ADDRESSING THE OPIOID EPIDEMIC

Is There a Role for Physician Education?

MOLLY SCHNELL
JANET CURRIE

ABSTRACT
Using national data on opioid prescriptions written by physicians from 2006 to 2014, we uncover a striking relationship between opioid prescribing and medical school rank. Even within the same specialty and practice location, physicians who completed their initial training at top medical schools write significantly fewer opioid prescriptions annually than physicians from lower-ranked schools. Additional evidence suggests that some of this gradient represents a causal effect of education rather than patient selection across physicians or physician selection across medical schools. Altering physician education may therefore be a useful policy tool in fighting the current epidemic.

KEYWORDS: opioid, prescribing, medical school rank, general practitioner
JEL CLASSIFICATION: I11

I. Introduction

Between 2000 and 2014, drug overdoses involving opioids rose 200 percent, fueling widespread concern about an opioid epidemic and spurring calls for changes in public policy (Chen, Hedegaard, and Warner 2014; Dart et al. 2015; Rudd et al. 2016). A distinguishing feature of the current epidemic of drug abuse is that many overdoses and deaths can be attributed to legal opioids that were prescribed by a physician. The clinical use of opioids in the United States has quadrupled since 1999, contributing to the rise in drug overdoses, emergency room visits, and admissions for drug treatment. Despite significant efforts to restrict the prescribing of opioids over the past decade, prescription opioid abuse and drug overdoses due to prescription opioids have continued to rise (Health and Human Services 2014; Meara et al. 2016).

Recent evidence suggests that doctors play a key role in the opioid epidemic. While prescription drug monitoring programs (PDMPs)—prescription databases that allow physicians to check for signs of opioid abuse before prescribing—have little effect on average (Paulozzi, Kilbourne, and Desai 2011; Reifler et al. 2012; Haegerich et al. 2014; Meara et al. 2016), research shows that they are more effective when states require physicians to consult them (Dowell et al. 2016; Buchmueller and Carey 2017; Dave, Grecu,

Molly Schnell, Princeton University. Janet Currie (corresponding author, jcurrie@princeton.edu), Princeton University and NBER.

The statements, findings, conclusions, views, and opinions contained and expressed herein are not necessarily those of QuintilesIMS or any of its affiliated or subsidiary entities.

doi:10.1162/ajhe_a_00113
American Journal of Health Economics 4(3): 383–410

and Saffer 2017). Furthermore, among patients treated in the same emergency room, Barnett, Olenski, and Jena (2017) demonstrate that those who happen to be treated by a physician with a higher propensity to prescribe opioids are more likely to be dependent on opioids 12 months later. Despite being the gatekeepers of the legal opioid supply, very little is known about why some physicians are more likely to prescribe opioids than others[1] or about what role physician training can play in bringing the epidemic under control.

In this paper, we use comprehensive data on all opioid prescriptions written by doctors in the United States between 2006 and 2014 to examine the relationship between opioid prescribing and training. In particular, we ask how the number of opioid prescriptions written yearly by individual physicians varies with a key feature of the school where they received their initial medical training: the rank of the medical school.[2] As general practitioners (GPs) account for 48 percent of opioid prescriptions written by physicians in our sample, we examine the relationship between medical school rank and opioid prescriptions both across all physicians and separately for GPs.[3]

We find that where a doctor received his/her initial training matters in terms of predicting how likely they are to prescribe opioids: physicians trained at the lowest-ranked US medical schools prescribe nearly three times as many opioids per year as physicians trained at the top medical school. This striking inverse relationship reflects two factors: (1) physicians from lower-ranked medical schools are more likely to write any opioid prescriptions; and (2) conditional on being an opioid prescriber, physicians for lower-ranked medical schools write more opioid prescriptions on average. This prescribing gradient is particularly pronounced among GPs. Our results demonstrate that if all GPs prescribed like those from the top-ranked school, we would have had 56.5 percent fewer opioid prescriptions and 8.5 percent fewer deaths over the period 2006 to 2014.

Differences in the propensity to prescribe opioids across medical schools need not reflect a causal effect of training. If physicians from lower-ranked medical schools systematically see patients with a greater need for opioids, then at least part of the relationship between medical school rank and prescribing will reflect patient sorting across physicians. Furthermore, if people who have a higher probability of getting into selective medical schools are systematically less likely to write opioid prescriptions ex ante, then the prescribing gradient will also reflect selection into medical schools. While we cannot definitively quantify the role of training, we provide three additional sets of analyses that suggest that selection alone cannot account for the differences in prescribing habits that we observe across medical school ranks.

1 Recent evidence documents differences in opioid prescribing by medical specialty (Volkow et al. 2011; Ringwalt et al. 2014; Levy et al. 2015).

2 Our data do not include information on the number of patients seen by each physician. Using data for Medicare Part D, we demonstrate that our results are robust to using opioid prescription rates (total prescriptions / number of unique patients) in the Medicare population.

3 We define GPs as physicians in general practice, family practice, and internal medicine. Results are quite similar if we exclude internal medicine.

First, we demonstrate that the relationship between opioid prescriptions and medical school rank persists conditional on physician specialty and county of practice.[4] It is therefore unlikely that differences in patient need across physicians can account for the entirety of the prescribing gradient. Second, we demonstrate that the prescribing gradient is flatter among physicians in specialties that receive specific training in the use of opioids after medical school. If physicians who go on to prescribe fewer opioids select into higher-ranked medical schools (or if patients with a high need for opioids sort towards physicians from lower-ranked schools), then the prescribing gradient should not be dependent on subsequent training in pain management. Finally, we demonstrate that the prescribing gradient is flatter in more recent cohorts. Since selectivity at top medical schools has been increasing over time, a story of selection would instead imply that the relationship should be stronger in more recent cohorts.

This paper contributes to a growing empirical literature on policies to address the opioid epidemic. In addition to the introduction of PDMPs,[5] researchers have examined the impact of the introduction of abuse-deterrent opioids (Cicero, Ellis, and Surratt 2012; Alpert, Powell, and Pacula 2016; Evans, Lieber, and Power 2017), the strengthening of pain clinic laws (Kennedy-Hendricks et al. 2016; Meinhofer 2016), and improvements in access to opioid antagonists such as naloxone (Mueller et al. 2015; Rees et al. 2017) on opioid abuse and related health outcomes. To the best of our knowledge, this is the first study to examine whether additional physician training is likely to have a significant role to play in addressing the opioid epidemic.

This paper further contributes to a large literature in health economics on the determinants of physician practice style. While a physician's network is known to influence how they practice (Coleman, Katz, and Menzel 1957; Soumerai et al. 1998; Epstein and Nicholson 2009; Lucas et al. 2010), the rank of a physician's initial medical school is one aspect of a physician's network that has received surprisingly little attention. A notable exception is Doyle, Ewer, and Wagner (2010), who demonstrate that patients randomly assigned to a doctor who attended a higher-ranked medical school have less expensive stays but no difference in health outcomes compared with patients who instead see physicians from a lower-ranked program.[6]

Finally, we contribute to a literature on the impacts of selectivity in higher education on subsequent outcomes. While the literature on the effects of university rank highlights that at least some of the "effect" of going to a higher-ranked school is the result of selection into schools rather than a consequence of any difference in the education received, the evidence suggests that there are economic returns to attending more selective institutions

4 Taking this analysis a step further, we also demonstrate that a prescribing gradient exists among specialists who practice in the exact same hospital or clinic.

5 See Haegerich et al. (2014) for a review of earlier studies and Meara et al. (2016), Dowell et al. (2016), Patrick et al. (2016), Bao et al. (2016), Buchmueller and Carey (2017), and Dave, Grecu, and Saffer (2017) for more recent work.

6 Although not focused on practice style, Hartz, Kuhn, and Pulido (1999) find that surgeons who trained at prestigious residency or fellowship programs are more likely to be regarded as a "best doctor" by other physicians in the same market.

(Brewer, Eide, and Ehrenberg 1999; Dale and Krueger 2002; Hoekstra 2009; Hoxby 2016). Our work demonstrates that the value-added of attending a selective medical school may include broader public health benefits resulting from differences in clinical practice as a result of the training received.

The paper proceeds as follows. Section II introduces the data. Section III asks how the number of annual opioid prescriptions written by individual physicians varies with the rank of the medical school where they were initially training. Section IV introduces three sets of empirical exercises that can be used to probe whether a causal effect of training contributes to the prescribing gradient that we observe. Section V provides the results from these ancillary analyses. Section VI discusses limitations of our study and provides a variety of robustness checks to help mitigate these concerns. Section VII provides a discussion and conclusions.

II. Data

To examine the relationship between opioid prescribing and training, we combine prescription data from QuintilesIMS with medical school rankings from US News and World Report and a new data set documenting the countries of over 900 foreign medical schools. These data are supplemented with locations of teaching hospitals from the American Hospital Association's (AHA) annual surveys, physician-level opioid prescription rates from the Centers for Medicare and Medicaid Services (CMS) 2014 provider utilization and payment data, county-level characteristics from the five-year pooled 2008–12 American Community Survey (ACS), and county-level mortality from the US Mortality Files.

