

Artificial Intelligence in Healthcare? Evidence from Online Job Postings

Forthcoming AEA P&P

Avi Goldfarb

Univ of Toronto & NBER

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Burning Glass Technologies

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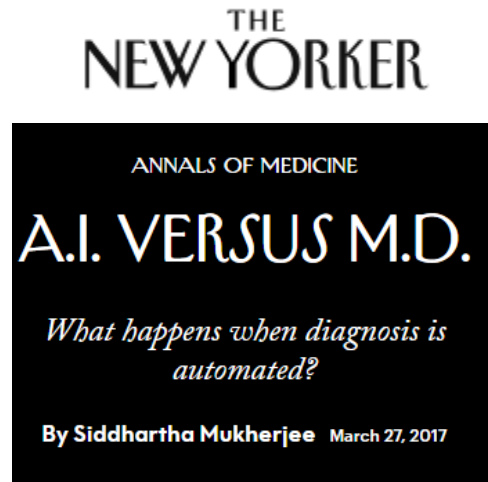
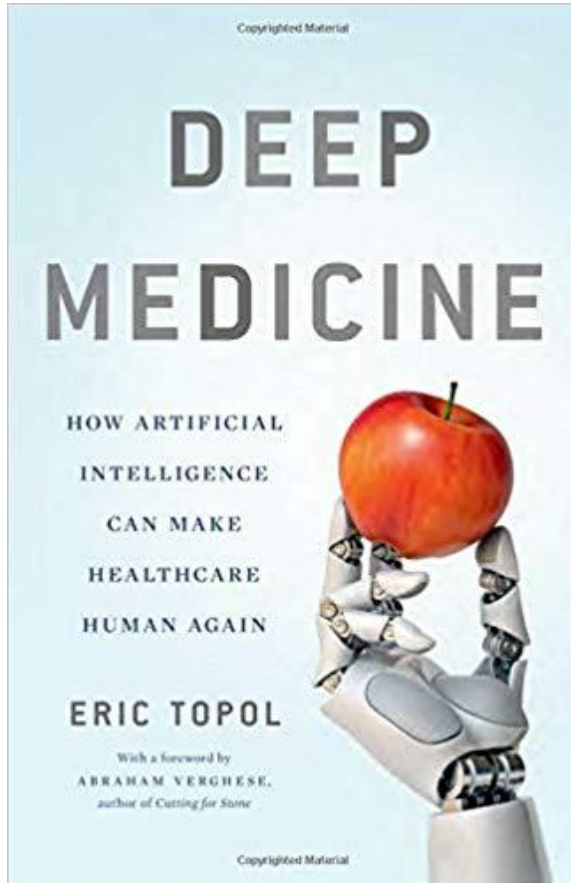
Univ of Southern California

ACM CHIL

ACM CHIL 2020 will be held in Toronto, Canada, April 2-4, 2020.

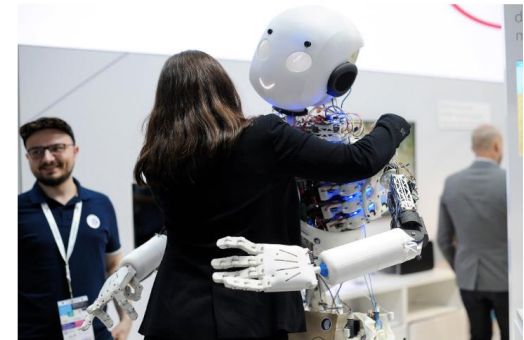
The ACM Conference on Health, Inference, and Learning (CHIL), targets a cross-disciplinary representation of clinicians and researchers (from industry and academia) in machine learning, health policy, causality, fairness, and other related areas. ACM CHIL 2020 builds on the success of the [ML4H Unconference](#), held in Toronto, and the [Machine Learning for Health Workshop at NeurIPS](#), held in Vancouver.

A.I. in Healthcare: Hype, Fear



The New York Times

Warnings of a Dark Side to A.I. in Health Care



Scientists worry that with just tiny tweaks to data, neural networks can be fooled into committing "adversarial attacks" that mislead rather than help. Joan Cros/NurPhoto, via Getty Images

By Cade Metz and Craig S. Smith

March 21, 2019



Last year, the Food and Drug Administration approved a device that can capture an image of your retina and automatically detect signs of

Rotman Chair in Artificial Intelligence and Healthcare Named at the University of Toronto.

