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ADDRESSING THE OPIOID EPIDEMIC: IS THERE A ROLE FOR PHYSICIAN EDUCATION?

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ABSTRACT

Using data on all 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 county of practice, 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.

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I. Introduction

Between 2000 and 2014, drug overdoses involving opioids rose 200%, fueling widespread concern about an opioid epidemic and spurring calls for changes in public policy (Chen et al., 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 et al., 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 et al., 2017). Furthermore, among patients treated in the same emergency room, Barnett et al. (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.

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

In this paper, we use comprehensive data on all opioid prescriptions written by doctors in the US 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. As general practitioners (GPs) account for 48% 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.[2]

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% fewer opioid prescriptions and 8.5% 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

[2] We define GPs as physicians in general practice, family practice, and internal medicine.

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.

First, we demonstrate that the relationship between opioid prescriptions and medical school rank persists conditional on physician specialty and county of practice.[3] 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,[4] researchers have examined the impact of the introduction of abuse-deterrent opioids (Cicero and Ellis, 2012; Alpert et al., 2016; Evans et al., 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,

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[3] 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.

[4] 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 et al. (2017) for more recent work.

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 et al., 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 et al. (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 to patients who instead see physicians from a lower ranked program.[5]

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 (Brewer et al., 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

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[5] Although not focused on practice style, Hartz (1999) finds 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.

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 dataset documenting the countries of over 900 foreign medical schools. This data is supplemented with locations of teaching hospitals from the American Hospital Association's (AHA) annual surveys, county-level characteristics from the five-year pooled 2008-2012 American Community Survey (ACS), and county-level mortality from the US Mortality Files.

Our prescription data was purchased from QuintilesIMS, a public company specializing in pharmaceutical market intelligence. This dataset 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.[6]

[6] In particular, we keep prescribers whose status is listed as "active" in 2014 (94.20% of prescribers) and who list a specialty that requires either the degree of medical doctor (MD) or doctor of osteopathic medicine (DO). We

Summary statistics for the annual, physician-level prescription measures that we use are provided in Table 1. We have nine observations for every physician in our sample—one for each year between 2006 and 2014. Table 1 shows that 2.16 billion opioid prescriptions were written between 2006 and 2014; 72.9% of these were written by the 742,297 physicians in our cleaned sample.[7] Although GPs (here defined as physicians in general practice, family practice, and internal medicine) make up only 27.4% of our sample, they wrote 48.2% of all opioids prescribed by physicians between 2006 and 2014 (35.1% of all opioid prescriptions).

Table 1 shows a continuous increase in the number of opioid prescriptions from 2006 to 2012 and then a slight moderation. Nevertheless, in 2014 the average physician wrote 221.7 opioid prescriptions. This figure includes zeros—in 2014, 28.3% of physicians did not write any opioid prescriptions. Among physicians in general practice, these statistics are even more striking: only 16.2% 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."[8] Although medical school rankings change from year to year, we construct a composite medical school rank to use in our analyses. In particular, we take the average of a school's non-missing rankings from 2010 to 2017 and then re-rank schools

exclude physicians whose medical school is not provided or whose medical school name is ambiguous (2.29% of active physicians have missing medical school; 0.12% of active physicians list "University of Medicine" or "College of Medical Sciences" as their medical school). We also exclude prescribers who list a P.O. Box, a home address, or an address of unknown type (0.49% of remaining physicians) in place of an office address as well as physicians whose offices are in US territories (0.06% of remaining physicians). Finally, to avoid including physicians who only practiced for part of a year, we exclude physicians who graduated medical school in 2006 or later (15.93% of remaining physicians).

[7] 19.1% of the remaining prescriptions were written by non-physician providers including dentists, nurse practitioners, and physician assistants. We exclude non-physician providers from our analysis since our data includes no information on where they were trained.

[8] Latest rankings available at https://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-medical-schools.html.

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).[9] Refer to Table S1 for a list of these composite rankings. Figure 1 shows how our composite ranking compares to annual rankings from 2010 to 2017. There is a high correlation between the rankings of medical schools over time (pairwise correlation coefficients are all greater than 0.96 across annual rankings from 2010 to 2017).

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."[10] While the QuintilesIMS data does 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 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 Figure S1 for the distribution of medical schools and physicians in our data across world regions.

In a robustness exercise we exclude physicians whose practice address is in the same zip code as a university-affiliated hospital. To obtain the zip codes of university-affiliated hospitals, we use the AHA's annual surveys from 2007 to 2013. We consider a zip code as containing a university-affiliated hospital if it contained a hospital that reported a university affiliation to the

[9] 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.
[10] Available at http://www.unep.org/tunza/tunzachildren/downloads/country-Classification.pdf; last accessed September 5, 2016).

AMA in any year between 2007 and 2013. According to this measure, 9.4% of zip codes with any physicians in our data include a university-affiliated hospital.

The last piece of information necessary for our analysis are mortality rates. County-level deaths are measured using the US Vital Statistics Mortality Files. 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 under dosing 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 F11-F16, F18, F19). Our results are robust to only including deaths where a drug overdose is listed as the cause of death.

Summary statistics for the annual, county-level mortality measures that we use are provided in Table 2. The table shows the 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 (c.f. 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 (Table 1), 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 2 shows the average number of opioid prescriptions written yearly per physician by medical school rank, both among all physicians (Subfigure A) and among GPs (Subfigure 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 (Table S3).

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. As shown in Figure 3 and Table S2, only 65% of physicians trained at Harvard Medical School wrote at least one opioid prescription in a given year between 2006 and 2014 compared to nearly 80% of physicians from the lowest ranked medical schools.[11] 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% more opioid prescriptions per year than opioid prescribers from Harvard (146.4 versus 381.6; see Table S2).

Turning to the results for physicians trained at unranked medical schools, we see from

[11] Refer to Figure S2 and Table S3 for analogous results for GPs.

Figure 2 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 (Subfigure A) and among GPs (Subfigure B). Comparing the prescribing habits of DOs to MDs, we see that 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.

Figure 4 examines whether there are differences in prescribing practices across world regions of training, both for all physicians (Subfigure A) and for GPs (Subfigure B). Especially among GPs, physicians trained in most regions outside of the US prescribe similarly to physicians trained domestically at top schools. 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. These differences suggest considerable variation in attitudes towards opioids across world regions which doctors bring with them to the US.

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 tradeoff 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**[12]
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 3, there are differences in both the specialties and practice locations chosen across medical school rankings.[13] While only 20% of doctors from the top 30 medical schools are in general practice, over 50% of DOs are GPs. Furthermore, while doctors from the top 30 schools tend to practice in places with greater population density, lower percentages of

[12] We 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.

[13] The eight specialties shown in Table 3 are the top eight opioid-prescribing specialties (Table 4) and together account for 84% of opioid prescriptions in our sample.

white 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 Figures 2-4 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:

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

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, etc. Including this vector of indicators allows the effect of school rank to be non-linear. 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 attended different medical school but who practice in the same county. 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 form:

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

where $Rank_i$ is a continuous measure of medical school rank (graduates of Harvard receive a value of 1, graduates of Johns Hopkins receive a values of 2, etc.)[14] 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.

[14] Refer to Table S1 for a full list of the medical school rankings used.

To estimate the prescribing gradient across different specialties, we estimate Equations (1) and (2) separately for the top eight opioid-prescribing specialties.[15] As shown in Table 4, the eight specialties with the most opioid prescriptions over our sample period are general practice, orthopaedic surgery, emergency medicine, pain medicine, physical medicine and rehabilitation, obstetrics and gynecology, anesthesiology, and general surgery. Of these specialties, those in pain medicine, physical medicine and rehabilitation, and anesthesiology 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 (Figure 1), 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.

[15] 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 sub-specialty fixed effects to account for differences across the three categories of sub-specialties we include in our definition of GPs (general practice, family practice, and internal medicine).

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 5 provides coefficient estimates and 95% confidence intervals on indicators for medical school rank bins from estimation of Equation (1), both for all physicians (Subfigure A) and for GPs (Subfigure B). The figures are scaled so that the coefficients on the highest ranked medical school (Harvard) are set to zero, and all other schools are compared to it. A comparison of Figures 2 and 5 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.

A comparison of specifications with and without controls is shown more formally in Table 5. 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)).[16] 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 5 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 5 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 5, we see that among all physicians (Subfigure 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 2, foreign-trained doctors actually write fewer opioid prescriptions than US-trained doctors once we control for specialty and county of practice.

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

The behavior of foreign-trained doctors is probed further in Figure 6. Here, we plot coefficient estimates from a regression similar to the specification outlined in Equation (1) 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 US write significantly fewer opioid prescriptions per year on average than physicians trained domestically. The stark differences between physicians trained in various regions of the world suggest that differences in training are likely to be important.

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 Figure 7 and column (6) of Table 5. 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 (see Table 4 for opioid prescriptions by specialty). 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 8 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.[17] This can also be seen in Table 6, 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—we see virtually no relationship between initial medical school rank and opioid prescribing, as hypothesized above. This is true despite the fact that doctors who specialize in pain medicine, for example, prescribe many more opioids per physician than doctors in other specialties.[18]

c. Prescribing Gradient Across Cohorts

Figure 9 and Table 7 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 due to the increasing selectivity at top medical schools.

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[17] Figure S3 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.

[18] As shown in Table 4, physicians in pain medicine write an average of 2,040.2 opioid prescriptions per year compared to an average of 414.1 for GPs.

The results show that the relationship between initial medical school rank and opioid prescribing, while significant in all cohorts, has become consistently flatter over time. 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 to 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.

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. To investigate this possibility, we replicate our analysis excluding physicians who practice in a zip code containing a university-affiliated hospital. The results for all physicians and for GPs are shown in columns (2) and (4) of Table 8 and are remarkably consistent with those discussed above (reproduced in columns (1) and (3) of Table 8 for convenience of comparison).[19]

A second limitation is that we do not know either the number or the strength of the pills included in each prescription. If physicians trained at top schools always write prescriptions for a

[19] See Figure S4 for a graphical representation.

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, Table 9 shows that 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% increase in opioid prescriptions annually is associated with a 1.5% increase in deaths involving drugs each year. 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.

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 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. Previous research indicating that differences in practice style are largely set as early as the first year of medical practice (Epstein et al., 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 medical schools such as Harvard, 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, although the evidence suggests that not all physicians receive the same training. A review of the curricula at all four medical schools in Massachusetts, for example, 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 Center for Disease Control's new opioid-prescribing guidelines into their curriculum. Over 60 medical schools announced that they would update their curriculum by the fall of 2016, with 28% (43%) of ranked (unranked) US medical schools taking the pledge.[20] If such 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. 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. Physician education therefore likely has a role to play in addressing the opioid epidemic.

[20] 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.

