	0.038***	0.009
Specialist Count	-0.067***	0.016

Largest response to failures (reduction in referral probability) in markets with more specialists and fewer PCPs

Forward-looking PCP

- PCP incorporates value of experimenting with unknown specialists
- Value to learning about other specialists in the market
- Reduces to optimal stopping rule (when to try someone new)
- Dynamic problem simplifies with *Gittins Index*, $g(m_{ijt}, v_{ijt})$

$$\max_j \mathbf{E}\left[V_{ijt} | a_{ij,t-1}, b_{ij,t-1}\right] = \max_j \left\{g(m_{ijt}, v_{ijt}) + \epsilon_{ijt}\right\}$$

Forward-looking PCP

From Brezzi and Lai (2002) JEDC, close approximation to Gittins Index in our case is:

$$q_{ij} + \sqrt{v_{ij}} \cdot \psi \left(-\left(\ln(\beta) \left(n_{ij} + 1 \right) \right)^{-1} \right)$$

Wrapping Up

Summary so far

- Some response to failures
- Heterogeneous across markets
- Next steps:
  - Expand into forward-looking learning framework
  - Continue work on reduced form identification (PCP movers, etc.)
  - Understand environment in which learning appears to take place