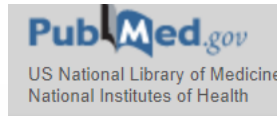
[Media Centre](#) > [News Releases](#) > [Rotman Chair in Artificial Intelligence and Healthcare Named at the University of Toronto.](#)

October 24, 2018

Toronto – A professor of marketing at the University of Toronto's Rotman School of Management will be the first holder of the Rotman Chair in Artificial Intelligence and Healthcare.

Prof. Avi Goldfarb will be the first holder of the chair, which was established earlier this year by a generous gift from the Rotman family. The gift provided funding

And we have been waiting for it since the 70s!

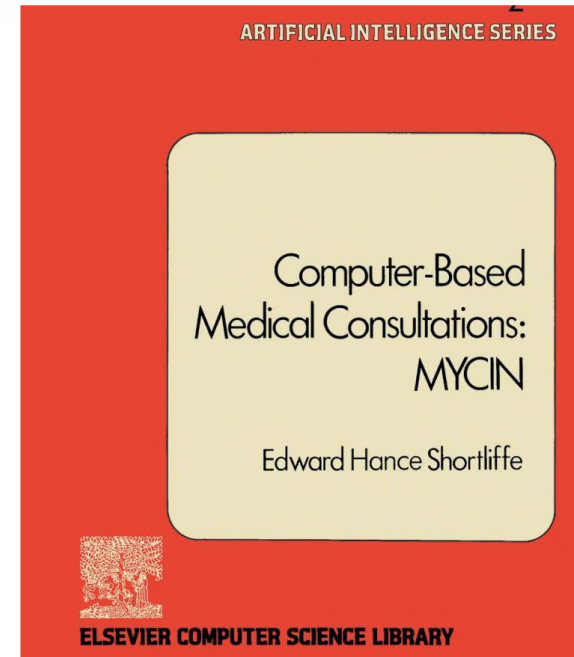
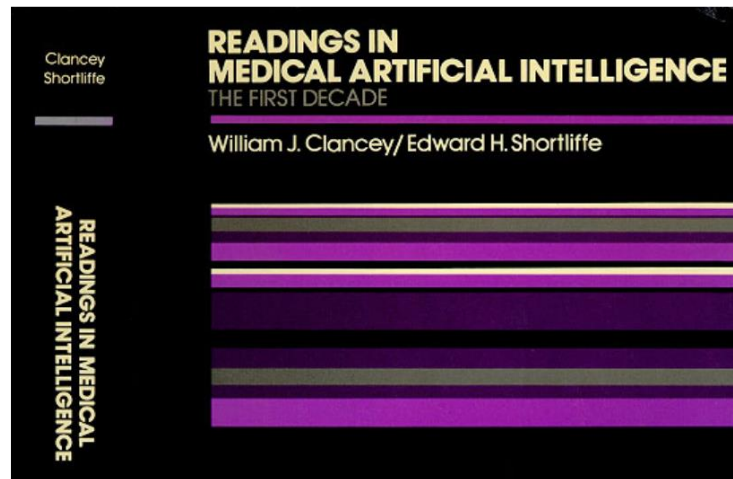


Artif Intell Med. 1993 Apr;5(2):93-106.

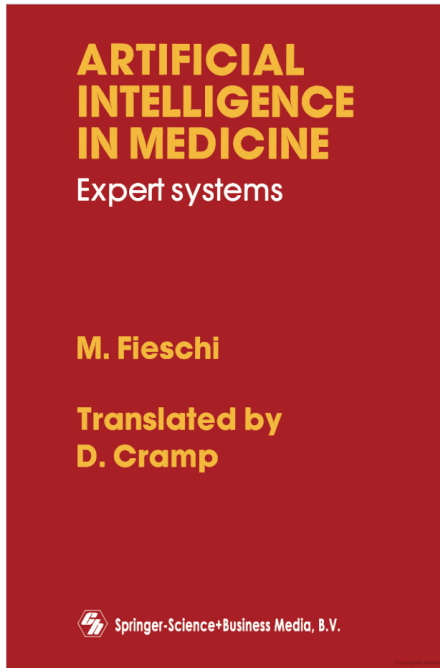
The adolescence of AI in medicine: will the field come of age in the '90s?