Our primary prescription data were purchased from QuintilesIMS, a public company specializing in pharmaceutical market intelligence. This data set contains the number of prescriptions filled for opioid analgesics at US retail pharmacies in each year from 2006 to 2014 at the prescriber level. In addition to the number of prescriptions, the QuintilesIMS data contain information on each prescriber provided by the American Medical Association (AMA). In particular, we know each prescriber's specialty, current practice address as of 2014, the medical school where they obtained their first medical degree, and the year in which they graduated from medical school. We use ArcGIS to extract each provider's county of practice from their practice address. To create the sample of physicians used in the paper, we keep active physicians who graduated from medical school before 2006 and are not missing any information necessary for our analysis.[7]

7 In particular, we keep prescribers whose status is listed as "active" in 2014 (94.20 percent of prescribers) and who list a specialty that requires either the degree of medical doctor (MD) or doctor of osteopathic medicine (DO). We exclude physicians whose medical school is not provided or whose medical school name is ambiguous (2.29 percent of active physicians have missing medical school; 0.12 percent of active physicians list "University of Medicine" or "College of Medical Sciences" as their medical school). We also exclude prescribers who list a post office box, a home address, or an address of unknown type (0.49 percent of remaining physicians) in place of an office address as well as physicians whose offices are in US territories (0.06 percent of remaining physicians). Finally, to avoid including physicians who are still doing a residency or other training, we exclude physicians who graduated medical school in 2006 or later (15.93 percent of

We therefore have nine observations for every physician in our sample—one for each year between 2006 and 2014. Altogether, 2.16 billion opioid prescriptions were written between 2006 and 2014; 72.9 percent of these were written by the 742,297 physicians in our cleaned sample.[8] Although GPs (here defined as physicians in general practice, family practice, and internal medicine) make up only 27.4 percent of our sample, they wrote 48.2 percent of all opioids prescribed by physicians between 2006 and 2014 (35.1 percent of all opioid prescriptions). See Online Appendix Table 2 (http://www.mitpressjournals.org/doi/suppl/10.1162/ajhe_a_00113) for an overview of these summary statistics.

There was a continuous increase in the number of opioid prescriptions from 2.04 million in 2006 to 2.6 million in 2012 and then a slight moderation. Nevertheless, in 2014 the average physician still wrote 221.7 opioid prescriptions. This figure includes zeros—in 2014, 28.3 percent of physicians did not write any opioid prescriptions. Among physicians in general practice, these statistics are even more striking: only 16.2 percent of GPs wrote no opioid prescriptions in 2014, with opioid-prescribing GPs writing 480.3 prescriptions on average.

In order to rank medical schools, we use US News and World Report's "Best Medical Schools: Research Rankings."[9] Although medical school rankings change from year to year, we construct a composite medical school rank to use in our analyses.[10] In particular, we take the average of a school's nonmissing rankings from 2010 to 2017 and then re-rank schools according to this average rank (assigning a rank of "1" to the school with the lowest average rank, "2" to the school with the next lowest average rank, and so on).[11] Refer to Online Appendix Table 1 for a list of these composite rankings.

There are 92 ranked medical schools and 55 unranked US medical schools in these data. We divide unranked schools by whether they grant the degree of medical doctor (MD) or doctor of osteopathic medicine (DO) (35 and 20 medical schools, respectively).

We group foreign medical schools based on the UN's classification of countries by major area and region of the world.[12] While the QuintilesIMS data do not provide information on the location of each medical school, we googled all medical schools with 10 or more opioid prescribers in the main sample and recorded the country of the school's

---

remaining physicians). Note that we purchased data from QuintilesIMS for both antidepressant and opioid prescriptions. Of physicians who appear in the AMA data set, only 0.45 percent do not appear in our QuintilesIMS prescription data.

8 Nonphysician providers, including dentists, nurse practitioners, and physician assistants, wrote 19.1 percent of the remaining prescriptions. We exclude nonphysician providers from our analysis since our data include no information on where they were trained.

9 The latest rankings are available at https://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-medical-schools.html.

10 Online Appendix Figure 2 shows how our composite ranking compares with annual rankings from 2010 to 2017. There is a high correlation between the rankings of medical schools over time, with pairwise correlation coefficients all greater than 0.96 across annual rankings from 2010 to 2017.

11 We exclude schools that are ranked in only one or two years over the sample (eight medical schools). Of the remaining medical schools, each school is ranked in 7.4 years on average.

12 Available at http://www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.pdf; last accessed September 5, 2016.

primary campus (902 medical schools). Foreign medical schools with fewer than 10 opioid prescribers in the main sample are labeled as "Uncategorized" (695 medical schools). Refer to Online Appendix Figure 1 for the distribution of medical schools and physicians in our data across world regions.

While the QuintilesIMS data contain information representative of all opioid prescriptions filled at US retail pharmacies, it is not without limitations. As of 2014, QuintilesIMS directly surveyed 86 percent of retail pharmacies, with the remaining prescriptions imputed to add to industry totals using a patented projection method. The fraction of pharmacies directly surveyed has increased slightly since 2006. Since hospital pharmacies are not included in the data, prescriptions of specialists who practice primarily in hospitals, such as surgeons, may be underrepresented. This is one motivation for looking at the relationship between prescribing and rank by specialty, as discussed further below. Also, the QuintilesIMS Xponent data we purchased contain no information on the number of patients seen by each physician or about the strength or number of pills included in each prescription. We use three additional data sets to verify that these data shortcomings are unlikely to drive our results.

First, using the AHA's annual surveys from 2007 to 2013, we demonstrate that our results are robust to excluding physicians who practice in a zip code containing a university-affiliated hospital. We consider a zip code as containing a university-affiliated hospital if it contained a hospital that reported a university affiliation to the AMA in any year between 2007 and 2013. According to this measure, 9.4 percent of zip codes with any physicians in our data include a university-affiliated hospital.

Second, using publicly available data from CMS's Medicare Part D provider utilization and payment data files,[13] we demonstrate that our results are consistent to using opioid prescription rates as opposed to prescription levels in the Medicare population. While these data do not include information on each physician's medical school, we merge the Medicare Part D data with CMS's publicly available Physician Compare database to extract this information.[14,15]

Finally, using county-level deaths from the US Vital Statistics Mortality Files, we demonstrate that the number of opioid prescriptions correlates with deaths involving drugs. To measure "deaths involving drugs," we include all deaths where either the underlying cause of death or a condition contributing to death indicates accidental poisoning by and exposure to drugs (ICD-10 codes X40–X44); intentional self-poisoning by exposure to drugs (ICD-10 codes X60–X64); poisoning by and exposure to drugs (ICD-10 codes Y10–Y14); and poisoning by, adverse effects of, or underdosing of drugs excluding anesthetics (ICD-10 codes T40, T42, T43). We further include deaths where drug dependence, excluding alcohol or tobacco, is indicated on the death certificate (ICD-10 codes

13 Available at https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Provider-Charge-Data/Part-D-Prescriber.html; last accessed August 10, 2017.

14 Available at https://data.medicare.gov/data/physician-compare; last accessed August 10, 2017.

15 This merge is not perfect. According to CMS, clinicians are only listed on Physician Compare if they are in "approved" status in the Medicare enrollment system (PECOS), have a specialty and at least one practice address listed, and have submitted at least one Medicare fee-for-service claim within the past 12 months.

F11–F16, F18, F19).[16] Summary statistics for the annual, county-level mortality measures that we use are provided in Online Appendix Table 3. There was a clear upward trend in deaths due to drugs between 2006 and 2014 from 12.9 to 17.4 per 100,000—a trend that has received a great deal of recent attention (cf. Case and Deaton 2015).

III. Opioid Prescriptions and Medical School Rankings

We are interested in whether the propensity to prescribe opioids is associated with the rank of the medical school where a physician attained his/her initial medical education. We consider three outcomes: (1) the number of opioid prescriptions written annually by each physician including physician-years with no opioid prescriptions, (2) the number of opioid prescriptions excluding physician-years with no opioid prescriptions, and (3) an indicator denoting physician-years with at least one opioid prescription. As GPs account for nearly half of the opioid prescriptions written in the sample (Online Appendix Table 2), we look at all physicians as well as GPs separately. For ease of presentation, we present graphs summarizing the empirical findings as well as tables with regression output.