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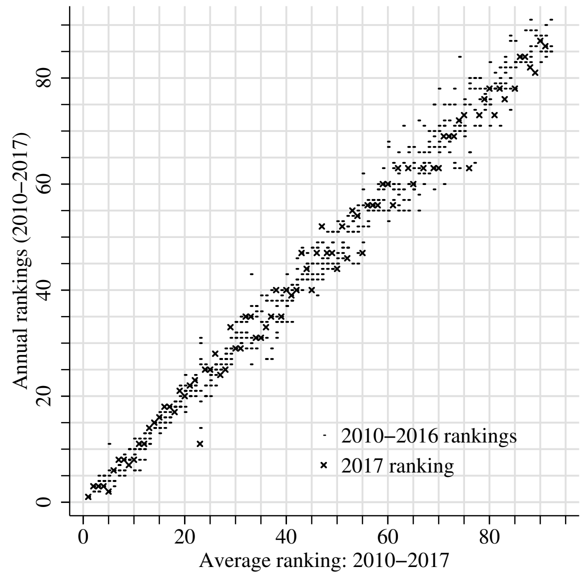
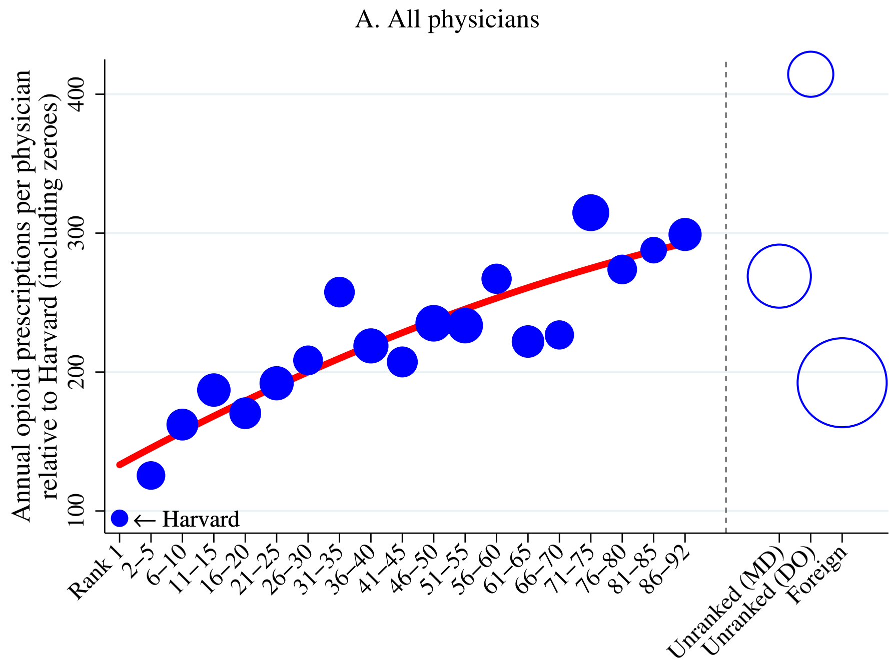
1 Figures

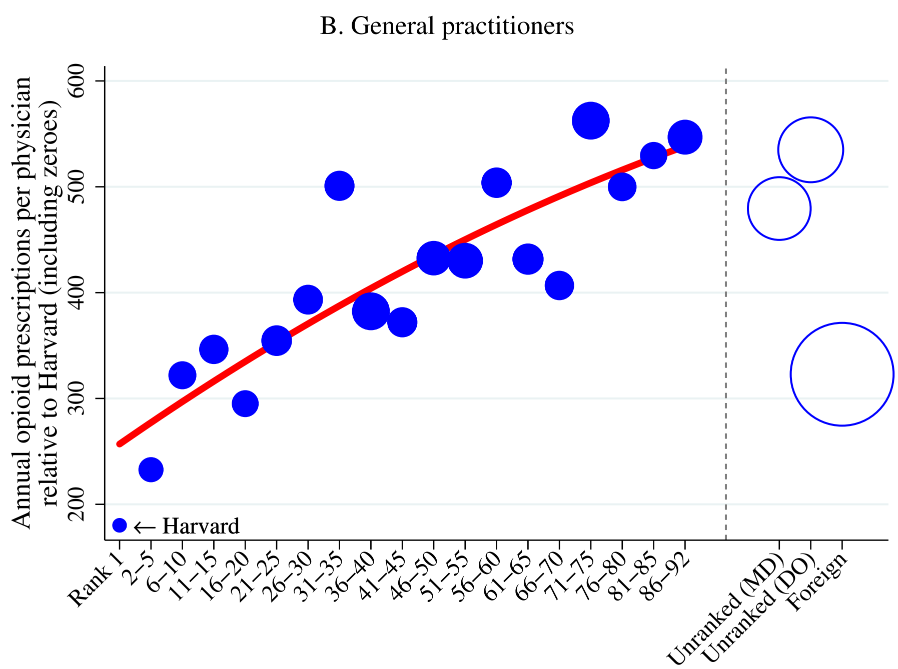
Figure 1: Persistence Across Medical School Rankings Over Time



Notes: The above figure depicts how our composite ranking compares to annual rankings from 2010 to 2017. For each composite rank on the x-axis, there are up to eight observations denoting the corresponding medical school's rank in each year between 2010 and 2017. Annual rankings from 2010-2016 are denoted by a point; the most recent ratings (2017) are denoted by a cross.

Figure 2: Opioid Prescriptions by Medical School Rank

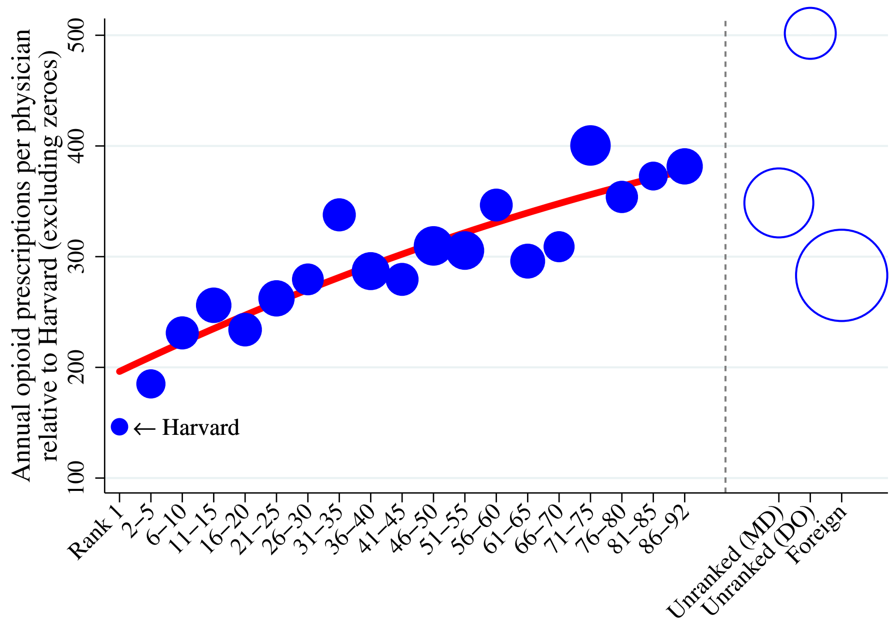




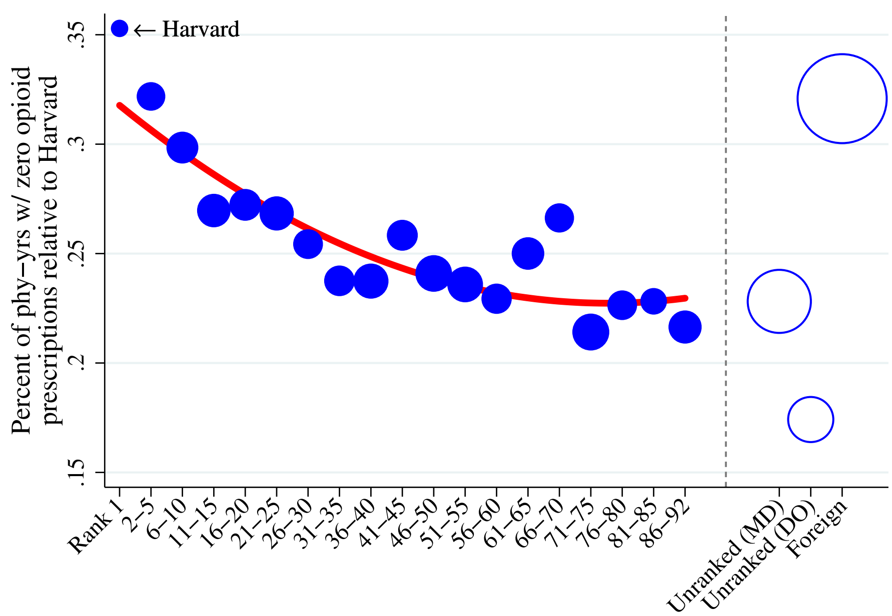
Notes: The above figures depict the average number of opioid prescriptions written yearly per physician by medical school rank. Subfigure A includes all physicians; Subfigure B only includes GPs (physicians in general practice, family practice, and internal medicine). Physician-years with zero opioid prescriptions are included. The size of the marker indicates the number of physician-year observations in a given bin. Refer to Tables S2 and S3 for the underlying averages for all physicians and GPs, respectively.

Figure 3: Opioid Prescriptions by Medical School Rank: Average Excluding Zeroes and Percent Zeroes

A. Average per physician (excluding zeroes)

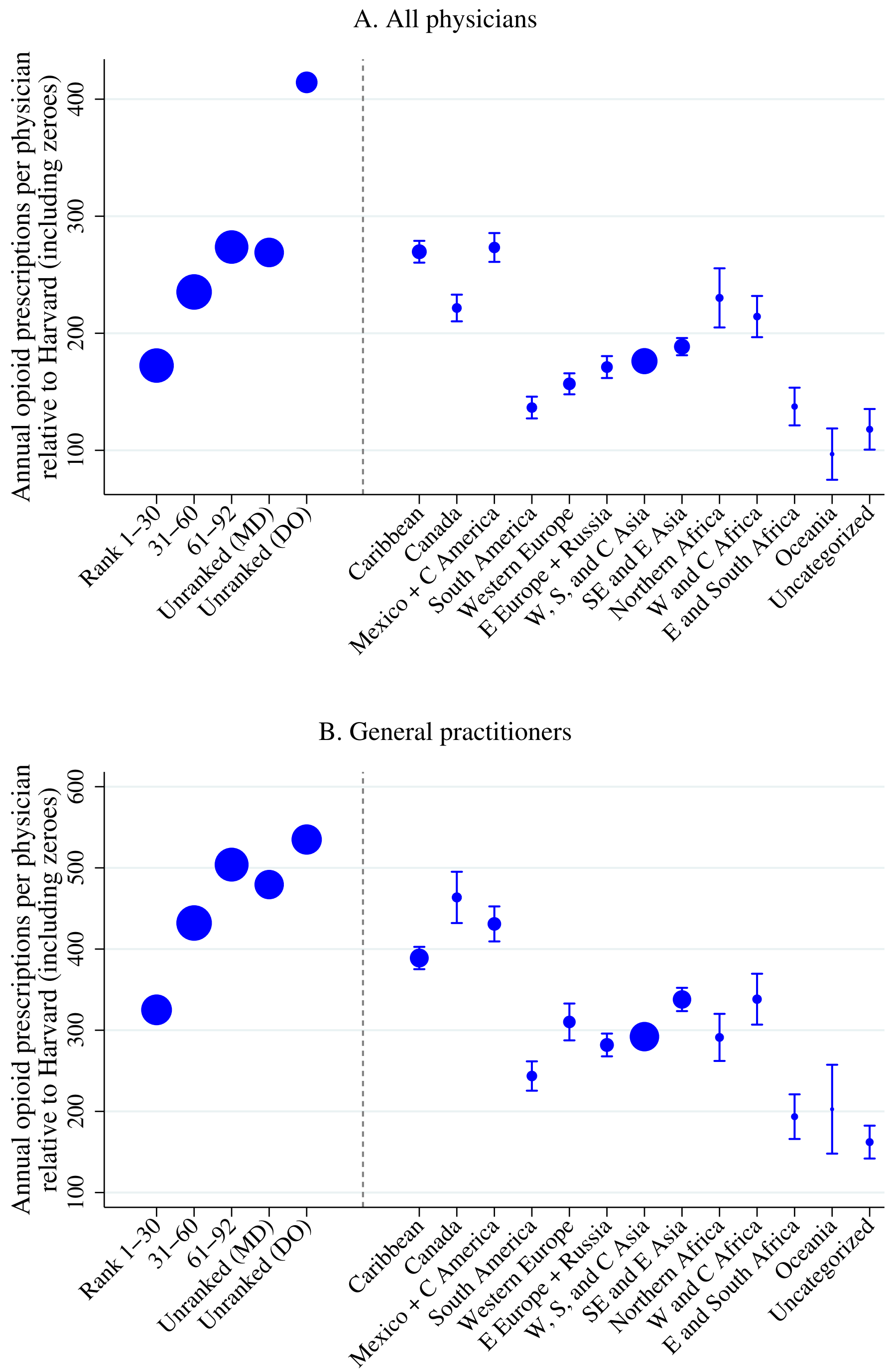


B. Percent with no opioid prescriptions



Notes: The above figures depict the average number of opioid prescriptions written yearly per physician conditional on writing at least one opioid prescription (Subfigure A) and the percent of physician-year observations with zero opioid prescriptions (Subfigure B) by medical school rank. All physicians are included; Figure S2 provides an analogous figure for GPs only. The size of the marker indicates the number of physician-year observations in a given bin. Refer to Table S2 for the underlying averages.