Shortliffe EH¹.

Published in 1984



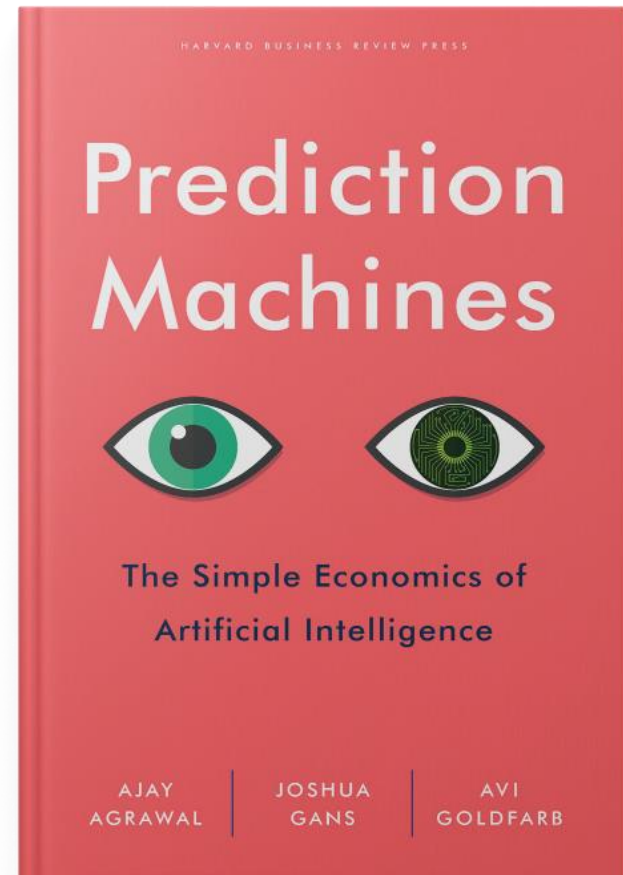
Published in 1976



Published in 1986

What do we mean by AI?

- **The theory and development of computer systems able to perform tasks normally requiring human intelligence.**



**DATA AND
EMPIRICAL STRATEGY**

Empirical approach

- In a number of papers, Prasanna Tambe emphasized that hiring decisions can be used to understand technology adoption and diffusion. (e.g. Tambe 2014; Tambe and Hitt 2012).
- 1.5 million job postings by US hospitals
- Combine with data on hospital management structure
- Document puzzle.
- Assess whether management structure might help explain?

Data I

Dataset 1: Burning Glass Technologies job postings 2007; 2010-2018

We focus on 2015-18, because before 2015 very little AI

- Burning Glass Technologies examines over 40,000 online job boards and company websites to aggregate job postings and create labor market analytics products
- They believe they have the near-universe of jobs that were posted online in 2007 and from 2010 through 2018
- Good data representativeness in healthcare and other industry sectors
- Weaknesses:
 - Vacancies are an imperfect measure of technology adoption
 - Representativeness of jobs

Source: Hershbein and Kahn (2018 AER)

Defining AI jobs

- For each job posting, Burning Glass classifies the skills listed into a number of skill clusters.
- We define AI as those jobs that they categorize into the following skill clusters: “Artificial Intelligence”, “Machine Learning”, and “Natural Language Processing”.
- In total, we find 1,479 AI job postings at 126 different hospitals.
- In addition to identifying which job postings require AI skills, we use the Burning Glass data to identify clinical, research, and administrative jobs (respectively 60%, 6%, and 34% of job postings).
 - AI adoption in research might enhance the capabilities of the physician-scientist (Adams-Huet and Ahn 2009), whereas clinical and administrative decision-makers might fear substitution (Jamieson and Goldfarb 2019).