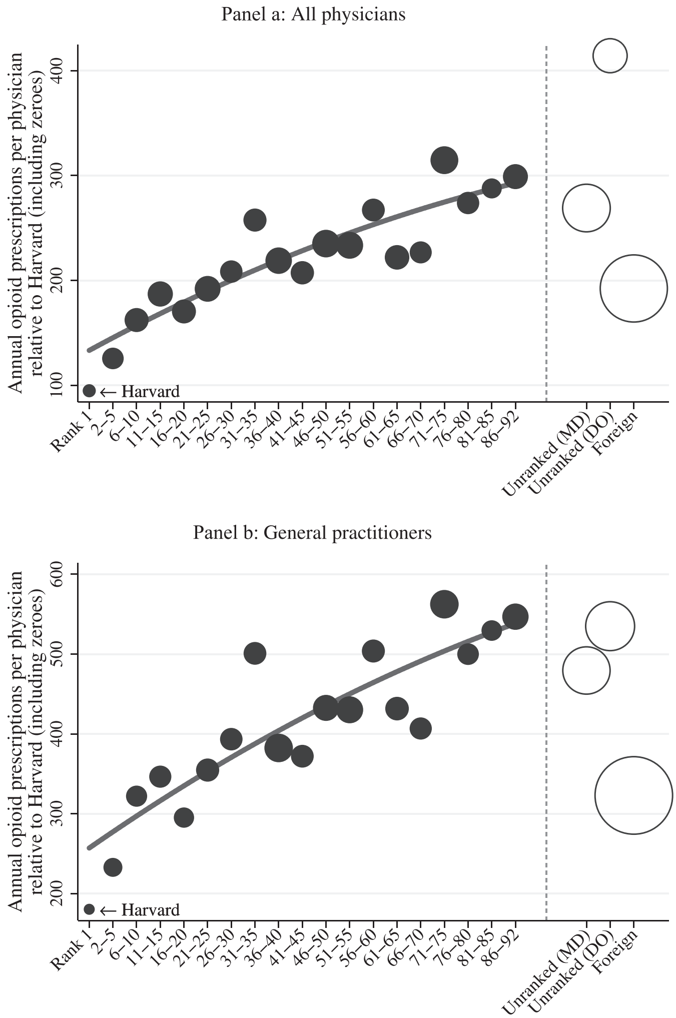
Figure 1 shows the average number of opioid prescriptions written yearly per physician by medical school rank, both among all physicians (panel a) and among GPs (panel b). We see that a higher medical school rank is associated with fewer opioid prescriptions: on average, physicians from the lowest-ranked US medical schools write three times as many opioid prescriptions as physicians trained at Harvard Medical School, the top-ranked school. While GPs trained at Harvard write an average of 180.2 opioid prescriptions per year, GPs from the lowest-ranked US medical schools write an average of nearly 550 opioid prescriptions per year (Online Appendix Table 5).

This striking inverse relationship between the number of annual opioid prescriptions and medical school rank reflects two factors: (1) physicians from higher-ranked medical schools are less likely to write *any* opioid prescriptions; and (2) conditional on writing any opioid prescription, physicians from higher-ranked medical schools write fewer opioid prescriptions on average. Only 65 percent of physicians trained at Harvard Medical School wrote at least one opioid prescription in a given year between 2006 and 2014 compared with nearly 80 percent of physicians from the lowest-ranked medical schools (see Figure 3 and Table 4 in the Online Appendix for all physicians and Figure 4 and Table 5 in the Online Appendix for GPs). Conditional on prescribing opioids, the behavior of physicians likewise varies with medical school rank: on average, opioid prescribers from the lowest-ranked medical schools write over 160 percent more opioid prescriptions per year than opioid prescribers from Harvard (146.4 versus 381.6; see Online Appendix Table 4).

Turning to the results for physicians trained at unranked medical schools, we see from Figure 1 that foreign doctors have similar prescribing habits as physicians trained at mid-tier US schools, while MDs from unranked US schools are closer to the average for physicians from the lowest-ranked schools. This is true both among all physicians (panel a) and among GPs (panel b). Comparing the prescribing habits of DOs to MDs, we see that

16 Our results are robust to only including deaths where a drug overdose is listed as the cause of death.

FIGURE 1. Opioid prescriptions by medical school rank



Notes: The above figures depict the average number of opioid prescriptions written yearly per physician by medical school rank. Panel a includes all physicians; panel b includes only GPs (physicians in general practice, family practice, and internal medicine). Physician-years with zero opioid prescriptions are included. The size of the marker indicates the number of physician-year observations in a given bin. Refer to Online Appendix Tables 4 and 5 for the underlying averages for all physicians and GPs, respectively.

DOs in general practice prescribe similarly to GPs trained at the lowest-ranked US schools. However, at an average of over 400 opioid prescriptions annually per physician, DOs across all specialties write more opioid prescriptions per prescriber than MDs trained either domestically or abroad.

IV. Empirical Strategy

The striking inverse relationship between opioid prescribing and medical school rank documented in Section III begs the question of *why* such a relationship exists. It is possible that medical schools have differing approaches to the trade-off between pain management and addiction and instill different beliefs among their graduates about the appropriate clinical use of opioids. However, a prescribing gradient across medical school rankings need not reflect a causal effect of training. There are two key threats to attributing the raw prescribing gradient to differences in training:

1. If physicians from lower-ranked medical schools are systematically more likely to see patients with a greater need for opioids, then at least part of the relationship between medical school rank and prescribing will reflect **patient sorting across physicians.**[17]
2. If physicians who have a higher probability of getting into a higher-ranked medical school have a lower propensity to prescribe opioids ex ante, then at least part of the relationship between medical school and prescribing will reflect **physician sorting across medical schools.**

While we do not have the data necessary to test whether physicians select into medical schools based on their outlooks towards opioids (or, more realistically, whether physicians select into medical schools based on characteristics that are correlated with their outlooks towards opioids), we can examine whether physicians from lower-ranked medical schools are more likely to encounter patients with a greater medical need for opioids. In particular, we can examine whether physicians from lower-ranked medical schools are systematically more likely to practice in specialties and/or locations where patient need for opioids may be higher.

As shown in Table 1, there are differences in both the specialties and practice locations chosen across medical school rankings. The eight specialties shown in the table are the top eight opioid-prescribing specialties (Online Appendix Table 6) and together account for 84 percent of opioid prescriptions in our sample. The table makes clear that while GPs prescribe the most opioids as a group, this is because they are the most numerous practitioners. Not surprisingly, other specialties, such as pain medicine, prescribe more on a per physician basis.

While only 20 percent of doctors from the top 30 medical schools are in general practice, over 50 percent of DOs are GPs. Furthermore, while doctors from the top 30 schools tend to practice in places with greater population density, lower percentages of white

17 Note that only a particular type of patient sorting threatens a causal interpretation of the relationship between opioid prescribing and medical school rank. If patients sort towards physicians from lower-ranked medical schools based on *medical need*, then the relationship between opioid prescribing and medical school rank cannot be attributed (at least entirely) to a causal effect of training. If, however, patients sort towards physicians from lower-ranked medical schools based on a *desire to misuse or abuse opioids* (for example because physicians from low-ranked schools are known to be more lenient prescribers), then this endogenous sorting is a consequence of the differences in prescribing practices that we want to capture.

TABLE 1. Opioid prescriptions and practice characteristics by medical school rank

	Full sample	US ranked			US unranked		Foreign
		Top 30	31–60	61–92	MD	DO	
N physicians	742,297	134,119	142,822	127,007	96,644	49,376	192,329
N physician-years (9 years/physician)	6,680,673	1,207,071	1,285,398	1,143,063	869,796	444,384	1,730,961
Opioid prescriptions							
Total (100 million)	15.7	2.1	3.0	3.1	2.3	1.8	3.3
Average per physician-year including zeroes	235.7	172.4	235.3	273.7	269.0	414.3	192.3
	(1.4)	(2.4)	(2.9)	(3.6)	(4.1)	(7.2)	(2.7)
Average per physician-year excluding zeroes	319.0	240.3	309.5	356.2	348.6	501.7	283.1
	(1.8)	(3.2)	(3.7)	(4.5)	(5.2)	(8.4)	(3.8)
Zeroes (% physician-years)	26.1	28.3	24.0	23.2	22.8	17.4	32.1
Specialties (% physicians)							
General practice	27.4	19.2	24.5	25.0	24.2	50.7	32.6
Orthopedic surgery	3.3	4.7	4.2	3.9	3.7	2.8	1.1
Emergency medicine	4.5	4.3	5.7	5.5	5.7	8.2	1.5
Pain medicine	0.5	0.3	0.5	0.5	0.5	0.6	0.7
Physical medicine & rehabilitation	1.1	0.7	1.0	1.1	1.3	1.8	1.2
Obstetrics & gynecology	5.4	5.2	5.9	6.5	7.1	4.5	3.6
Anesthesiology	4.4	3.9	4.7	4.8	4.4	3.9	4.3
General surgery	4.0	4.3	4.3	4.6	4.4	2.7	3.5

TABLE 1. *Continued*

		US ranked			US unranked		
	Full sample	Top 30	31–60	61–92	MD	DO	Foreign
County of practice (avg across phys-yrs)							
Pop density (People/1,000 sq miles)	3.6	4.9	3.0	2.3	3.6	2.0	4.5
Percentage white	71.0	69.2	72.2	72.6	70.0	76.8	69.4
Percentage HS or less	40.0	37.7	39.0	40.0	40.7	42.1	41.6
Percentage unemployed	9.3	9.2	9.2	9.1	9.2	9.4	9.7
Median household income	53.7	55.8	54.4	52.4	52.8	51.9	53.4
Percentage poverty	13.9	13.7	13.6	13.9	14.1	13.6	14.0
Percentage uninsured	14.4	13.9	14.1	14.1	14.8	14.0	14.9
Zip code of practice (% physicians)							
Contains university-affiliated hosp	45.0	51.1	45.4	44.9	43.7	30.6	44.9

Notes: Standard errors are displayed in parentheses and are clustered by physician. The displayed specialties are the top 8 specialties out of the 57 with the most opioid prescriptions collectively from 2006 to 2014 (Online Appendix Table 6). The prescription statistics are raw averages; that is, they do not control for physician specialty or county of practice.

inhabitants, and higher education levels (that is, in more urban settings), DOs practice in areas with low population density, a high percentage of white inhabitants, and the highest percentage of less educated residents. If, for example, GPs who practice in more rural settings see patients with a greater need for opioids, then the patterns documented in Figure 1 and Online Appendix Figures 3 and 4 could reflect differences in the specialties and practice locations chosen across medical school rankings.