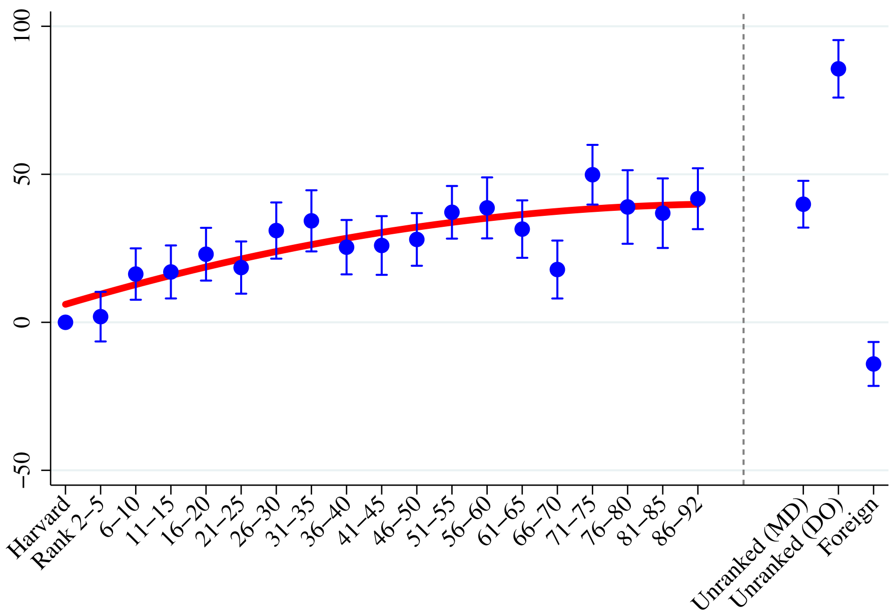
Figure 4: Opioid Prescriptions by US Rankings and Regions of Foreign Schools



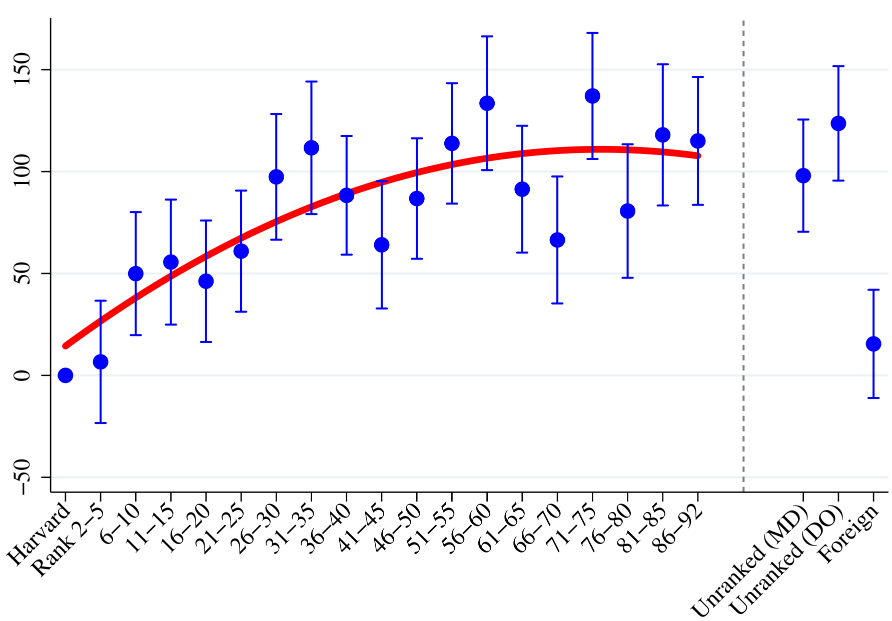
Notes: The above figures depict the average number of opioid prescriptions written yearly per physician by medical school rank for US-trained physicians and region of training for foreign-trained physicians. Subfigure A includes all physicians; Subfigure B only includes GPs (physicians in general practice, 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; confidence intervals not displayed are covered by the marker. Refer to Tables S2 and S3 for the underlying averages for all physicians and GPs, respectively.

Figure 5: Opioid Prescriptions by Medical School Rank Controlling for Specialty and County of Practice

A. All physicians



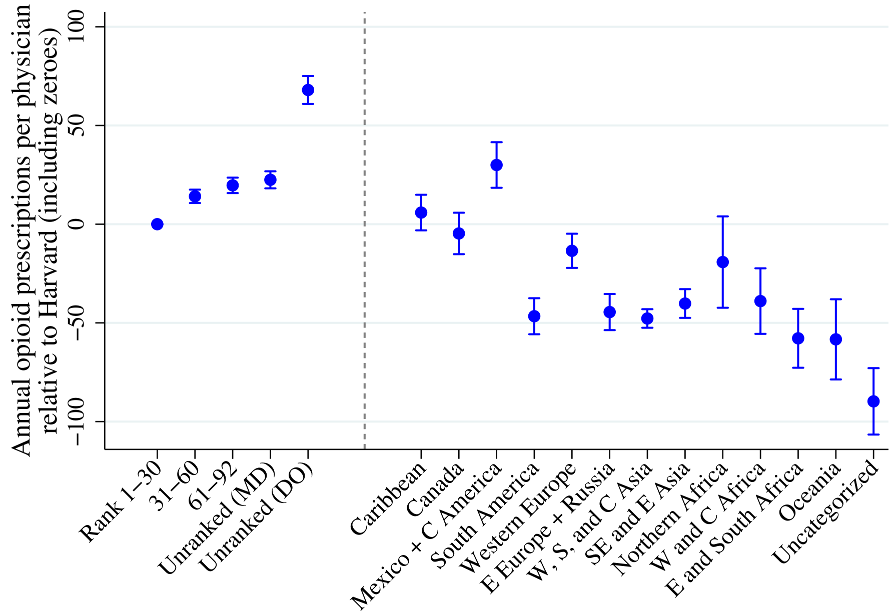
B. General practitioners



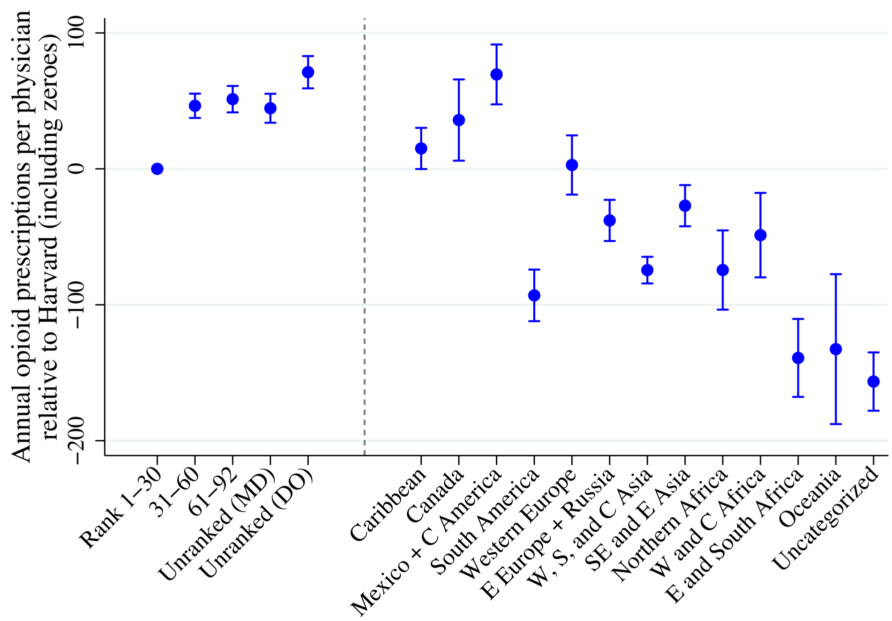
Notes: The above figures depict the coefficient estimates on indicators for medical school rank bins from regressions of opioid prescriptions at the physician-year level on medical school rank bin indicators with year, specialty, and county fixed effects (Equation (1)). Subfigure A includes all physicians; Subfigure B only includes 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 Tables S4 and S5 for the underlying coefficient estimates for all physicians and GPs, respectively.

Figure 6: Opioid Prescriptions by Regions of Foreign Schools Controlling for Specialty and County of Practice