Examples of AI healthcare job postings

- Title: Post-Doctoral Fellow In Cardiovascular Genomics And Biomedical Informatics
 - Skills: Genome, Epidemiology, Classification Algorithms, Genome Sequencing, Python, Written Communication, Communication Skills, Bioinformatics, Quality Assurance and Control, Research, UNIX, Genetics, Genomics, Medical Coding, Biostatistics, Cardiovascular Disease knowledge, Biology, Machine Learning, Cloud Computing

- Title: Research Fellow - Efficient MRI Acquisition
 - Skills: Siemens Nixdorf Hardware, Creativity, Machine Learning, Physics, Biomedical Engineering, Research, MATLAB, Scanners

- Title: Analytics Architect
 - Skills: Teamwork / Collaboration, Data Warehousing, Microsoft C#, Alteryx, Predictive Models, Presentation Skills, Salesforce, JavaScript Object Notation (JSON), PostgreSQL, Oracle, Oracle PL/SQL, Apache Hive, Extraction Transformation and Loading (ETL), Machine Learning, Cognos Impromptu, Tableau, Open Database Connectivity (ODBC), SAS, Presenting Solutions, Extensible Markup Language (XML), Big Data, MySQL, SQL, Java, SAP BusinessObjects, Python, Project Management, Apache Hadoop, Caching, Design Thinking, Artificial Intelligence, Visual Studio, Unified Modeling Language (UML)

- Title: Population Management Educator
 - Skills: Managed Care, eClinicalWorks, Change Management, Data Integration, Electronic Health Records, Microsoft Office, Training Materials, Strategic Thinking, Presentation Skills, Written Communication, Public Speaking, IBM Watson, Communication Skills, Information Systems, Building Effective Relationships