In the following section, we provide three sets of additional analyses that together provide evidence that neither patient sorting across physicians nor physician sorting across medical schools can account for all of the prescribing gradient that we observe. First, to control for differences in patient need, we replicate the analysis from Section III conditional on specialty and county of practice fixed effects. In particular, we estimate regressions of the following form:

$$Y_{itc} = \beta Rank_i + \delta Specialty_i + \alpha_c + \gamma_t + e_{itc} \quad (1),$$

where Y_{itc} denotes the number of opioid prescriptions written by doctor i in year t in county c; $Specialty_i$, α_c, and γ_t denote specialty, county, and year fixed effects, respectively; and e_{itc} is an error term. In some specifications, county fixed effects are replaced with either exact practice address fixed effects or a vector of county characteristics. $Rank_i$ is a vector of indicators for medical school rank group. Harvard is the top-ranked medical school, followed by schools ranked 2–5, 6–10, and so on. Including this vector of indicators allows the effect of school rank to be nonlinear. We further include separate indicators for unranked schools that grant MDs, unranked schools that grant DOs, and foreign schools. With the inclusion of county and specialty fixed effects, the parameters of interest—the vector β—are identified using variation in the number of prescriptions written by physicians within the same specialty who practice in the same county but who attended different medical schools. Standard errors are clustered by physician.

While equation 1 is useful for graphical analyses (the vector β can be plotted to visualize the prescribing gradient), we would like a parsimonious way to examine how the prescribing gradient changes when we include different controls. Hence, we also estimate equations similar to equation 1 where we replace indicators for medical school rank bins with a quadratic in continuous medical school rank. That is, we estimate equations of the following form:

$$Y_{itc} = \beta_1 Rank_i + \beta_2 Rank_i^2 + \delta Specialty_i + \alpha_c + \gamma_t + e_{itc} \quad (2),$$

where $Rank_i$ is a continuous measure of medical school rank (graduates of Harvard receive a value of one, graduates of Johns Hopkins receive a value of two, etc.) and all other variables are defined as in equation 1. We include a quadratic in medical school rank because results from equation 1 suggest that the relationship between medical school rank and annual opioid prescriptions is approximately quadratic. As there in no ordinal ranking for physicians who trained at unranked US medical schools or foreign institutions, we only include physicians who graduated from ranked US medical schools in these regressions. As before, standard errors are clustered by physician.

Next, instead of residualizing the number of prescriptions from specialty fixed effects, we examine whether the prescribing gradient is different across physicians in different specialties. If the prescribing gradient is driven entirely by patient sorting across physicians or physician selection into medical schools, then we would expect the prescribing gradient to be similar across specialties. If, however, there is a causal effect of training, then we would expect the prescribing gradient to be weaker in specialties that receive subsequent training in pain management.

To estimate the prescribing gradient across different specialties, we estimate equations 1 and 2 separately for the top eight opioid-prescribing specialties.[18] The eight specialties with the most opioid prescriptions over our sample period are general practice, orthopedic surgery, emergency medicine, pain medicine, physical medicine and rehabilitation, obstetrics and gynecology, anesthesiology, and general surgery (see Online Appendix Table 6). Of these specialties, those in pain medicine, physical medicine and rehabilitation, and anesthesiology prescribe the most on a per physician basis and have the most detailed subsequent training in the use of pain medicines.

Finally, we examine whether the prescribing gradient is different across graduation cohorts. While medical school rankings have been quite stable over time, the degree of selectivity at top schools has been increasing as the market for higher education has become national (and international) rather than being regionally segmented (Hoxby 2009). Hence, if the effect of medical school rank is due to the selection of more qualified people into higher-ranked schools, then we should see the effect of rank increase in more recent cohorts with increasing selectivity. Conversely, if the effect of rank is due to differences in training offered at different schools, and if training standards tend to diffuse downwards from the top schools over time, then the effect of rank should be less important in more recent cohorts. To examine whether the prescribing gradient is stronger in more selective cohorts, we estimate equations 1 and 2 separately for four broad cohorts: those who graduated before 1975, between 1976 and 1985, between 1986 and 1995, and after 1996.

V. The Role of Training

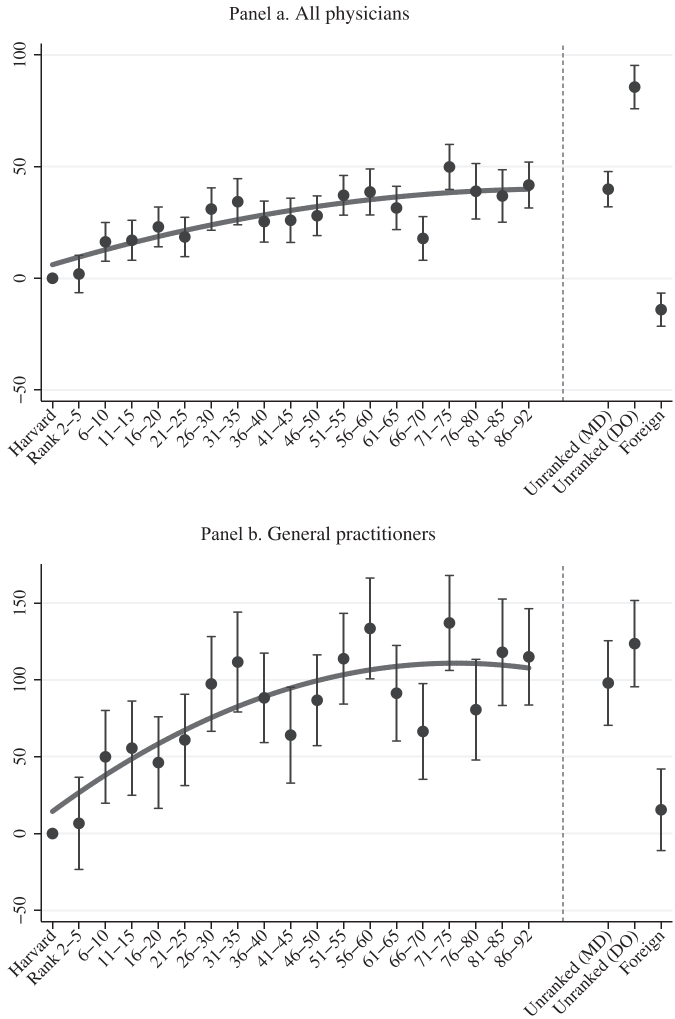
We now implement the three sets of empirical exercises introduced in Section IV to investigate whether there is evidence that the prescribing gradient we uncover in Section III is driven—at least in part—by a causal effect of training.

A. PRESCRIBING GRADIENT CONDITIONAL ON SPECIALTY AND PRACTICE LOCATION

Figure 2 provides coefficient estimates and 95 percent confidence intervals on indicators for medical school rank bins from estimation of equation 1, both for all physicians (panel a) and for GPs (panel b). The figures are scaled so that the coefficients on the

18 When these equations are estimated on a single specialty, specialty fixed effects are excluded. However, when we estimate these equations only on GPs, we include subspecialty fixed effects to account for differences across the three categories of subspecialties we include in our definition of GPs (general practice, family practice, and internal medicine).

FIGURE 2. Opioid prescriptions by medical school rank controlling for specialty and county of practice



Notes: The above figures depict the coefficient estimates on indicators for medical school rank bins from regressions of opioid prescriptions at the physician-year level on medical school rank bin indicators with year, specialty, and county fixed effects (equation 1). Panel a includes all physicians; panel b includes only GPs (physicians in general practice, family practice, and internal medicine). Physician-years with zero opioid prescriptions are included. The bars denote 95% confidence intervals; standard errors are clustered by physician. Refer to Online Appendix Tables 7 and 8 for the underlying coefficient estimates for all physicians and GPs, respectively.

highest-ranked medical school (Harvard) are set to zero, and all other schools are compared to it. A comparison of Figures 1 and 2 demonstrates that controlling for differences in specialties and practice locations moderates the relationship between medical school rank and opioid prescribing. However, even within the same specialty and county of practice, the relationship between medical school rank and opioid prescriptions remains highly statistically significant. This is particularly true among GPs, for whom the average number of opioid prescriptions written yearly per physician rises steeply with medical school rank until around the rank of 60, where the curve flattens out.[19]

A comparison of specifications with and without controls is shown more formally in Table 2. Here, we provide results for variants of equation 2 estimated on all physicians (panel a) and using GPs alone (panel b). Looking to the results for all physicians first, we see that a regression of annual opioid prescriptions on medical school rank yields a best fit line of $y = 117.07 + 2.44x - 0.01x^2$ (column 1). Controlling for specialty (column 2) reduces the derivative of y with respect to x by about half, as does controlling for county-level demographics from the ACS (column 3).[20] Comparing columns 3 and 4, we see that the estimates are very similar whether we control for observable differences across counties or for both observable and unobservable differences across counties using county fixed effects. Finally, column 5 shows estimates from a specification similar to that depicted in Figure 2 in that it includes both county and specialty fixed effects: here, the best fit line is given by $y = 111.57 + 0.64x - 0.003x^2$. Taking into account differences in specialties and counties of practice across medical school rankings, doctors from the lowest-ranked schools still write on average over 33 more opioid prescriptions per year than doctors from the highest-ranked schools.