A. All physicians

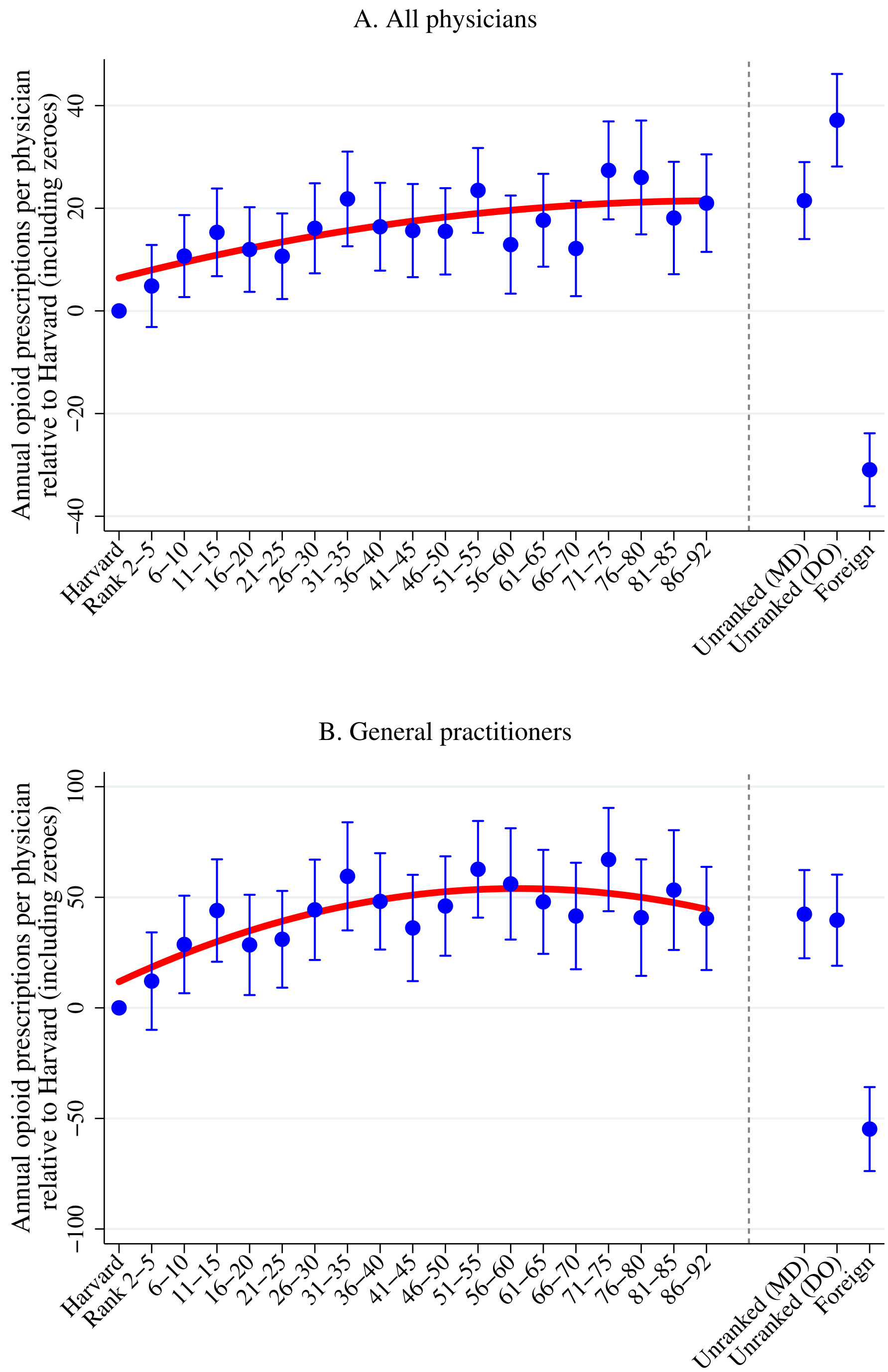


B. General practitioners



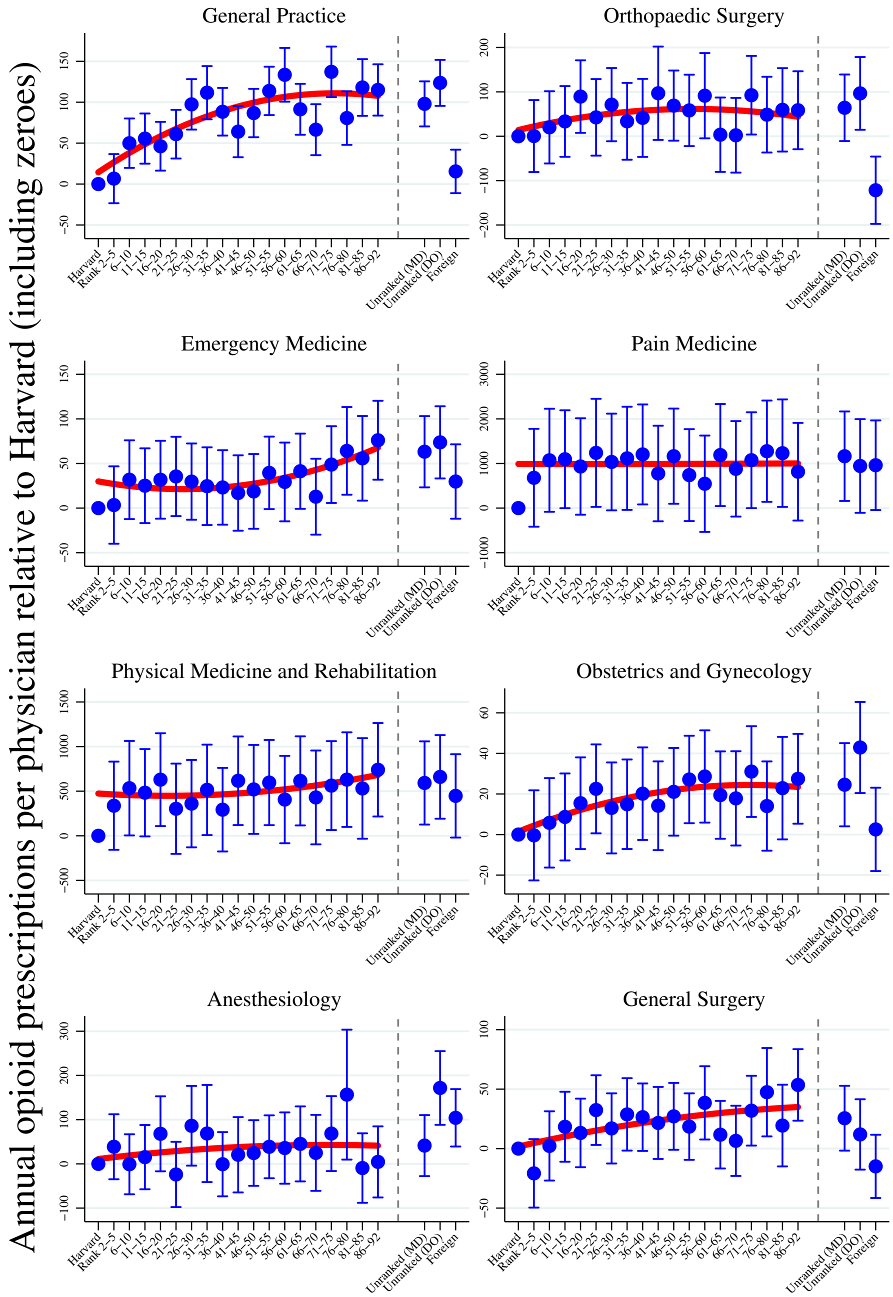
Notes: The above figures depict the coefficient estimates on indicators for medical school rank bins for US-trained physicians and regions of training for foreign-trained physicians from regressions of opioid prescriptions at the physician-year level on medical school rank bin or region indicators with year, specialty, and county fixed effects (variants of Equation (1)). Subfigure A includes all physicians; Subfigure B only includes 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 Tables S4 and S5 for the underlying coefficient estimates for all physicians and GPs, respectively.

Figure 7: Opioid Prescriptions by Medical School Rank Controlling for Specialty and Practice Address



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 practice address fixed effects (variants of Equation (1)). Subfigure A includes all physicians; Subfigure B only includes 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.

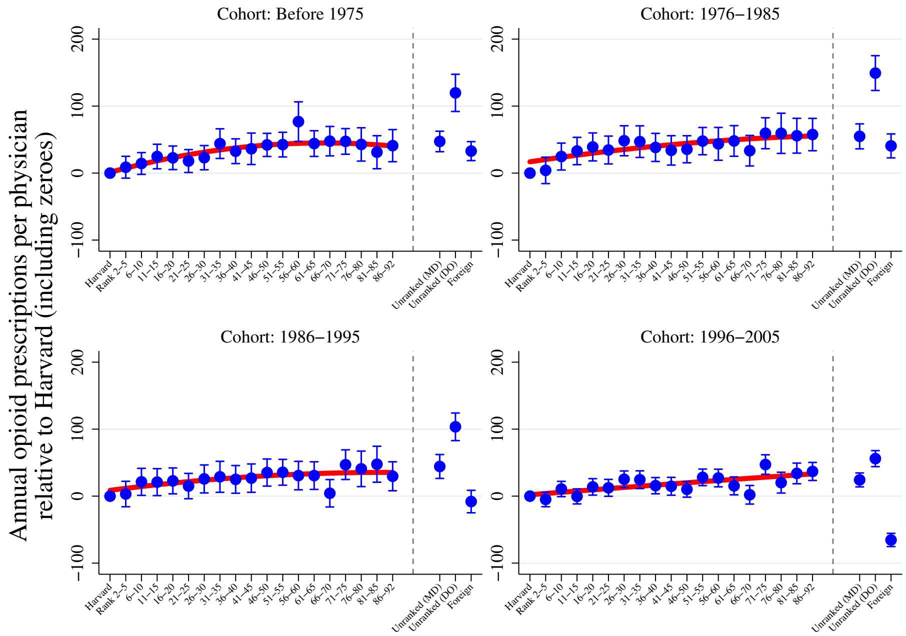
Figure 8: Opioid Prescriptions by Medical School Rank Across Specialties



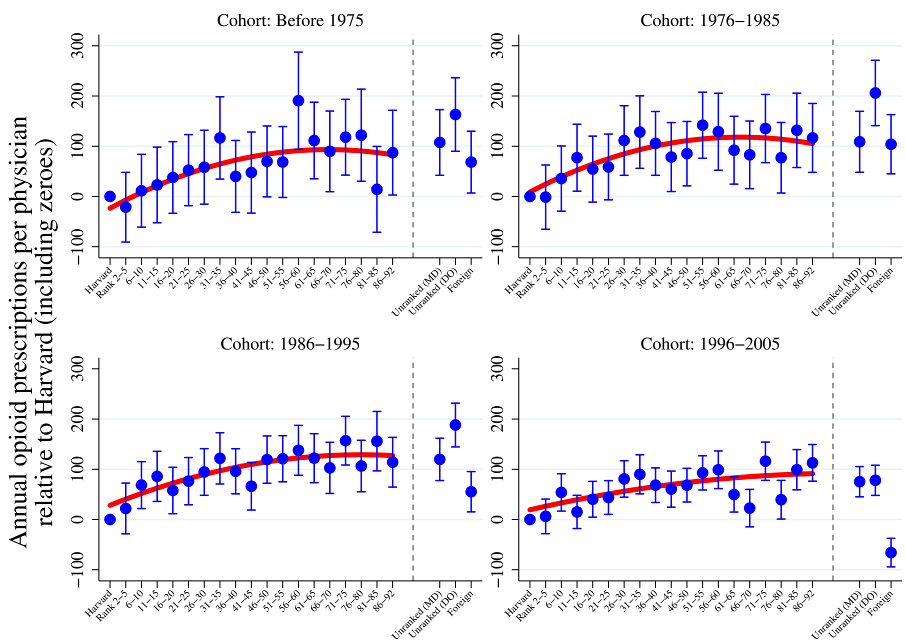
Notes: The above figures depict the coefficient estimates on indicators for medical school rank bins from regressions of opioid prescriptions at the physician-year level on medical school rank bin indicators with year and county fixed effects (variants of Equation (1)). The displayed specialties are the 8 specialties out of 57 specialties with the most opioid prescriptions collectively from 2006-2014 (Table 4). Physician-years with zero opioid prescriptions are included. The bars denote 95% confidence intervals; standard errors are clustered by physician.

Figure 9: Opioid Prescriptions by Medical School Rank Across Graduation Cohorts

A. All physicians



B. General practitioners



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)). Subfigure A includes all physicians; Subfigure B only includes 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.

2 Tables

Table 1: Summary Statistics: Prescription Data

	By year									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	*All*
Total opioids dispensed (100 million)	2.04	2.14	2.21	2.50	2.57	2.58	2.60	2.52	2.44	21.60
Panel A: All physicians										
N physicians	742,297	742,297	742,297	742,297	742,297	742,297	742,297	742,297	742,297	742,297
N physician-years	.	.	.	.	.	.	.	.	.	6,680,673
Opioids prescribed (100 million)	1.52	1.60	1.66	1.89	1.92	1.90	1.87	1.75	1.65	15.74
% of total dispensed	74.5	74.9	75.0	75.4	74.7	73.6	71.6	69.5	67.3	72.9
Average per physician-year	204.9	215.8	223.1	254.1	258.5	255.7	251.4	235.8	221.7	235.7
including zeroes	(1.2)	(1.3)	(1.4)	(1.6)	(1.6)	(1.7)	(1.6)	(1.6)	(1.5)	(1.4)
Average per physician-year	287.1	298.7	303.7	337.1	342.0	339.7	331.4	318.7	309.0	319.0
excluding zeroes	(1.7)	(1.8)	(1.8)	(2.0)	(2.1)	(2.1)	(2.1)	(2.1)	(2.1)	(1.8)
Zeroes (% physician-years)	28.6	27.7	26.5	24.6	24.4	24.7	24.2	26.0	28.3	26.1
Panel B: General practitioners										
N physicians	203,576	203,576	203,576	203,576	203,576	203,576	203,576	203,576	203,576	203,576
N physician-years	.	.	.	.	.	.	.	.	.	1,832,184
Opioids prescribed (100 million)	0.70	0.74	0.77	0.91	0.93	0.92	0.92	0.87	0.82	7.59
% of total dispensed	34.2	34.7	35.0	36.5	36.3	35.8	35.2	34.5	33.5	35.1
Average per physician-year	342.7	364.5	379.9	448.8	458.1	453.0	450.8	427.0	402.4	414.1
including zeroes	(2.8)	(3.0)	(3.1)	(3.5)	(3.6)	(3.5)	(3.5)	(3.3)	(3.2)	(2.9)
Average per physician-year	426.1	446.7	456.3	526.1	534.5	527.8	522.3	501.3	480.3	492.1
excluding zeroes	(3.3)	(3.5)	(3.6)	(3.9)	(4.0)	(4.0)	(3.9)	(3.8)	(3.7)	(3.3)
Zeroes (% physician-years)	19.6	18.4	16.7	14.7	14.3	14.2	13.7	14.8	16.2	15.8

Notes: Standard errors are displayed in parentheses and are clustered by physician. The top row displays the total number of opioids dispensed as reported in the QuintilesIMS data. The next two panels provide summary statistics for our cleaned sample of physicians (Panel A) and GPs (Panel B; physicians in general practice, family practice, and internal medicine). The prescription statistics are raw averages; that is, they do not control for physician specialty or county of practice.