Data II

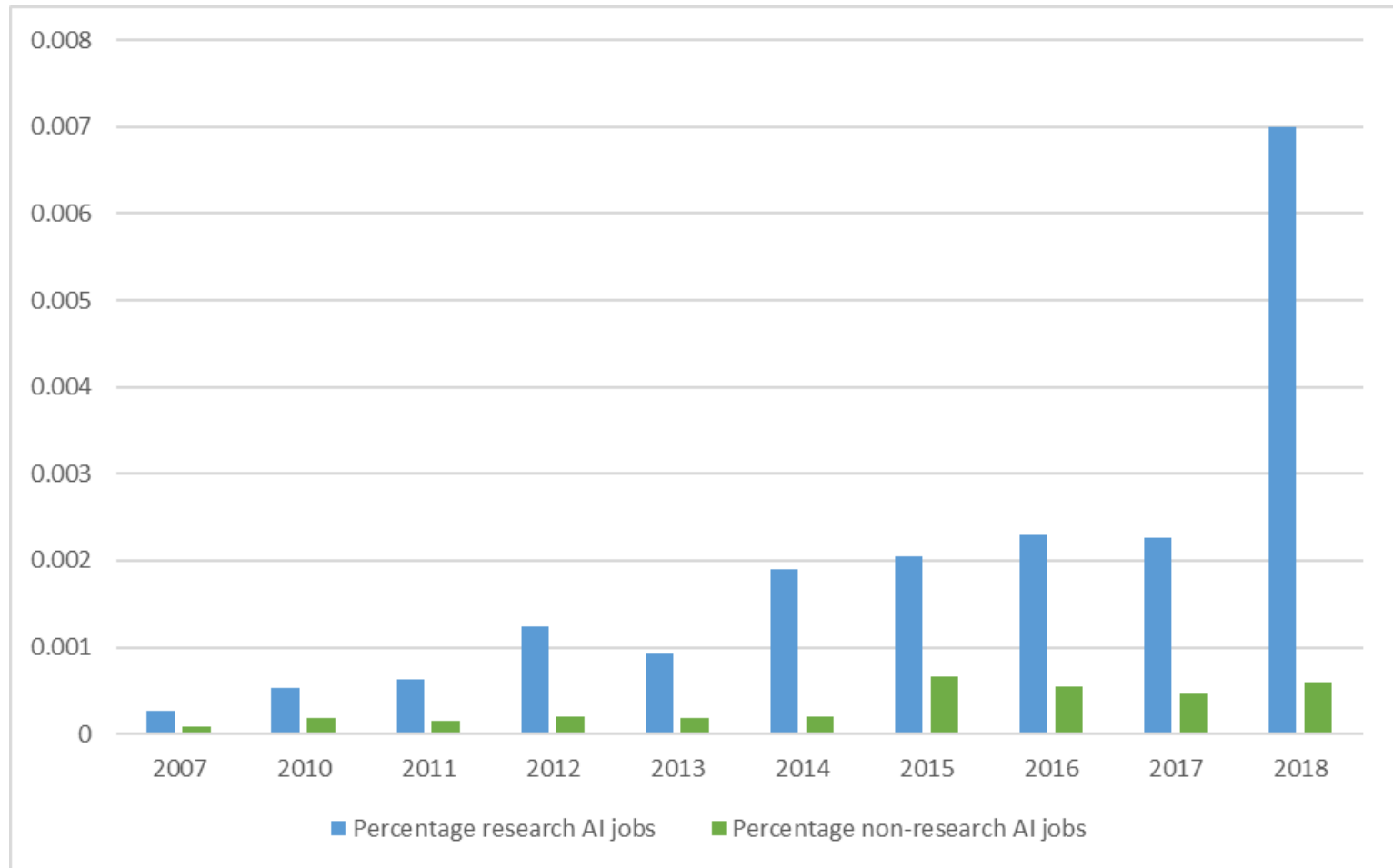
Dataset 2: US Census

- County and NAICS 2 level (25 different variables)
 - US Decennial Census (2010)
 - County business patterns (annual)
 - Focus on county-level payroll based on PCA

Dataset 3: American Hospital Association (AHA) Annual Survey (1994-2016)

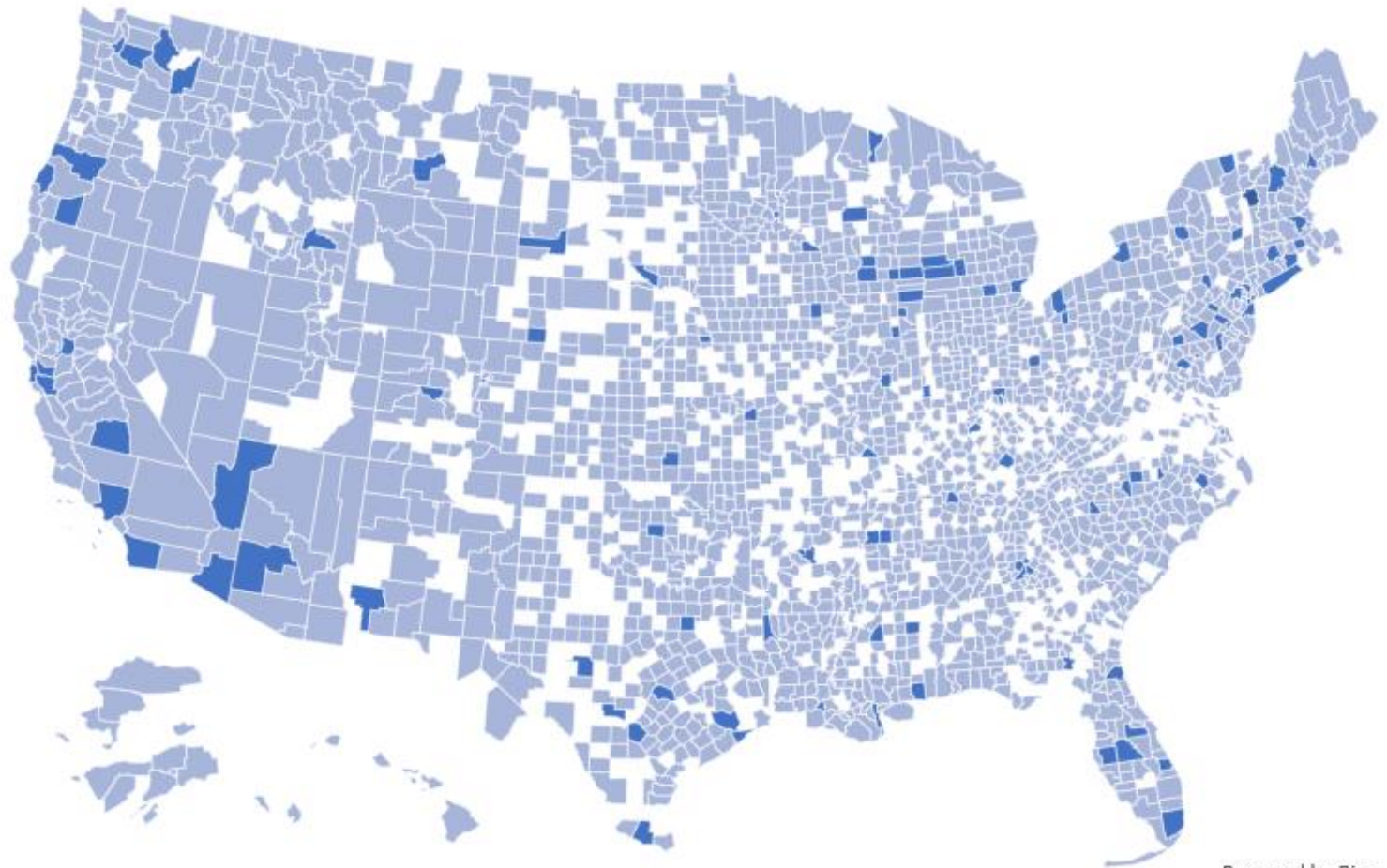
- Hospital characteristics (>200 different variables)
 - Includes information about hospital size, hospital ownership, integration with physicians, service offerings, and some financials.
 - Main analysis used whether integrated salary model, log full time employees, teaching hospital
 - Integrated salary model: doctors are given a salary from the hospital, rather than being paid for each service provided.
 - We consider this distinction because those fearing substitution would have less hiring decision power in integrated salary model hospitals
 - 53% of the job postings are in integrated salary model hospitals