While the prescribing gradient among GPs is also attenuated when we control for specialty and county of practice, we see from the regression output in panel b of Table 2 that a significant gradient persists among GPs practicing in the same county. Conditional on specialty and county of practice, GPs from the lowest-ranked schools write on average over 70 more opioid prescriptions per year than GPs from the highest-ranked schools (column 5).

Turning to the coefficients on unranked medical schools in Figure 2, we see that among all physicians (panel a), DOs write more prescriptions per prescriber than all other doctors even when we control for differences in specialties and practice locations. Furthermore, conditional on these controls, MDs trained at unranked US medical schools still prescribe similarly to physicians from the lowest third of ranked US medical schools, both among all physicians and among GPs. However, unlike in Figure 1, foreign-trained doctors actually write fewer opioid prescriptions than US-trained doctors once we control for specialty and county of practice.

The behavior of foreign-trained doctors is probed further in Figure 3. Here, we plot coefficient estimates from a regression similar to the specification outlined in equation 1

19 Online Appendix Tables 7 and 8 show the regression output underlying Figure 2.

20 Controls include population density; percentage male; percentage in 12 age bins; percentage white, black, and Hispanic; percentage in seven education categories; percentage unemployed; percentage in 16 income categories; percentage poverty for three different age ranges; percentage with public and private health insurance; and median age of housing stock.

TABLE 2. Opioid prescriptions by medical school rank

Panel a: All physicians

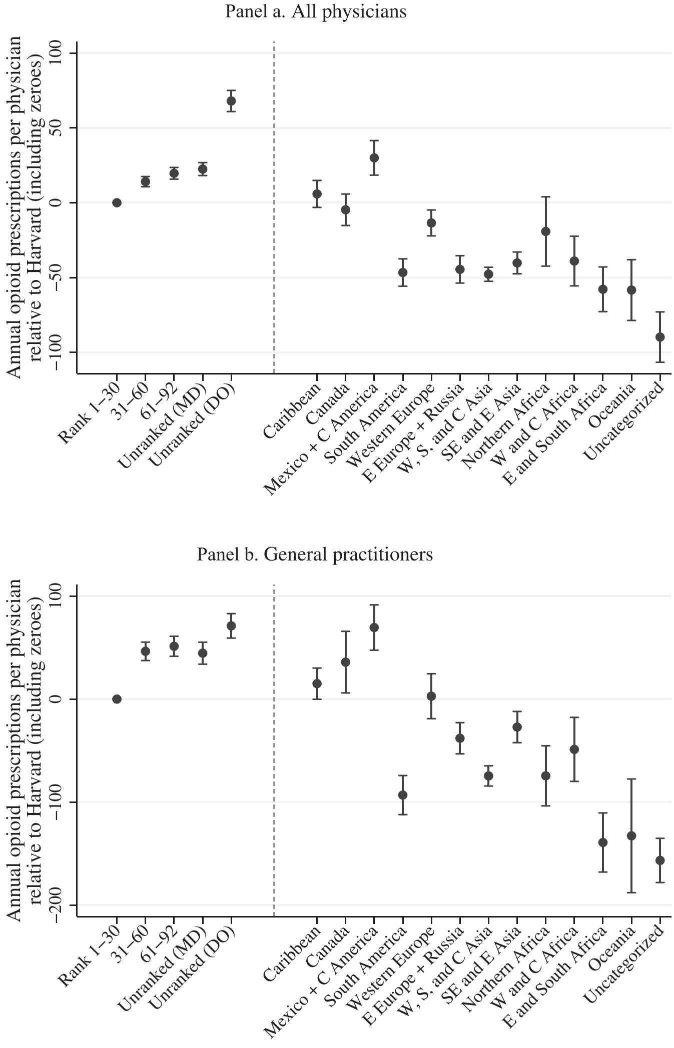
	Annual opioid prescriptions (including zeroes)					
	(1)	(2)	(3)	(4)	(5)	(6)
Medical rank	2.439[a]	1.243[a]	1.524[a]	1.502[a]	0.635[a]	0.263[a]
	(0.120)	(0.110)	(0.119)	(0.118)	(0.109)	(0.097)
(Medical rank)^2	−0.007[a]	0.001	−0.008[a]	−0.010[a]	−0.003[a]	−0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	117.071[a]	71.847[b]	−9.1e+03[a]	164.871[a]	111.570[a]	232.763[a]
	(2.074)	(30.845)	(623.952)	(2.120)	(31.767)	(39.732)
Specialty FEs	No	Yes	No	No	Yes	Yes
County demographics	No	No	Yes	No	No	No
County FEs	No	No	No	Yes	Yes	No
Practice address FEs	No	No	No	No	No	Yes
N (physician-years)	3,635,532	3,635,532	3,635,532	3,635,532	3,635,532	3,635,532
R^2	0.006	0.147	0.039	0.064	0.194	0.525

Panel b: General practitioners

	Annual opioid prescriptions (including zeroes)					
	(1)	(2)	(3)	(4)	(5)	(6)
Medical rank	4.147[a]	2.995[a]	2.644[a]	2.784[a]	2.418[a]	1.441[a]
	(0.309)	(0.307)	(0.301)	(0.292)	(0.292)	(0.257)
(Medical rank)^2	−0.011[a]	−0.003	−0.015[a]	−0.021[a]	−0.018[a]	−0.014[a]
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	202.380[a]	321.419[a]	−8.3e+03[a]	295.736[a]	354.644[a]	362.420[a]
	(5.818)	(6.521)	(1297.679)	(5.712)	(6.264)	(5.713)
Specialty FEs	No	Yes	No	No	Yes	Yes
County demographics	No	No	Yes	No	No	No
County FEs	No	No	No	Yes	Yes	No
Practice address FEs	No	No	No	No	No	Yes
N (physician-years)	832,005	832,005	832,005	832,005	832,005	832,005
R^2	0.014	0.029	0.096	0.174	0.178	0.636

Notes: The above table presents output from regressions of opioid prescriptions at the physician-year level on a quadratic in medical school rank (variants of equation 2). All specifications include year fixed effects. Standard errors are clustered by physician. Panel a includes all physicians; panel b includes only GPs (physicians in general practice, family practice, and internal medicine). Column 3 includes the following county-level controls: population density; percentage male; percentage in 12 age bins; percentage white, black, and Hispanic; percentage in 7 education categories; percentage unemployed; percentage in 16 income categories; percentage poverty for three different age ranges; percentage with public and private health insurance; and median age of housing stock. [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

FIGURE 3. Opioid prescriptions by regions of foreign schools controlling for specialty and county of practice



Notes: The above figures depict the coefficient estimates on indicators for medical school rank bins for US-trained physicians and regions of training for foreign-trained physicians from regressions of opioid prescriptions at the physician-year level on medical school rank bin or region indicators with year, specialty, and county fixed effects (variants of equation 1). Panel a includes all physicians; panel b includes only GPs (physicians in general practice, family practice, and internal medicine). Physician-years with zero opioid prescriptions are included. The bars denote 95% confidence intervals; standard errors are clustered by physician. Refer to Online Appendix Tables 7 and 8 for the underlying coefficient estimates for all physicians and GPs, respectively.

except that the categories for ranked US schools are collapsed and indicators are added for world region of training for foreign doctors. Conditional on specialty and county characteristics, physicians trained in most regions outside of the United States write significantly fewer opioid prescriptions per year on average than physicians trained domestically. In fact, GPs trained in the Caribbean, Canada, and Mexico/Central America are the only foreign-trained GPs who on average write more opioid prescriptions per year than GPs trained at the top 30 US schools. The stark differences between physicians trained in various regions of the world suggest considerable variation in attitudes towards opioids across world regions that practitioners bring with them to the United States, and provide further evidence that differences in training are likely to be important.[21]

It is possible that we are not fully controlling for medical need by controlling for physician specialty and county of practice. We can extend our analysis to compare the prescribing practices of physicians who practice in the *exact same hospital or clinic* by including practice address fixed effects in place of county fixed effects in equations 1 and 2. The results of this exercise for all physicians and GPs are shown in column 6 of Table 2 (see also Online Appendix Figure 6). Even within the same practice, opioid prescribing increases with medical school rank, although the relationship is flatter than in a specification without these controls. This reduction in the relationship between medical school rank and prescribing practices within a given practice location indicates either that practices tend to hire doctors with similar propensities to prescribe opioids or that the opioid prescribing behavior of physicians is influenced by the institutions where they practice and/or the behavior of their colleagues.