Table 2: Summary Statistics: County-Level Prescriptions and Mortality

	By year									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	*All*
N counties	3,140	3,140	3,140	3,140	3,140	3,140	3,140	3,140	3,140	3,140
N county-years	.	.	.	.	.	.	.	.	.	28,260
Unweighted averages										
Opioid prescriptions/ capita	0.53	0.55	0.56	0.65	0.65	0.65	0.67	0.66	0.64	0.62
Total deaths/100,000	1008.1	1004.8	1024.6	1002.3	1000.0	1015.6	1024.8	1040.0	1050.9	1019.0
Deaths involving drugs/100,000	12.9	13.7	14.0	14.4	14.7	16.0	15.8	16.7	17.4	15.1
Population-weighted averages										
Opioid prescriptions/ capita	0.64	0.67	0.69	0.77	0.79	0.79	0.79	0.76	0.73	0.74
Total deaths/100,000	813.3	804.8	813.1	794.6	797.9	806.9	809.6	820.7	823.6	809.5
Deaths involving drugs/100,000	14.9	15.2	15.1	15.1	15.5	16.7	16.6	17.5	18.6	16.2

Notes: "Deaths involving drugs" include poisonings from drugs resulting in death as well as deaths in which drug dependence was indicated on the death certificate.

Table 3: Opioid Prescriptions and Practice Characteristics by Medical School Rank

		U.S. Ranked			U.S. Unranked		
	Full sample	Top 30	31-60	61-92	M.D.	D.O.	Foreign
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	235.7	172.4	235.3	273.7	269.0	414.3	192.3
including zeroes	(1.4)	(2.4)	(2.9)	(3.6)	(4.1)	(7.2)	(2.7)
Average per physician-year	319.0	240.3	309.5	356.2	348.6	501.7	283.1
excluding zeroes	(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
Orthopaedic 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
County of practice (avg across phys-yrs)							
Pop density (People/1000 sq miles)	3.6	4.9	3.0	2.3	3.6	2.0	4.5
Percent white	71.0	69.2	72.2	72.6	70.0	76.8	69.4
Percent HS or less	40.0	37.7	39.0	40.0	40.7	42.1	41.6
Percent 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
Percent poverty	13.9	13.7	13.6	13.9	14.1	13.6	14.0
Percent uninsured	14.4	13.9	14.1	14.1	14.8	14.0	14.9
Zipcode 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 2006-2014 (Table 4). The prescription statistics are raw averages; that is, they do not control for physician specialty or county of practice.

Table 4: Opioid Prescriptions by Physician Specialty

		Opioid prescriptions					
			Including zeroes		Excluding zeroes		
	Unique physicians	Total (in millions)	Average per phys-yr	95% CI of average	Average per phys-yr	95% CI of average	Zeroes (% phys-yrs)
General Practice	203,576	758.8	414.1	(411, 417)	492.1	(489, 495)	15.8
Orthopaedic Surgery	24,385	147.2	670.5	(661, 681)	750.6	(740, 761)	10.7
Emergency Medicine	33,375	116.5	388.0	(384, 392)	429.7	(425, 434)	9.7
Pain Medicine	3,783	69.5	2040.2	(1947, 2133)	2454.7	(2349, 2560)	16.9
Physical Med & Rehab	8,218	62.2	841.2	(805, 877)	1028.0	(985, 1071)	18.2
Obstetrics & Gynecology	39,794	51.0	142.4	(140, 144)	166.1	(164, 168)	14.2
Anesthesiology	32,585	50.6	172.5	(162, 183)	460.6	(433, 488)	62.6
General Surgery	29,965	49.1	182.2	(179, 185)	224.9	(222, 228)	19.0
Neurology	14,092	30.9	243.3	(230, 256)	321.6	(305, 338)	24.3
Rheumatology	4,949	29.6	664.4	(636, 693)	775.4	(744, 807)	14.3
Hematology & Oncology	19,156	28.7	166.2	(163, 170)	196.7	(193, 201)	15.5
Neurological Surgery	5,540	19.5	391.2	(372, 410)	470.4	(448, 493)	16.8
Urology	10,099	17.6	193.8	(190, 198)	219.9	(216, 224)	11.9
Otolaryngology	9,588	17.3	200.7	(196, 205)	226.9	(222, 231)	11.5
Plastic Surgery	7,914	15.0	210.3	(205, 216)	237.9	(232, 244)	11.6
Sports Medicine	2,593	11.6	496.4	(474, 518)	552.9	(530, 576)	10.2
General other	6,593	10.9	183.2	(175, 191)	218.3	(209, 228)	16.1
Geriatrics	4,518	8.6	212.3	(198, 226)	275.2	(258, 293)	22.9
Cardiovascular Disease	23,274	8.2	39.4	(38, 41)	51.0	(49, 53)	22.8
Pediatrics	50,584	7.5	16.6	(16, 17)	24.5	(24, 26)	32.5

Notes: The displayed specialties are the 20 specialties out of 57 specialties with the most opioid prescriptions collectively from 2006-2014. “General Practice” includes physicians in general practice, family practice, and internal medicine. The prescription statistics are raw averages; that is, they do not control for county of practice. Standard errors are clustered by physician.

Table 5: Opioid Prescriptions by Medical School Rank

A. All physicians	Annual opioid prescriptions					
	(1)	(2)	(3)	(4)	(5)	(6)
Medical rank	2.439***	1.243***	1.524***	1.502***	0.635***	0.263***
	(0.120)	(0.110)	(0.119)	(0.118)	(0.109)	(0.097)
$(\text{Medical rank})^2$	-0.007***	0.001	-0.008***	-0.010***	-0.003***	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	117.071***	71.847**	-9.1e+03***	164.871***	111.570***	232.763***
	(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

B. General practitioners	Annual opioid prescriptions					
	(1)	(2)	(3)	(4)	(5)	(6)
Medical rank	4.147***	2.995***	2.644***	2.784***	2.418***	1.441***
	(0.309)	(0.307)	(0.301)	(0.292)	(0.292)	(0.257)
$(\text{Medical rank})^2$	-0.011***	-0.003	-0.015***	-0.021***	-0.018***	-0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	202.380***	321.419***	-8.3e+03***	295.736***	354.644***	362.420***
	(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 only includes GPs (physicians in general practice, family practice, and internal medicine). Column (3) includes the following county-level controls: population density; percent male; percent in 12 age bins; percent white, black, and Hispanic; percent in seven education categories; percent unemployed; percent in 16 income categories; percent poverty for three different age ranges; percent with public and private health insurance; and median age of housing stock.

Table 6: Opioid Prescriptions by Medical School Rank Across Specialties

	Annual opioid prescriptions (including zeroes)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specialty:	GP	ORS	EM	PMD	PM	OBG	AN	GS
Medical rank	2.418***	1.920**	-0.631*	-3.814	-4.467	0.658***	0.788	0.650***
	(0.292)	(0.846)	(0.368)	(9.275)	(4.110)	(0.181)	(0.865)	(0.244)
(Medical rank)^2	-0.018***	-0.018*	0.013***	0.038	0.067	-0.005**	-0.003	-0.003
	(0.003)	(0.009)	(0.004)	(0.101)	(0.044)	(0.002)	(0.010)	(0.003)
Constant	354.644***	537.923***	70.700***	1507.539***	301.616	87.348***	-26.520	126.145***
	(6.264)	(20.956)	(20.580)	(207.711)	(328.576)	(22.719)	(23.612)	(20.778)
N (phys-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 2006-2014 (Table 4): they are general practice (GP), orthopaedic surgery (ORS), emergency medicine (EM), pain medicine (PMD), physician medicine and rehabilitation (PM), obstetrics and gynecology (OBG), anesthesiology (AN), and general surgery (GS).

Table 7: Opioid Prescriptions by Medical School Rank Across Cohorts

A. All physicians	Annual opioid prescriptions (including zeroes)				
	(1)	(2)	(3)	(4)	(5)
Graduation cohort:	All	$\leq$ 1975	1976-1985	1986-1995	1996-2005
Medical rank	0.635***	1.242***	0.718***	0.481**	0.264*
	(0.109)	(0.219)	(0.242)	(0.240)	(0.143)
(Medical rank)^2	-0.003***	-0.009***	-0.003	-0.002	-0.000
	(0.001)	(0.003)	(0.003)	(0.003)	(0.002)
Constant	111.570***	29.659	185.029***	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

B. General practitioners	Annual opioid prescriptions (including zeroes)				
	(1)	(2)	(3)	(4)	(5)
Graduation cohort:	All	$\leq$ 1975	1976-1985	1986-1995	1996-2005
Medical rank	2.418***	3.551***	3.210***	2.073***	1.277***
	(0.292)	(0.745)	(0.613)	(0.547)	(0.410)
(Medical rank)^2	-0.018***	-0.027***	-0.026***	-0.014**	-0.009**
	(0.003)	(0.009)	(0.007)	(0.006)	(0.004)
Constant	354.644***	354.397***	437.960***	375.733***	247.608***
	(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 only includes GPs (physicians in general practice, family practice, and internal medicine).

Table 8: Opioid Prescriptions by Medical School Rank Excluding University-Affiliated Zip Codes

	Annual opioid prescriptions (including zeroes)			
	All physicians		General practitioners	
	(1)	(2)	(3)	(4)
Medical rank	0.635***	0.814***	2.418***	2.325***
	(0.109)	(0.168)	(0.292)	(0.415)
(Medical rank)^2	-0.003***	-0.006***	-0.018***	-0.018***
	(0.001)	(0.002)	(0.003)	(0.004)
Constant	111.570***	93.507**	354.644***	391.920***
	(31.767)	(36.805)	(6.264)	(9.011)
Excl. uni. zips	No	Yes	No	Yes
N (physician-years)	3,635,532	1,922,193	832,005	539,064
R^2	0.194	0.209	0.178	0.186

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)). Columns (1)-(2) include all physicians; Columns (3)-(4) only include GPs (physicians in general practice, family practice, and internal medicine). Columns (2) and (4) exclude physicians whose practice address is in a zip code with a university-affiliated hospital. Standard errors are clustered by physician.

Table 9: Opioid Prescriptions and Deaths Involving Drugs

	ln(Deaths involving drugs per capita)	
	(1)	(2)
ln(Opioid prescriptions per capita)	0.286***	0.150***
	(0.026)	(0.040)
County FEs	No	Yes
N (county-years)	22,801	22,801
R^2	0.118	0.706

Notes: The above table presents output from regressions of log deaths involving drugs per capita at the county-year year on log opioid prescriptions per capita at the county-year level. All specifications include year fixed effects. Standard errors are clustered by county. We define "deaths involving drugs" as both poisonings from drugs resulting in death as well as deaths in which drug dependence was indicated on the death certificate.