Healthcare ML job postings (AHA data) 2007; 2010-2018



AHA % AI Jobs (2007; 2010-2018)

■ Cat1:0% ■ Cat2:0% to <3% ■ Cat3:3%to<6%



RESULTS

Regression analysis of AI jobs

- Unit of observation is the job posting.
- Dependent variable is “AI skills in job posting”. Logit regression.
- Observation period: 2015-2018

- Covariates: whether the hospital has an integrated salary model, county payroll, hospital size, teaching hospital, and a variety of other controls

- SUGGESTIVE ANALYSIS: THIS PAPER IS MEANT TO MOTIVATE FUTURE WORK THAT DIGS INTO WHETHER OUR EVIDENCE IS LIKELY TO BE CAUSAL!

TABLE 1: LOGIT REGRESSION OF AI SKILLS ON HOSPITAL

AND JOB CHARACTERISTICS

	(1)	(2)	(3)	(4)	(5)
Integrated Salary model	0.840 (0.251)	0.764 (0.226)	1.124 (0.267)		0.840 (0.251)
Teaching hospital				-0.080 (0.516)	-0.079 (0.552)
Research Posting		0.243 (0.244)	1.105 (0.201)		
Clinical Posting		2.528 (0.318)	-2.022 (0.332)		
Integrated Salary model x Research Posting			-1.108 (0.321)		
Integrated Salary model x Clinical Posting			-0.655 (0.541)		
Log county payroll (millions)	0.486 (0.175)	0.388 (0.158)	0.392 (0.157)	0.407 (0.172)	0.489 (0.180)
Log full time hospital employees	0.679 (0.210)	0.581 (0.213)	0.588 (0.212)	0.784 (0.249)	0.690 (0.251)
Pseudo-R ²	0.109	0.164	0.167	0.101	0.109

Unit of observation is the job posting. Dependent variable is AI skills mentioned in the job posting. All models are logit; standard errors in parentheses are clustered at the hospital level. Data includes all job postings by hospitals in the AHA data from 2015-2018 (1,582,333 observations). Regressions include year fixed effects and hospital-level controls.

CONCLUSION

AI Adoption in Hospitals

- This paper documents a fact: ML/AI adoption in hospitals lags other industries, as measured by hiring.
- It provides suggestive evidence that hiring incentives play a role. More likely to hire for jobs that replace doctors in hospitals that have more professional management.
- Lots of limitations:
 - Adoption might be through software—so hiring occurs in other industries
 - Results are suggestive. More work needed to determine if causal!
 - Need better measures of “professional management”
 - Etc!
- Nevertheless, informative about current hype around AI in healthcare.

THANK YOU!