B. PRESCRIBING GRADIENT ACROSS SPECIALTIES

We next ask whether there are differences in the prescribing gradient across the top eight opioid-prescribing specialties. As discussed in Section IV, if differences in opioid prescribing across medical school ranks are in fact driven by differences in training, then we expect the rank of a physician's initial medical school to be a less important predictor of opioid prescribing behavior among specialties that receive subsequent training in the use of opioids.

Figure 7 in the Online Appendix shows that there is an inverse relationship between medical school rank and opioid prescribing in most of the top eight opioid-prescribing specialties, although the relationship is generally much flatter in other specialties than that observed for GPs.[22] This can also be seen in Table 3, which provides estimates of equation 2 for physicians in different specialties. For pain medicine, physical medicine and rehabilitation, and anesthesiology—the specialties where all practitioners could be expected to receive specific training in the use of opioids and have high per physician prescribing of

21 Online Appendix Figure 5 plots similar estimates from models without specialty and county controls both for all physicians (panel a) and for GPs (panel b).

22 Online Appendix Figure 8 shows similar figures for two specialties where many observers agree that opioids are often necessary for adequate pain relief: oncology and nephrology. These figures show that a relationship between medical school rank and opioid prescribing exists even among specialties where the use of opioids is uncontroversial, although the relationship is much flatter than that found for GPs.

TABLE 3. Opioid prescriptions by medical school rank across specialties

	Annual opioid prescriptions (including zeroes)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specialty:	General practice	Orthopedic surgery	Emergency medicine	Pain medicine	Phy. med. & rehab.	Ob./gyn.	Anesthesiology	General surgery
Medical rank	2.418[a]	1.920[b]	−0.631[c]	−3.814	−4.467	0.658[a]	0.788	0.650[a]
	(0.292)	(0.846)	(0.368)	(9.275)	(4.110)	(0.181)	(0.865)	(0.244)
(Medical rank)^2	−0.018[a]	−0.018[c]	0.013[a]	0.038	0.067	−0.005[b]	−0.003	−0.003
	(0.003)	(0.009)	(0.004)	(0.101)	(0.044)	(0.002)	(0.010)	(0.003)
Constant	354.644[a]	537.923[a]	70.700[a]	1507.539[a]	301.616	87.348[a]	−26.520	126.145[a]
	(6.264)	(20.956)	(20.580)	(207.711)	(328.576)	(22.719)	(23.612)	(20.778)
N (physician-years)	832,005	155,547	187,785	15,318	33,462	213,282	162,225	158,913
R^2	0.178	0.195	0.245	0.356	0.288	0.210	0.118	0.235

Notes: The above table presents output from regressions of opioid prescriptions at the physician-year level on a quadratic in medical school rank with year and county fixed effects (variants of equation 2) estimated separately across different specialties. Standard errors are clustered by physician. The displayed specialties are the 8 specialties out of 57 specialties with the most opioid prescriptions collectively from 2006 to 2014 (Online Appendix Table 6). [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

opioids relative to GPs[23]—we see virtually no relationship between initial medical school rank and opioid prescribing, as hypothesized above. For ER doctors, Online Appendix Figure 7 indicates a relationship between rank and prescribing that is basically flat up to about rank 50 and then increases. In the quadratic regressions (Table 3), this concavity is captured by a negative main effect and a positive coefficient on the quadratic term, with a turnaround point right around rank 50, consistent with the figure.

C. PRESCRIBING GRADIENT ACROSS COHORTS

We next turn to the question of cohort-level differences in the relationship between medical school rank and opioid prescribing. As discussed in Section IV, if the prescribing gradient is driven by physician selection into medical schools, then the gradient should be stronger in more recent cohorts because of the increasing selectivity at top medical schools.

We find that the relationship between initial medical school rank and opioid prescribing, while significant in all cohorts, has become consistently flatter over time (see Table 4 and Online Appendix Figure 9). For GPs who graduated from medical school before 1976 for instance, a regression of annual opioid prescriptions on a quadratic in continuous medical school rank with year, specialty, and county fixed effects (equation 2) yields a best fit line of $y = 354.40 + 3.55x - 0.03x^2$ (column 2 of panel b) compared with the best fit line of $y = 247.61 + 1.28x - 0.01x^2$ for the cohort that graduated between 1996 and 2005 (column 5 of panel b). This flattening gradient is inconsistent with the idea that the relationship between medical school rank and opioid prescribing is driven by selection into the top medical schools.[24]

VI. Robustness

One limitation of these data is that they do not include information about the number of patients seen by each physician. If doctors trained at top schools are more likely to engage part-time in research or teaching and therefore see fewer patients than doctors from lower-ranked medical schools, then a correlation between medical school rank and prescriptions could emerge because of differences in workloads. Unfortunately, there is currently no data set available that has patient volumes for every doctor in the United States.

Despite this limitation, it is unlikely that differences in the number of patients seen can explain our findings. Recall that a strong relationship between prescribing and school rank remains throughout the distribution of medical school ranks. In order for patient volume to explain our findings, GPs from the 30th ranked schools would have to see significantly fewer patients on average than GPs from the 40th ranked schools, for example. We do not think there is any evidence or reason to think that this is the case. Furthermore, large

23 As shown in Online Appendix Table 6, physicians in pain medicine write an average of 2,040.2 opioid prescriptions per year compared with an average of 414.1 for GPs.

24 Online Appendix Table 9 shows results for pain medicine specialists separately. Consistent with the results for pain specialists across all cohorts, there is no statistically significant association between initial medical school rank and opioid prescribing for pain specialists of any cohort.

TABLE 4. Opioid prescriptions by medical school rank across cohorts

Panel a: All physicians

	Annual opioid prescriptions (including zeroes)				
	(1)	(2)	(3)	(4)	(5)
Graduation cohort:	All	≤1975	1976–1985	1986–1995	1996–2005
Medical rank	0.635[a]	1.242[a]	0.718[a]	0.481[b]	0.264[c]
	(0.109)	(0.219)	(0.242)	(0.240)	(0.143)
(Medical rank)^2	−0.003[a]	−0.009[a]	−0.003	−0.002	−0.000
	(0.001)	(0.003)	(0.003)	(0.003)	(0.002)
Constant	111.570[a]	29.659	185.029[a]	220.612	417.002
	(31.767)	(21.114)	(47.655)	(159.558)	(297.311)
N (physician-years)	3,635,532	675,396	936,018	1,006,704	1,017,414
R^2	0.194	0.181	0.236	0.232	0.226

Panel b: General practitioners

	Annual opioid prescriptions (including zeroes)				
	(1)	(2)	(3)	(4)	(5)
Graduation cohort:	All	≤1975	1976–1985	1986–1995	1996–2005
Medical rank	2.418[a]	3.551[a]	3.210[a]	2.073[a]	1.277[a]
	(0.292)	(0.745)	(0.613)	(0.547)	(0.410)
(Medical rank)^2	−0.018[a]	−0.027[a]	−0.026[a]	−0.014[b]	−0.009[b]
	(0.003)	(0.009)	(0.007)	(0.006)	(0.004)
Constant	354.644[a]	354.397[a]	437.960[a]	375.733[a]	247.608[a]
	(6.264)	(16.873)	(12.799)	(11.540)	(8.794)
N (physician-years)	832,005	132,849	232,596	244,278	222,282
R^2	0.178	0.256	0.261	0.241	0.264

Notes: The above table presents output from regressions of opioid prescriptions at the physician-year level on a quadratic in medical school rank with year, specialty, and county fixed effects (equation 2) estimated separately across different graduation cohorts. Standard errors are clustered by physician. Panel a includes all physicians; panel b includes only GPs (physicians in general practice, family practice, and internal medicine). [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$.

differences in opioid prescribing patterns exist across foreign-trained physicians—a significant share of practicing US physicians—depending on the world region in which they were trained. We are not aware of evidence suggesting that there are large differences in patient volume by region of origin.

To investigate the possibility of differential patient loads more formally, we provide two additional analyses. First, we replicate our analysis excluding physicians who practice in a zip code containing a university-affiliated hospital. If doctors from top-ranked medical schools see fewer patients on average because they are more likely to engage part-time in teaching or research, then we would expect our results to be attenuated when we exclude physicians in university-affiliated zip codes. The results for all physicians and for GPs are remarkably consistent with those discussed above (see Online Appendix Figure 10 and Online Appendix Table 10).

Second, since publicly available Medicare data include information on both the number of Medicare beneficiaries seen and the number of opioid prescriptions written, we can verify that our results are robust to using a prescription rate (total prescriptions divided by the total number of unique patients) in the Medicare population. As shown in Figure 4, using total prescriptions or prescription rates paints a very similar picture: physicians who attended higher-ranked medical schools prescribe significantly fewer opioids.