A Supplementary Tables and Figures

Table S1: Composite Medical School Rankings

1	HARVARD MEDICAL SCHOOL	47	WAKE FOREST SCHOOL OF MEDICINE
2	JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE	48	INDIANA UNIVERSITY SCHOOL OF MEDICINE
3	PERELMAN SCHOOL OF MEDICINE AT UPENN	49	TUFTS UNIVERSITY SCHOOL OF MEDICINE
4	UCSF SCHOOL OF MEDICINE	50	UNIVERSITY OF MIAMI MILLER SCHOOL OF MEDICINE
5	STANFORD UNIVERSITY SCHOOL OF MEDICINE	51	UNIVERSITY OF MASSACHUSETTS MEDICAL SCHOOL
6	WASH U IN ST LOUIS SCHOOL OF MEDICINE	52	UNIVERSITY OF UTAH SCHOOL OF MEDICINE
7	YALE UNIVERSITY SCHOOL OF MEDICINE	53	MEDICAL COLLEGE OF WISCONSIN
8	DUKE UNIVERSITY SCHOOL OF MEDICINE	54	TEMPLE UNIVERSITY SCHOOL OF MEDICINE
9	COLUMBIA U COLLEGE OF PHYSICIANS AND SURGEONS	55	UNIVERSITY OF ILLINOIS AT CHICAGO COLLEGE OF MEDICINE
10	UNIVERSITY OF WASHINGTON SCHOOL OF MEDICINE	56	UNIVERSITY OF TEXAS MEDICAL SCHOOL AT HOUSTON
11	UNIVERSITY OF MICHIGAN MEDICAL SCHOOL	57	SCHOOL OF MEDICINE AT STONY BROOK UNIVERSITY
12	UCHICAGO PRITZKER SCHOOL OF MEDICINE	58	UNIVERSITY OF VERMONT COLLEGE OF MEDICINE
13	DAVID GEFFEN SCHOOL OF MEDICINE AT UCLA	59	MEDICAL UNIVERSITY OF SOUTH CAROLINA
14	VANDERBILT UNIVERSITY SCHOOL OF MEDICINE	60	UT SCHOOL OF MEDICINE AT SAN ANTONIO
15	UNIVERSITY OF PITTSBURGH SCHOOL OF MEDICINE	61	SIDNEY KIMMEL MEDICAL COLLEGE AT THOMAS JEFFERSON U
16	UCSD SCHOOL OF MEDICINE	62	UNIVERSITY OF CONNECTICUT SCHOOL OF MEDICINE
17	WEILL CORNELL MEDICAL COLLEGE	63	UNIVERSITY AT BUFFALO SCHOOL OF MEDICINE
18	NORTHWESTERN UNIVERSITY	64	GEORGE WASHINGTON UNIVERSITY SCHOOL OF MEDICINE
19	ICHAN SCHOOL OF MEDICINE AT MOUNT SINAI	65	UNIVERSITY OF KENTUCKY COLLEGE OF MEDICINE
20	BAYLOR COLLEGE OF MEDICINE	66	UNIFORMED SERVICES F E HEBERT SCHOOL OF MEDICINE
21	UNC AT CHAPEL HILL SCHOOL OF MEDICINE	67	UNIVERSITY OF NEBRASKA COLLEGE OF MEDICINE
22	EMORY UNIVERSITY SCHOOL OF MEDICINE	68	RUSH MEDICAL COLLEGE OF RUSH UNIVERSITY
23	NEW YORK UNIVERSITY SCHOOL OF MEDICINE	69	ST LOUIS UNIVERSITY SCHOOL OF MEDICINE
24	UT SOUTHWESTERN MEDICAL SCHOOL	70	UNIVERSITY OF ARIZONA COLLEGE OF MEDICINE
25	CASE WESTERN UNIVERSITY SCHOOL OF MEDICINE	71	UNIVERSITY OF KANSAS SCHOOL OF MEDICINE
26	UNIVERSITY OF VIRGINIA SCHOOL OF MEDICINE	72	VIRGINIA COMMONWEALTH U SCHOOL OF MEDICINE
27	MAYO MEDICAL SCHOOL	73	WAYNE STATE UNIVERSITY SCHOOL OF MEDICINE
28	UNIVERSITY OF WISCONSIN SCHOOL OF MEDICINE	74	UNIVERSITY OF OKLAHOMA COLLEGE OF MEDICINE
29	UNIVERSITY OF IOWA	75	MEDICAL COLLEGE OF GEORGIA AT GEORGIA REGENTS U
30	UNIVERSITY OF ROCHESTER SCHOOL OF MEDICINE	76	U OF SOUTH FLORIDA HEALTH MORSANI COLLEGE OF MEDICINE
31	BOSTON UNIVERSITY SCHOOL OF MEDICINE	77	RUTGERS ROBERT WOOD JOHNSON MEDICAL SCHOOL
32	WARREN ALPERT MEDICAL SCHOOL OF BROWN	78	RUTGERS NEW JERSEY MEDICAL SCHOOL
33	UNIVERSITY OF ALABAMA SCHOOL OF MEDICINE	79	UNIVERSITY OF MISSOURI COLUMBIA SCHOOL OF MEDICINE
34	OREGON HEALTH & SCIENCE UNIVERSITY	80	UNIVERSITY OF LOUISVILLE SCHOOL OF MEDICINE
35	KECK SCHOOL OF MEDICINE OF THE USC	81	UNIVERSITY OF TENNESSEE COLLEGE OF MEDICINE
36	OHIO STATE UNIVERSITY COLLEGE OF MEDICINE	82	CREIGHTON UNIVERSITY SCHOOL OF MEDICINE
37	UNIVERSITY OF COLORADO SCHOOL OF MEDICINE	83	TEXAS A&M UNIVERSITY COLLEGE OF MEDICINE
38	GEISEL SCHOOL OF MEDICINE AT DARTMOUTH	84	UNIVERSITY OF HAWAII AT MANOA
39	UNIVERSITY OF MINNESOTA MEDICAL SCHOOL	85	UNIVERSITY OF NEW MEXICO SCHOOL OF MEDICINE
40	UNIVERSITY OF MARYLAND SCHOOL OF MEDICINE	86	UNIVERSITY OF ARKANSAS COLLEGE OF MEDICINE
41	ALBERT EINSTEIN COLLEGE OF MEDICINE OF YESHIVA U	87	TEXAS TECH UNIVERSITY SCHOOL OF MEDICINE
42	UNIVERSITY OF CINCINNATI COLLEGE OF MEDICINE	88	DREXEL UNIVERSITY COLLEGE OF MEDICINE
43	UC DAVIS SCHOOL OF MEDICINE	89	UNIVERSITY OF NEVADA SCHOOL OF MEDICINE
44	UC IRVINE COLLEGE OF MEDICINE	90	MICHIGAN STATE UNIVERSITY COLLEGE OF HUMAN MEDICINE
45	UNIVERSITY OF FLORIDA COLLEGE OF MEDICINE	91	WEST VIRGINIA UNIVERSITY SCHOOL OF MEDICINE
46	GEORGETOWN UNIVERSITY SCHOOL OF MEDICINE	92	UNIVERSITY OF SOUTH CAROLINA SCHOOL OF MEDICINE

Notes: The above table lists the composite rankings used for ranked US medical schools. Refer to Section II for a detailed overview of how these rankings are constructed.

Table S2: Opioid Prescriptions by Medical School Rank

		Opioid prescriptions					
			Including zeroes		Excluding zeroes		
	Unique physicians	Total (in millions)	Average per phy-yr	95% CI of average	Average per phy-yr	95% CI of average	Zeroes (% phys-yrs)
A. US trained							
Ranked							
1 (Harvard)	5,762	4.9	94.7	(88, 102)	146.4	(136, 157)	35.3
2-5	17,155	19.4	125.5	(120, 131)	185.1	(178, 192)	32.2
6-10	21,602	31.5	162.2	(156, 168)	231.2	(223, 239)	29.8
11-15	24,031	40.4	187.0	(181, 193)	256.1	(248, 264)	27.0
16-20	21,589	33.1	170.4	(164, 177)	234.1	(226, 242)	27.2
21-25	25,246	43.6	191.9	(186, 198)	262.3	(254, 270)	26.8
26-30	18,734	35.1	208.4	(202, 215)	279.5	(271, 288)	25.4
31-35	19,919	46.2	257.5	(249, 266)	337.8	(327, 349)	23.8
36-40	26,607	52.4	218.8	(213, 225)	286.9	(279, 295)	23.7
41-45	20,308	37.9	207.3	(199, 215)	279.5	(269, 290)	25.8
46-50	29,076	61.5	235.1	(229, 241)	309.7	(302, 318)	24.1
51-55	27,519	57.8	233.5	(227, 240)	305.6	(298, 313)	23.6
56-60	19,393	46.6	267.1	(259, 276)	346.6	(336, 357)	22.9
61-65	22,628	45.2	222.0	(214, 229)	296.0	(286, 306)	25.0
66-70	18,054	36.8	226.7	(219, 234)	309.0	(299, 319)	26.6
71-75	29,563	83.7	314.7	(307, 323)	400.4	(391, 410)	21.4
76-80	18,561	45.7	273.8	(263, 285)	354.0	(340, 368)	22.6
81-85	14,668	38.0	287.7	(277, 298)	372.8	(360, 386)	22.8
86-92	23,533	63.3	299.0	(291, 307)	381.6	(371, 392)	21.6
Unranked							
US (MD)	96,644	234.0	269.0	(265, 273)	348.6	(343, 354)	22.8
US (DO)	49,376	184.1	414.3	(407, 422)	501.7	(493, 510)	17.4
US total	549,968	1241.5	250.8	(249, 252)	330.2	(328, 332)	24.0
B. Foreign trained							
Caribbean	21,154	51.3	269.7	(260, 279)	363.7	(352, 376)	25.9
Canada	7,931	15.8	221.6	(210, 233)	324.7	(309, 341)	31.8
Mexico + C America	11,502	28.3	273.3	(261, 286)	357.4	(342, 373)	23.5
South America	9,501	11.7	136.6	(127, 146)	214.3	(200, 228)	36.3
Western Europe	14,673	20.7	156.8	(148, 166)	242.2	(229, 256)	35.2
E Europe + Russia	12,185	18.8	171.1	(162, 180)	256.4	(243, 270)	33.2
W, S, and C Asia	74,392	118.0	176.2	(172, 180)	257.8	(252, 264)	31.7
SE and E Asia	25,053	42.5	188.6	(181, 196)	291.1	(280, 302)	35.2
Northern Africa	4,843	10.0	230.2	(205, 255)	344.1	(307, 381)	33.1
W and C Africa	4,177	8.1	214.3	(197, 232)	313.7	(289, 339)	31.7
E and South Africa	2,671	3.3	137.4	(121, 154)	215.0	(191, 239)	36.1
Oceania	863	0.8	96.8	(75, 119)	178.0	(139, 217)	45.6
Uncategorized	3,384	3.6	118.0	(101, 135)	233.0	(200, 266)	49.4
Foreign total	192,329	332.8	192.3	(190, 195)	283.1	(279, 287)	32.1
Total	742,297	1574.3	235.7	(234, 237)	319.0	(317, 321)	26.1

Notes: The prescription statistics are raw averages; that is, they do not control for specialty or county of practice. Standard errors are clustered by physician.

Table S3: Opioid Prescriptions by Medical School Rank: General Practitioners

		Opioid prescriptions					
			Including zeroes		Excluding zeroes		
	Unique physicians	Total (in millions)	Average per phy-yr	95% CI of average	Average per phy-yr	95% CI of average	Zeroes (% phys-yrs)
A. US trained							
Ranked							
1 (Harvard)	947	1.5	180.2	(153, 207)	248.9	(214, 284)	27.6
2-5	3,175	6.6	232.7	(217, 248)	298.4	(279, 317)	22.0
6-10	4,029	11.7	321.9	(306, 338)	398.1	(379, 417)	19.1
11-15	4,447	13.9	346.4	(330, 363)	410.8	(392, 430)	15.7
16-20	3,693	9.8	295.1	(280, 310)	354.2	(337, 372)	16.7
21-25	4,890	15.6	354.6	(339, 370)	420.0	(403, 437)	15.6
26-30	4,610	16.3	393.3	(377, 410)	444.4	(427, 462)	11.5
31-35	4,718	21.3	500.9	(478, 524)	580.5	(555, 606)	13.7
36-40	7,625	26.2	382.4	(370, 394)	435.8	(423, 449)	12.3
41-45	4,719	15.8	372.0	(354, 390)	436.7	(417, 457)	14.8
46-50	6,295	24.5	432.5	(418, 447)	498.6	(482, 515)	13.3
51-55	6,762	26.2	430.2	(415, 445)	488.3	(472, 505)	11.9
56-60	4,839	21.9	503.8	(483, 525)	562.8	(540, 585)	10.5
61-65	5,107	19.8	431.6	(413, 451)	495.7	(475, 517)	12.9
66-70	4,463	16.3	406.7	(390, 424)	484.7	(466, 503)	16.1
71-75	7,645	38.7	562.5	(546, 579)	627.6	(610, 645)	10.4
76-80	4,228	19.0	499.9	(477, 523)	569.7	(545, 595)	12.3
81-85	3,801	18.1	529.5	(505, 554)	600.9	(575, 627)	11.9
86-92	6,452	31.8	546.9	(528, 566)	613.7	(593, 635)	10.9
Unranked							
US (MD)	23,363	100.8	479.4	(470, 488)	542.4	(533, 552)	11.6
US (DO)	25,020	120.5	534.9	(525, 545)	608.5	(597, 620)	12.1
US total	140,828	576.4	454.8	(451, 458)	522.9	(519, 527)	13.0
B. Foreign trained							
Caribbean	8,904	31.2	388.9	(375, 403)	466.1	(450, 482)	16.5
Canada	2,064	8.6	463.6	(432, 495)	579.8	(543, 617)	20.0
Mexico + C America	4,203	16.3	431.0	(409, 453)	509.9	(485, 534)	15.5
South America	2,325	5.1	243.6	(226, 262)	327.5	(305, 350)	25.6
Western Europe	3,501	9.8	310.2	(287, 333)	396.4	(368, 424)	21.8
E Europe + Russia	4,451	11.3	281.8	(268, 296)	353.7	(337, 370)	20.3
W, S, and C Asia	23,502	61.8	292.1	(284, 300)	384.4	(375, 394)	24.0
SE and E Asia	8,472	25.8	337.9	(324, 352)	434.2	(417, 452)	22.2
Northern Africa	1,477	3.9	291.1	(262, 320)	393.6	(357, 431)	26.0
W and C Africa	1,759	5.4	338.2	(307, 370)	454.0	(414, 494)	25.5
E and South Africa	810	1.4	193.5	(166, 221)	278.1	(241, 315)	30.4
Oceania	138	0.3	202.7	(148, 257)	305.1	(232, 379)	33.6
Uncategorized	1,142	1.7	162.1	(142, 182)	272.9	(242, 304)	40.6
Foreign total	62,748	182.3	322.9	(318, 328)	414.9	(409, 421)	22.2
Total	203,576	758.8	414.1	(411, 417)	492.1	(489, 495)	15.8

Notes: Only GPs are included (physicians in general practice, family practice, and internal medicine). The prescription statistics are raw averages; that is, they do not control for specialty or county of practice. Standard errors are clustered by physician.

Table S4: Opioid Prescriptions by Medical School Rank Controlling for Specialty and County of Practice

	Annual opioid prescriptions					
	Including zeroes		Excluding zeroes		I[zero]	
	Coeff.	s.e.	Coeff.	s.e.	Coeff.	s.e.
A. By medical school rank						
1 (Harvard)	0	-	0	-	0	-
2-5	1.91	(4.27)	0.33	(5.99)	-0.02***	(0.00)
6-10	16.30***	(4.42)	16.93***	(6.17)	-0.03***	(0.00)
11-15	17.00***	(4.57)	14.52**	(6.28)	-0.05***	(0.00)
16-20	23.00***	(4.54)	21.86***	(6.24)	-0.05***	(0.00)
21-25	18.49***	(4.50)	17.29***	(6.17)	-0.05***	(0.00)
26-30	30.99***	(4.84)	29.96***	(6.58)	-0.05***	(0.00)
31-35	34.27***	(5.27)	31.98***	(7.04)	-0.06***	(0.00)
36-40	25.37***	(4.69)	23.38***	(6.36)	-0.06***	(0.00)
41-45	25.95***	(5.06)	22.82***	(6.86)	-0.06***	(0.00)
46-50	27.99***	(4.54)	25.86***	(6.15)	-0.06***	(0.00)
51-55	37.16***	(4.54)	36.59***	(6.14)	-0.06***	(0.00)
56-60	38.65***	(5.26)	33.11***	(6.97)	-0.07***	(0.00)
61-65	31.48***	(4.95)	29.34***	(6.71)	-0.06***	(0.00)
66-70	17.83***	(4.99)	21.51***	(6.77)	-0.03***	(0.00)
71-75	49.85***	(5.15)	44.37***	(6.81)	-0.07***	(0.00)
76-80	38.96***	(6.34)	35.70***	(8.29)	-0.07***	(0.00)
81-85	36.86***	(5.99)	35.10***	(7.83)	-0.07***	(0.00)
86-92	41.75***	(5.25)	34.50***	(6.95)	-0.07***	(0.00)
Unranked US (MD)	39.89***	(4.03)	35.69***	(5.58)	-0.07***	(0.00)
Unranked US (DO)	85.63***	(4.95)	85.53***	(6.46)	-0.06***	(0.00)
Foreign	-14.07***	(3.79)	-4.55	(5.36)	0.02***	(0.00)
B. By regions of training						
Rank 1-30	0	-	0	-	0	-
31-60	14.10***	(1.73)	12.53***	(2.23)	-0.02***	(0.00)
61-92	19.67***	(2.00)	17.59***	(2.55)	-0.02***	(0.00)
Unranked US (MD)	22.49***	(2.21)	19.18***	(2.81)	-0.03***	(0.00)
Unranked US (DO)	67.99***	(3.61)	68.79***	(4.28)	-0.02***	(0.00)
Caribbean	5.88	(4.60)	14.96**	(5.92)	0.01***	(0.00)
Canada	-4.69	(5.36)	14.60**	(7.31)	0.07***	(0.00)
Mexico + C America	29.99***	(5.90)	40.17***	(7.40)	-0.01***	(0.00)
South America	-46.63***	(4.66)	-40.44***	(6.77)	0.08***	(0.00)
Western Europe	-13.49***	(4.42)	-2.33	(6.45)	0.07***	(0.00)
E Europe + Russia	-44.53***	(4.67)	-42.60***	(6.57)	0.05***	(0.00)
W, S, and C Asia	-47.78***	(2.40)	-40.53***	(3.30)	0.06***	(0.00)
SE and E Asia	-40.19***	(3.71)	-29.63***	(5.36)	0.07***	(0.00)
Northern Africa	-19.20	(11.81)	1.39	(16.90)	0.06***	(0.00)
W and C Africa	-38.97***	(8.47)	-19.44*	(11.70)	0.08***	(0.00)
E and South Africa	-57.82***	(7.61)	-55.52***	(10.77)	0.07***	(0.01)
Oceania	-58.35***	(10.37)	-56.02***	(16.23)	0.14***	(0.01)
Uncategorized	-89.76***	(8.59)	-70.70***	(15.59)	0.20***	(0.01)

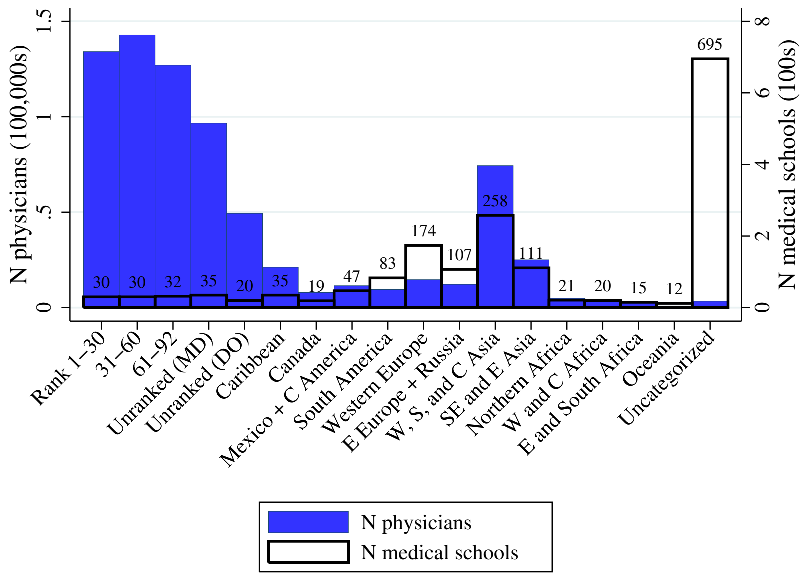
Notes: The prescription statistics control for specialty and county of practice and are relative to either Harvard (Panel A) or the top 30 schools (Panel B). Standard errors are clustered by physician.

Table S5: Opioid Prescriptions by Medical School Rank Controlling for Specialty and County of Practice: GPs

	Annual opioid prescriptions					
	Including zeroes		Excluding zeroes		I[zero]	
	Coeff.	s.e.	Coeff.	s.e.	Coeff.	s.e.
A. By medical school rank						
1 (Harvard)	0	-	0	-	0	-
2-5	6.64	(15.31)	5.42	(19.72)	-0.03***	(0.01)
6-10	49.94***	(15.40)	50.82***	(19.72)	-0.05***	(0.01)
11-15	55.59***	(15.65)	47.53**	(19.83)	-0.08***	(0.01)
16-20	46.20***	(15.20)	39.53**	(19.35)	-0.08***	(0.01)
21-25	60.95***	(15.16)	51.25***	(19.30)	-0.08***	(0.01)
26-30	97.40***	(15.73)	87.96***	(19.73)	-0.10***	(0.01)
31-35	111.66***	(16.59)	103.54***	(20.69)	-0.09***	(0.01)
36-40	88.33***	(14.85)	78.90***	(18.92)	-0.10***	(0.01)
41-45	64.06***	(15.93)	52.70***	(20.09)	-0.08***	(0.01)
46-50	86.77***	(15.08)	77.79***	(19.12)	-0.10***	(0.01)
51-55	113.82***	(15.07)	105.32***	(19.09)	-0.10***	(0.01)
56-60	133.52***	(16.74)	116.44***	(20.65)	-0.11***	(0.01)
61-65	91.34***	(15.87)	77.10***	(19.91)	-0.10***	(0.01)
66-70	66.45***	(15.89)	73.15***	(20.02)	-0.06***	(0.01)
71-75	137.10***	(15.77)	119.81***	(19.70)	-0.11***	(0.01)
76-80	80.64***	(16.72)	64.85***	(20.68)	-0.09***	(0.01)
81-85	118.01***	(17.67)	106.02***	(21.62)	-0.10***	(0.01)
86-92	115.03***	(16.00)	92.48***	(20.01)	-0.11***	(0.01)
Unranked US (MD)	98.00***	(14.05)	79.71***	(18.16)	-0.11***	(0.01)
Unranked US (DO)	123.64***	(14.33)	120.13***	(18.41)	-0.09***	(0.01)
Foreign	15.47	(13.55)	31.14*	(17.73)	-0.02	(0.01)
B. By regions of training						
Rank 1-30	0	-	0	-	0	-
31-60	46.39***	(4.56)	41.19***	(5.12)	-0.03***	(0.00)
61-92	51.28***	(4.95)	42.97***	(5.54)	-0.03***	(0.00)
Unranked US (MD)	44.58***	(5.44)	31.37***	(6.07)	-0.04***	(0.00)
Unranked US (DO)	71.10***	(6.06)	72.58***	(6.72)	-0.02***	(0.00)
Caribbean	15.01*	(7.73)	23.55***	(8.80)	0.00	(0.00)
Canada	35.91**	(15.25)	71.68***	(17.81)	0.05***	(0.01)
Mexico + C America	69.48***	(11.24)	83.89***	(12.67)	-0.01**	(0.00)
South America	-93.09***	(9.67)	-79.11***	(11.85)	0.08***	(0.01)
Western Europe	2.84	(11.12)	22.31*	(13.52)	0.04***	(0.01)
E Europe + Russia	-37.95***	(7.72)	-26.09***	(9.00)	0.03***	(0.00)
W, S, and C Asia	-74.50***	(5.00)	-54.32***	(5.99)	0.07***	(0.00)
SE and E Asia	-27.10***	(7.73)	-7.07	(9.32)	0.05***	(0.00)
Northern Africa	-74.43***	(14.87)	-49.87***	(18.71)	0.09***	(0.01)
W and C Africa	-48.76***	(15.84)	-12.53	(19.83)	0.09***	(0.01)
E and South Africa	-139.10***	(14.63)	-131.26***	(19.23)	0.13***	(0.01)
Oceania	-132.62***	(28.13)	-112.65***	(36.33)	0.16***	(0.03)
Uncategorized	-156.49***	(10.95)	-118.82***	(15.58)	0.23***	(0.01)