Another limitation of the QuintilesIMS data is that we do not know either the number or the strength of the pills included in each prescription. To the extent that physicians trained in different specialties tend to prescribe opioids of different strengths, estimating models by specialty as we have done above will help to mitigate the problem. Still, even within specialty, if physicians trained at top schools always write prescriptions for a month's supply of high-dose opioids, whereas physicians trained at lower-ranked schools always write prescriptions for a few low-dose pills, then differences in the number of prescriptions could emerge without this association having any bearing on the overall provision of opioids. However, even when looking within a given county over time, there is a significant relationship between the number of opioid prescriptions and deaths involving drugs: on average, a 10 percent increase in opioid prescriptions annually is associated with a 1.5 percent increase in deaths involving drugs each year (see Online Appendix Table 11). This relationship suggests that differences in prescribing patterns are not fully offset by differences in the number or strength of pills prescribed, and thus it is meaningful to look at the number of prescriptions as an indicator of physician practice style.

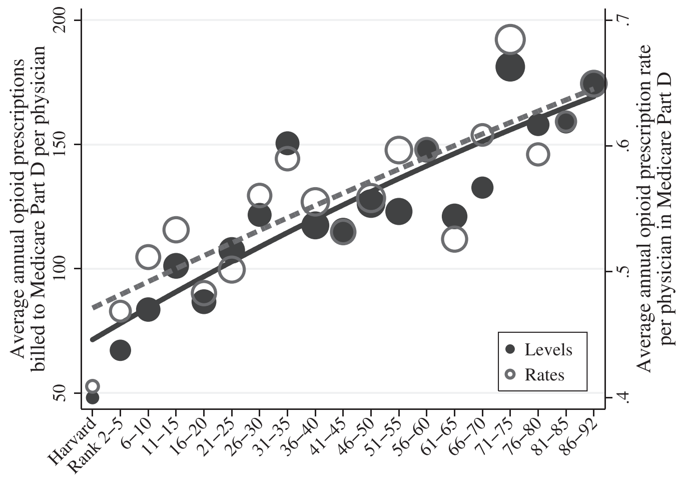
A final limitation is that we only observe where each physician completed his or her initial medical training. Hence, we cannot say how the rankings of institutions where physicians receive subsequent training are related to the propensity to prescribe opioids. However, the fact that physicians in specialties with significant further training in pain management have flatter relationships between opioid prescribing and initial medical school rank strongly suggests that the nature and type of further training is an important determinant of physician practice style. If physicians who receive their initial training at top medical schools are more likely to go on to residencies that offer better training in the use of pain medications, then this could be viewed as one of the mechanisms whereby initial medical school rank affects prescribing behavior.

VII. Discussion and Conclusions

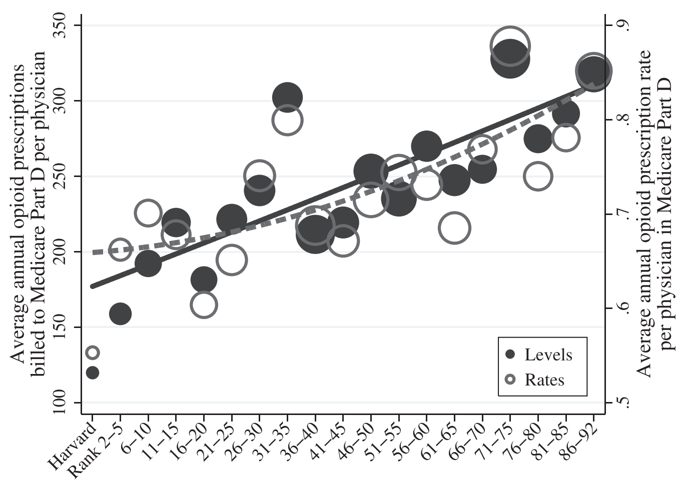
This study offers several new facts about how doctor characteristics are related to their propensity to prescribe opioids. First, between 2006 and 2014, nearly half of all opioids prescribed by doctors were prescribed by GPs. This is true even though doctors in some specialties, like pain medicine, write many more prescriptions per practitioner. Thus, it will be important to understand and modify the prescribing behavior of GPs as well as

FIGURE 4. Opioid prescriptions by medical school rank: Levels versus rates in Medicare Part D

Panel a. All physicians



Panel b. General practitioners



Notes: The above figures depict (1) the average number of opioid prescriptions written per physician and (2) the average opioid prescription rate per physician in Medicare Part D in 2014. Panel a includes all physicians; panel b includes only GPs (physicians in general practice, family practice, and internal medicine). Data on both the number of opioid prescriptions billed to Medicare Part D and the number of Medicare beneficiaries seen per physician are taken from CMS's public use Medicare files; these data are merged via NPI with CMS's Physician Compare database to extract the medical school for each provider.

those of doctors in certain key specialties like pain medicine if the opioid epidemic is to be successfully addressed.

Second, there is a striking inverse relationship between the rank of a physician's medical school and his/her propensity to prescribe opioids, especially among GPs. Previous research indicating that differences in practice style are largely set as early as the first year of medical practice (Epstein, Nicholson, and Asch 2016) suggests that the relationship between initial medical school rank and opioid prescribing behavior could reflect differences in training regarding the appropriate use of opioids across schools. An alternative hypothesis is that the estimated effect of medical school rank on the propensity to prescribe opioids reflects differences in either the types of patients seen by physicians who attend medical schools of higher and lower rank or the types of physicians who are selected into these schools.

While we cannot definitively rule out these alternatives, our ancillary results support the training hypothesis. In particular, the relationship between medical school rank and propensity to prescribe opioids persists even among specialists who attended different medical schools but practice in the exact same hospital or clinic—where patients can be assumed to be relatively homogenous in their need for opioids. Furthermore, the prescribing gradient is less pronounced in specialties in which physicians might be expected to receive specialized training in dealing with pain medications, such as pain medicine and anesthesiology. Finally, given the increasing competition to get into top-ranked medical schools, the fact that the relationship between medical school rank and prescribing behavior has weakened over time (rather than strengthening) further suggests that the relationship reflects the more rapid diffusion of best practices in top schools rather than the selection of certain types of physicians.

We cannot know how training regarding opioids has differed across medical schools over time, or even whether the differences in prescribing practices that we see reflect specific training about opioids. They might, for example, reflect more subtle differences in how doctors are taught to think about potential harms from medication, or periodic reviews of medications that patients are taking. Or they might reflect physician attitudes towards evidence-based medicine more generally.

A review of the curricula at all four medical schools in Massachusetts found that there was no standard in place to make sure that all students were taught safe and effective opioid-prescribing practices before graduation (Antman et al. 2016). Recognizing that more comprehensive training will be needed to improve prescriber practices, in March 2016 the White House asked medical schools to pledge to include the Centers for Disease Control's new opioid-prescribing guidelines in their curriculum. Over 60 medical schools announced that they would update their curriculum by the fall of 2016, with 28 percent (43 percent) of ranked (unranked) US medical schools taking the pledge.[25] If such

25 Refer to https://obamawhitehouse.archives.gov/the-press-office/2016/03/29/fact-sheet-obama-administration-announces-additional-actions-address for a list of the medical schools that pledged to incorporate the CDC's opioid-prescribing guidelines; these guidelines are available at https://www.cdc.gov/mmwr/volumes/65/rr/rr6501e1.htm (Dowell, Haegerich, and Chou 2016).

training is effective in reducing opioid prescribing, then policy makers might consider offering stronger inducements for medical schools to incorporate these guidelines.

Taken together, our findings suggest that a doctor's initial training has a large impact on their attitudes towards opioid prescribing, especially for GPs who are less likely to receive subsequent training in pain management. Since variations in opioid prescribing have contributed to deaths due to the current opioid epidemic, training aimed at reducing prescribing rates among the most liberal prescribers—who disproportionately come from the lowest-ranked medical schools—could possibly have large public health benefits. Education targeting the physicians responsible for the majority of opioid prescribing therefore likely has a role to play in addressing the opioid epidemic.

ACKNOWLEDGEMENTS

We thank Michael Barnett, Amitabh Chandra, Angus Deaton, Jonathan Skinner, Atheendar Venkataramani, and seminar participants at Johns Hopkins Center for Innovative Medicine and the 2016 Population Health Sciences Research Workshop for their helpful feedback.

FUNDING INFORMATION

Generous financial support from the Program on US Health Policy at the Center for Health and Wellbeing at Princeton University is gratefully acknowledged.

REFERENCES

Alpert, Abby, David Powell, and Rosalie Liccardo Pacula. 2016. "Supply-Side Drug Policy in the Presence of Substitutes: Evidence from the Introduction of Abuse-Deterrent Opioids." RAND Working Paper No. WR-1181. Accessed July 2017. http://www.rand.org/pubs/working_papers/WR1181.html.

Antman, Karen H., Harris A. Berman, Monica Bharel, Terence R. Flotte, Jeffrey S. Flier, and Dennis M. Dimitri. 2016. "Developing Core Competencies for the Prevention and Management of Prescription Drug Misuse: A Medical Education Collaboration in Massachusetts." *Academic Medicine* 91 (10): 1348–51.

Bao, Yuhua, Yijun Pan, Aryn Taylor, Sharmini Radakrishnan, Feijun Luo, Harold Alan Pincus, and Bruce R. Schackman. 2016. "Prescription Drug Monitoring Programs Are Associated with Sustained Reductions in Opioid Prescribing by Physicians." *Health Affairs* 35 (6): 1045–51.

Barnett, Michael, Andrew Olenski, and Anupam Jena. 2017. "Opioid-Prescribing Patterns of Emergency Physicians and Risk of Long-Term Use." *New England Journal of Medicine* 376:663–73.