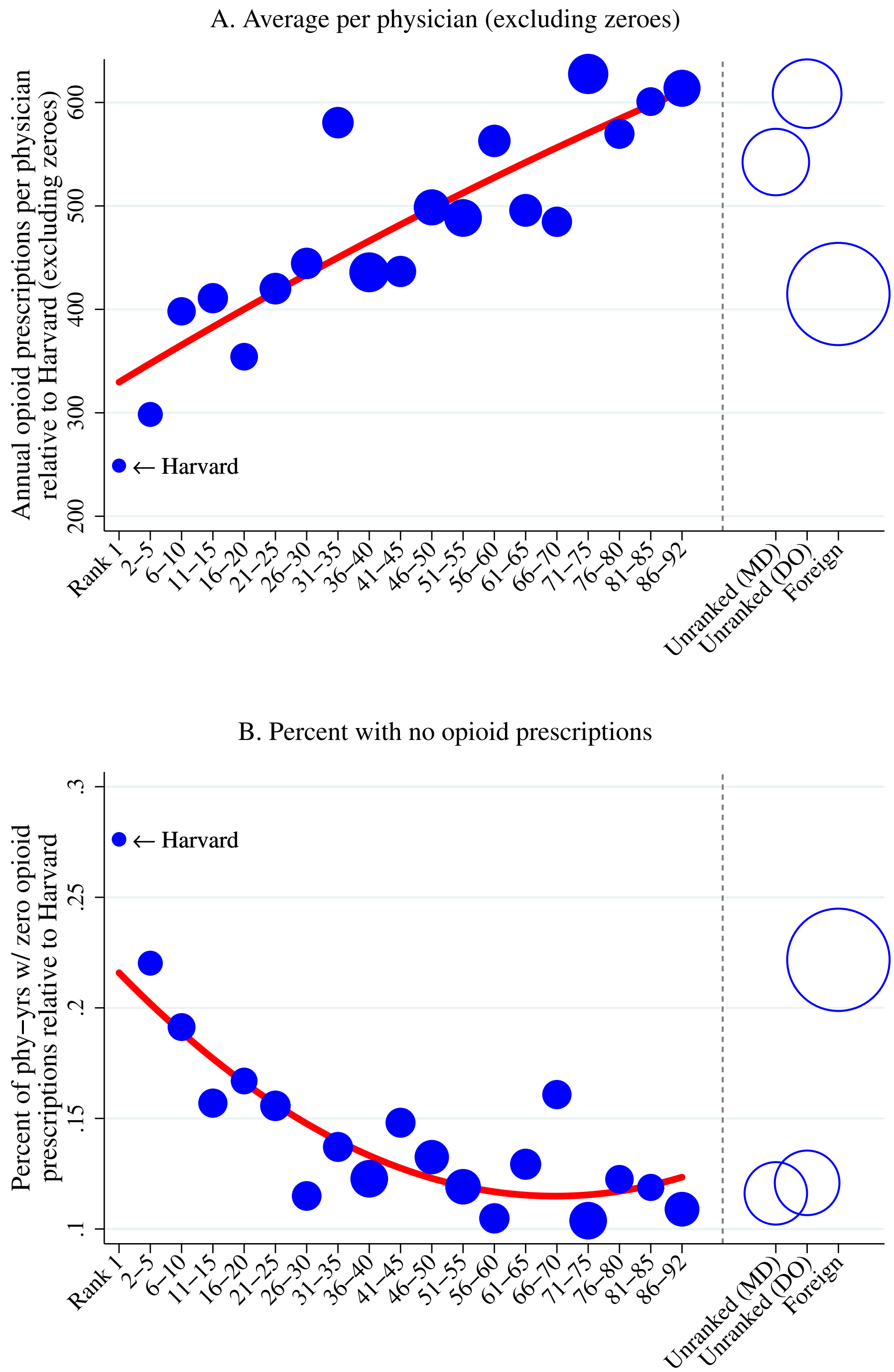
Notes: Only GPs are included (physicians in general practice, family practice, and internal medicine). The prescription statistics control for specialty and county of practice and are relative to either Harvard (Panel A) or the top 30 schools (Panel B). Standard errors are clustered by physician.

Figure S1: Number of Physicians and Medical Schools Across Rankings and World Regions



Notes: Rankings for the top 92 US schools are defined as in Section II. US medical schools that are not ranked are divided by whether they grant the degree of DO or MD. Foreign medical schools are grouped according to the UN's classification of countries by world regions. For foreign medical schools with 10 or more opioid prescribers in our main sample, we googled the medical school and recorded the country of the school's primary campus. For foreign medical schools with fewer than 10 opioid prescribers in our main sample, we assign the medical school to the "Uncategorized" group.

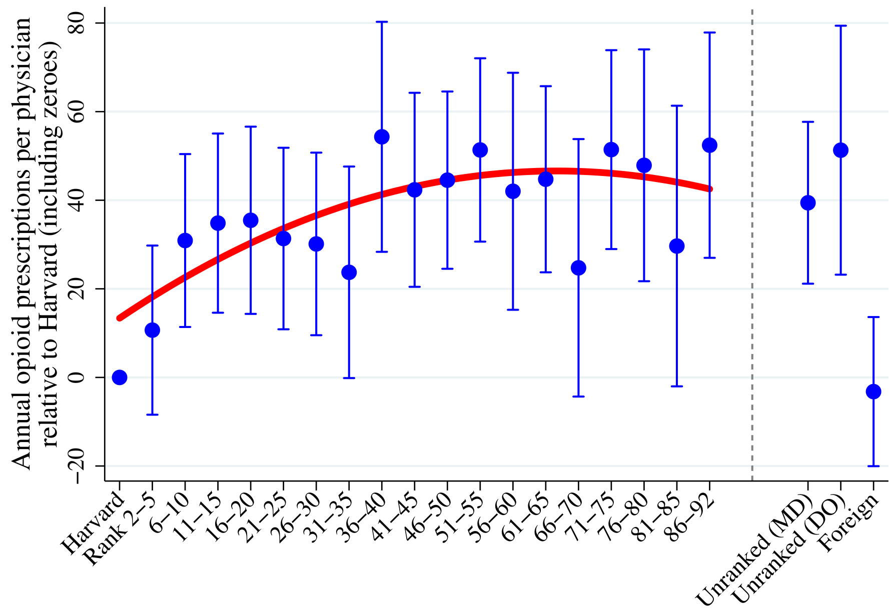
Figure S2: Opioid Prescriptions by Medical School Rank: Average Excluding Zeroes and Percent Zeroes



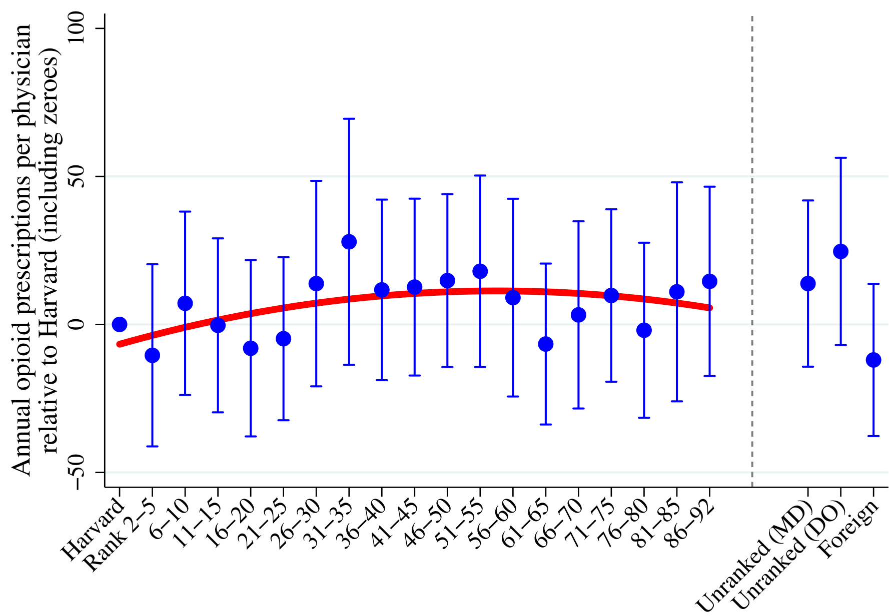
Notes: The above figures depict the average number of opioid prescriptions written yearly per physician conditional on writing at least one opioid prescription (Subfigure A) and the percent of physician-year observations with zero opioid prescriptions (Subfigure B) by medical school rank. Only GPs are included (physicians in general practice, family practice, and internal medicine); Figure 3 provides an analogous figure for all physicians. The size of the marker indicates the number of physician-year observations in a given bin. Refer to Table S3 for the underlying averages.

Figure S3: Opioid Prescriptions by Medical School Rank: Oncology and Nephrology

A. Hematology and oncology



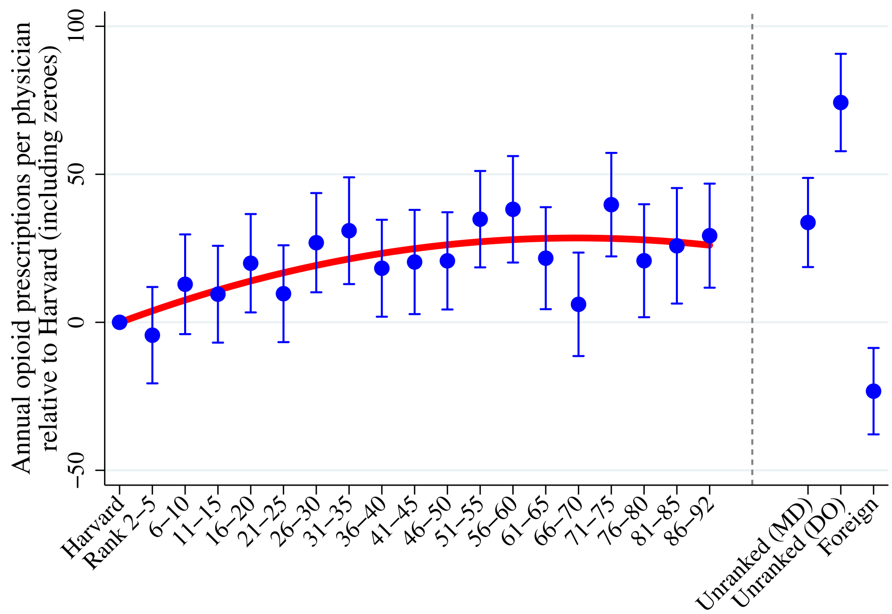
B. Nephrology



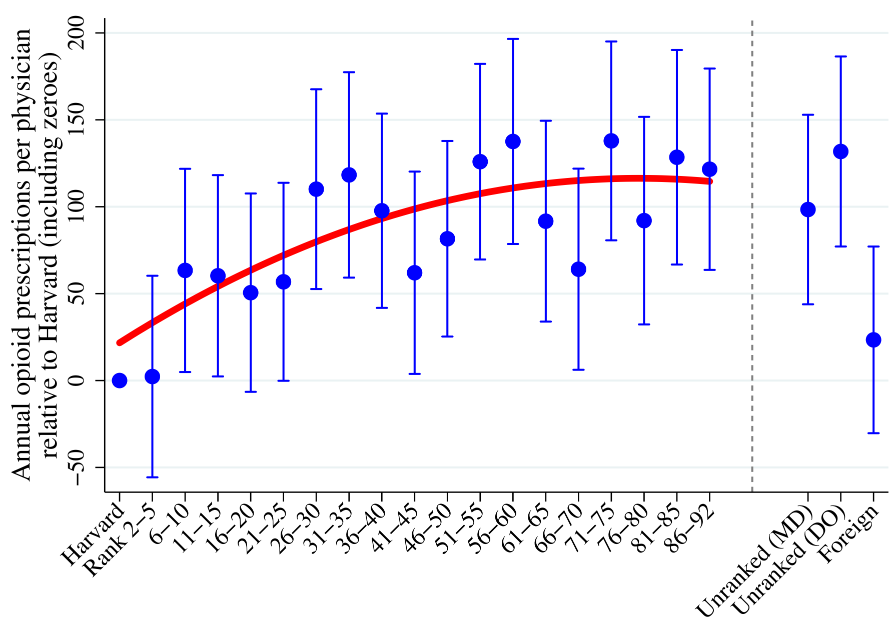
Notes: The above figures depict the coefficient estimates on indicators for medical school rank bins from regressions of opioid prescriptions at the physician-year level on medical school rank bin indicators with year and county fixed effects (variants of Equation (1)). Subfigure A includes physicians in hematology or oncology; Subfigure B includes physicians in nephrology. Physician-years with zero opioid prescriptions are included. The bars denote 95% confidence intervals; standard errors are clustered by physician.

Figure S4: Opioid Prescriptions by Medical School Rank Excluding University-Affiliated Zip Codes

A. All physicians



B. General practitioners



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)). Physicians whose practice address is in a zip code with a university-affiliated hospital are excluded. Physician-years with zero opioid prescriptions are included. The bars denote 95% confidence intervals; standard errors are clustered by physician.