Brewer, Dominic J., Eric R. Eide, and Ronald G. Ehrenberg. 1999. "Does It Pay to Attend an Elite Private College? Cross-Cohort Evidence on the Effects of College Type on Earnings." *Journal of Human Resources* 34 (1): 104–23.

Buchmueller, Thomas C., and Colleen Carey. 2017. "The Effect of Prescription Drug Monitoring Programs on Opioid Utilization in Medicare." NBER Working Paper No. 23148. Accessed July 2017. http://www.nber.org/papers/w23148.

Case, Anne, and Angus Deaton. 2015. "Rising Morbidity and Mortality in Midlife among White Non-Hispanic Americans in the 21st Century." *Proceedings of the National Academy of Sciences* 112 (49): 15078–83.

Chen, Li-Hui, Holly Hedegaard, and Margaret Warner. 2014. "Drug-Poisoning Deaths Involving Opioid Analgesics: United States, 1999–2011." NCHS Data Brief No. 166. Accessed July 2017. http://www.cdc.gov/nchs/data/databriefs/db166.pdf.

Cicero, Theodore J., Matthew S. Ellis, and Hilary L. Surratt. 2012. "Effect of Abuse-Deterrent Formulation of OxyContin." *New England Journal of Medicine* 367 (2): 187–89.

Coleman, James, Elihu Katz, and Herbert Menzel. 1957. "The Diffusion of an Innovation among Physicians." *Sociometry* 20 (4): 253–70.

Dale, Stacy B., and Alan B. Krueger. 2002. "Estimating the Payoff to Attending a More Selective College: An Application of Selection on Observables and Unobservables." *Quarterly Journal of Economics* 117 (4): 1491–527.

Dart, Richard C., Hilary L. Surratt, Theodore J. Cicero, Mark W. Parrino, Geoff Severtson, Becki Bucher-Bartelson, and Jody L. Green. 2015. "Trends in Opioid Analgesic Abuse and Mortality in the United States." *New England Journal of Medicine* 372:241–48.

Dave, Dhaval M., Anca M. Grecu, and Henry Saffer. 2017. "Mandatory Access Prescription Drug Monitoring Programs and Prescription Drug Abuse." NBER Working Paper No. 23537. Accessed July 2017. http://www.nber.org/papers/w23537.

Dowell, Deborah, Tamara M. Haegerich, and Roger Chou. 2016. "CDC Guideline for Prescribing Opioids for Chronic Pain—United States, 2016." *MMWR Recommendations and Reports* 65 (1): 1–49.

Dowell, Deborah, Kun Zhang, Rita K. Noonan, and Jason M. Hockenberry. 2016. "Mandatory Provider Review and Pain Clinic Laws Reduce the Amounts of Opioids Prescribed and Overdose Death Rates." *Health Affairs* 35 (10): 1876–83.

Doyle, Joseph J., Steven M. Ewer, and Todd H. Wagner. 2010. "Returns to Physician Human Capital: Evidence from Patients Randomized to Physician Teams." *Journal of Health Economics* 29 (6): 866–82.

Epstein, Andrew J., and Sean Nicholson. 2009. "The Formation and Evolution of Physician Treatment Style: An Application to Cesarean Sections." *Journal of Health Economics* 28 (6): 1126–40.

Epstein, Andrew J., Sean Nicholson, and David A. Asch. 2016. "The Production of and Market for New Physicians' Skill." *American Journal of Health Economics* 2 (1): 41–65.

Evans, William N., Ethan Lieber, and Patrick Power. 2017. "How the Reformulation of OxyContin Ignited the Heroin Epidemic." Working paper. Accessed July 2017. http://www3.nd.edu/~elieber/research/ELP.pdf.

Haegerich, Tamara M., Leonard Paulozzi, Brian J. Manns, and Christopher Jones. 2014. "What We Know, and Don't Know, About the Impact of State Policy and Systems-Level Interventions on Prescription Drug Overdose." *Drug and Alcohol Dependence* 145:34–47.

Hartz, Arthur J., Evelyn M. Kuhn, and Jose Pulido. 1999. "Prestige of Training Programs and Experience of Bypass Surgeons as Factors in Adjusted Patient Mortality Rates." *Medical Care* 37 (1): 93–103.

Health and Human Services, Substance Abuse and Mental Health Services Administration. 2014. "Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings." NSDUH Series H-48, HHS Publication No. (SMA) 14-4863.

Hoekstra, Mark. 2009. "The Effect of Attending the Flagship State University on Earnings: A Discontinuity-Based Approach." *Review of Economics and Statistics* 91 (4): 717–24.

Hoxby, Caroline M. 2009. "The Changing Selectivity of American Colleges." *Journal of Economic Perspectives* 23 (4): 95–118.

———. 2016. "The Dramatic Economics of the US Market for Higher Education." *NBER Reporter* 3:1–6.

Kennedy-Hendricks, Alene, Matthew Richey, Emma E. McGinty, Elizabeth A. Stuart, Colleen L. Barry, and Daniel W. Webster. 2016. "Opioid Overdose Deaths and Florida's Crackdown on Pill Mills." *American Journal of Public Health* 106 (2): 291–97.

Levy, Benjamin, Leonard Paulozzi, Karin A. Mack, and Christopher Jones. 2015. "Trends in Opioid Analgesic-Prescribing Rates by Specialty, US, 2007–2012." *American Journal of Preventive Medicine* 49 (3): 409–13.

Lucas, Francis L., Brenda E. Sirovich, Patricia M. Gallagher, Andrea E. Siewers, and David E. Wennberg. 2010. "Variation in Cardiologists' Propensity to Test and Treat: Is It Associated with Regional Variation in Utilization?" *Circulation: Cardiovascular Quality and Outcomes* 3 (3): 253–60.

Meara, Ellen, Jill R. Horwitz, Wilson Powell, Lynn McClelland, Weiping Zhou, James O'Malley, and Nancy E. Morden. 2016. "State Legal Restrictions and Prescription Opioid Use among Disabled Adults." *New England Journal of Medicine* 375:44–53.

Meinhofer, Angelica. 2016. "The War on Drugs: Estimating the Effect of Prescription Drug Supply-Side Interventions." Working Paper. Accessed July 2017. http://ssrn.com/abstract=2716974.

Mueller, Shane R., Alexander Y. Walley, Susan L. Calcaterra, Jason M. Glanz, and Ingrid A. Binswanger. 2015. "A Review of Opioid Overdose Prevention and Naloxone Prescribing: Implications for Translating Community Programming into Clinical Practice." *Substance Abuse* 36 (2): 240–53.

Patrick, Stephen W., Carrie E. Fry, Timothy F. Jones, and Melinda B. Buntin. 2016. "Implementation of Prescription Drug Monitoring Programs Associated with Reductions in Opioid-Related Death Rates." *Health Affairs* 35 (7):1324–32.

Paulozzi, Leonard J., Edwin M. Kilbourne, and Hema A. Desai. 2011. "Prescription Drug Monitoring Programs and Death Rates from Drug Overdose." *Pain Medicine* 12 (5): 747–54.

Rees, Daniel I., Joseph J. Sabia, Laura M. Argys, Joshua Latshaw, and Dhaval Dave. 2017. "With a Little Help from My Friends: The Effects of Naloxone Access and Good Samaritan Laws on Opioid-Related Deaths." NBER Working Paper No. 23171. Accessed July 2017. http://www.nber.org/papers/w23171.

Reifler, Liza M., Danna Droz, J. Elise Bailey, Sidney H. Schnoll, Reginald Fant, Richard C. Dart, and Becki Bucher-Bartelson. 2012. "Do Prescription Monitoring Programs Impact State Trends in Opioid Abuse/Misuse?" *Pain Medicine* 13 (3): 434–42.

Ringwalt, Chris, Hallam Gugelmann, Mariana Garrettson, Nabarun Dasgupta, Arlene E. Chung, Scott K. Proescholdbell, and Ashley C. Skinner. 2014. "Differential Prescribing of Opioid Analgesics According to Physician Specialty for Medicaid Patients with Chronic Noncancer Pain Diagnoses." *Pain Research and Management* 19 (4): 179–85.

Rudd, Rose A., Noah Aleshire, Jon E. Zibbell, and Matthew Gladden. 2016. "Increases in Drug and Opioid Overdose Deaths—United States, 2000–2014." *Morbidity and Mortality Weekly Report (MMWR)* 64 (50): 1378–82.

Soumerai, Stephen, Thomas McLaughlin, Jerry H. Gurwitz, Edward Guadagnoli, Paul Hauptman, Catherine Borbas, Nora Morris, Barbara McLaughlin, Xiaoming Gao, Don Willison, et al. 1998. "Effect of Local Medical Opinion Leaders on Quality of Care for Acute Myocardial Infarction: A Randomized Controlled Trial." *JAMA* 279 (17): 1358–63.

Volkow, Nora D., Thomas A. McLellan, Jessica H. Cotto, Meena Karithanom, and Susan R. B. Weiss. 2011. "Characteristics of Opioid Prescriptions in 2009." *JAMA* 305 (13): 1299–301.