Mandatory Disclosure: Theory and Evidence from Industry-Physician Relationships

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ABSTRACT

The interaction of disclosure laws and the targeted behavior is typically unknown since data on disclosed activity rarely exist in the absence of disclosure laws. We exploit legal settlements disclosing pharmaceutical company payments across the United States. Strong-disclosure states (requiring publicly available data) had reduced payments among doctors accepting less than $100 and increased payments among doctors accepting greater than $100. Weak-disclosure states (requiring reporting to state authorities), despite imposing administrative compliance costs to industry, were indistinguishable from nondisclosure states, which suggests physicians' disclosure aversion as a primary mechanism. Additional analyses holding fixed the cost for pharmaceutical companies of disclosing data and a differences-in-discontinuities model in distribution of payments at the disclosure threshold among strong- and weak-disclosure states support this interpretation. Significant disclosure aversion reducing conflicts of interest is consistent with the policy goals of mandatory disclosure, though the increased payments among those receiving large payments may have been unintended.

1. INTRODUCTION

The relationship between the pharmaceutical industry and the medical profession is the subject of heated debate in both the United States and Europe (see, for example, European Parliament and Council Directive 2001/83/EC, 2001 O.J. [L. 311/67], art. 94, for the European Community code relating to medicinal products for human use, as amended; Ger-

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man Supreme Court decisions in BGH, May 5, 2011, 3 StR 458/10, NJW 472; BGH, November 25, 2003, 4 StR 239/03 BGHSt 49, 17; and BGH, April 27, 2004, 1 StR 165/03, NStZ 2004, 568). In recent years, professional organizations have produced policy recommendations to limit contact between physicians and the pharmaceutical industry (see, for example, European Federation of Pharmaceutical Industries and Associations Code on the Promotion of Prescription-Only Medicines to, and Interactions with, Healthcare Professionals, arts. 9–14; World Health Organization and Health Action International [2011], aimed at health care professionals; various other World Health Organization publications). A large body of research summarized by the World Health Organization suggests that physicians may be influenced by financial conflicts of interest (Norris et al. 2005); recommendations limiting the size of transactions between physicians and pharmaceutical companies have been adopted by professional and industry groups.

Spending by the pharmaceutical industry on promotions and marketing in the United States grew from $11 billion in 1996 to an estimated $29 billion in 2011 (Donohue, Cevasco, and Rosenthal 2007), with other independent estimates placing the number much higher (Donohue, Cevasco, and Rosenthal 2007; IMS Health 2011; Kerber 2004; Wolfe 1996; Gagnon and Lexchin 2008). Even accounting for direct-to-consumer advertising, 90 percent of promotional expenditures are directed toward physicians, amounting to between $30,000 and $61,000 per physician each year (Donohue, Cevasco, and Rosenthal 2007). Although direct payments to physicians appear to constitute a relatively small proportion of these promotional expenditures, they are the subject of professional and political controversy. There is concern that these transactions may create conflicts of interest that undermine clinical objectivity and public trust in physicians' recommendations (Wazana 2000; Studdert, Mello, and Brennan 2004; Chimonas, Brennan, and Rothman 2007; Campbell 2007). Moreover, industry-physician relationships have been linked to medical research, discovery, and promulgation of new drugs (Cockburn and Henderson 1998; Chatterji et al. 2008; Zinner et al. 2009).

The prevailing strategy for addressing potential conflicts of interest has been enhancement and enforcement of disclosure (Katz, Caplan, and

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Merz 2010). This has been the case despite a lack of empirical evidence regarding the effects of disclosure on industry-physician financial relationships. Prior to federal legislation on disclosure in 2014, several states enacted "sunshine laws" that required companies to report payments to physicians (Brennan and Mello 2007). In Massachusetts, Vermont, and Minnesota, disclosures were public (Mass. Gen. Laws, ch. 111N, sec. 6; Minn. Stat., sec. 151.461; Vt. Stat. Ann. tit. 18, secs. 4631–32), and since 2009, many pharmaceutical companies have publicly disclosed payment data for all 50 states (Merrill et al. 2013). Beginning in 2014, the Patient Protection and Affordable Care Act required disclosure of payments from pharmaceutical companies to physicians and the compilation of these data into a publicly searchable online database (42 C.F.R. secs. 402–3).

Critics of disclosure suggest that these laws stigmatize physicians who maintain collaborative relationships with industry that are essential to innovation and product feedback (Sade 2011; Sigworth, Nettleman, and Cohen 2001; Santhakumar and Adashi 2015). Some contend that disclosure may have the unintended consequence of moral licensing among physicians to conduct themselves in a biased manner and/or of producing greater public trust in physicians who have received larger payments (Cain, Loewenstein, and Moore 2005; Loewenstein, Sah, and Cain 2012; Loewenstein, Cain, and Sah 2011; Koch and Schmidt 2010). Still others claim that disclosure laws have limited effects on prescribing behavior (Pham-Kanter, Alexander, and Nair 2012; Guo, Sriram, and Manchanda 2017) and, as a result, merely increase the cost of doing health care. Despite such speculative arguments, however, the interaction of disclosure laws with the mediating channel of industry-physician relationships remains unknown.

It is difficult to analyze the interaction of disclosure laws and payments, and no previous study examines whether payments to physicians from pharmaceutical companies are lower when disclosure is mandatory. Data for this type of comparative empirical analysis are rarely available, have been of poor quality (Ross et al. 2007), and typically are available only for states that have instituted disclosure requirements. Researchers have had to rely on physicians' self-reporting of payments in nondisclosure states. We bypass this obstacle by utilizing national data released by pharmaceutical companies through legal settlements unlikely to have been predicted at the time physicians received payments.

The scope and size of our data also make this a more comprehensive industry-wide analysis. Twelve US pharmaceutical companies representing 42 percent of total pharmaceutical industry revenues released

data on payments from 2009 to 2011 totaling $316 million to 316,622 physicians in 50 states and Washington, DC. States (and Washington, DC) were classified as having disclosure laws that were strong (Massachusetts, Vermont, and Minnesota), weak (West Virginia, District of Columbia, Maine, and California), or nonexistent (44 states) according to whether data were reported to state authorities (weak) or were made publicly available (strong). Our analysis of state laws is limited by the lack of true randomization of laws or randomization of the assignment of decision makers responsible for creating the laws. There is no way to rule out omitted variables without a randomized control trial of laws, so our study faces the same limitation as other studies of the impact of policies without random assignment. Thus, we use two approaches in our analysis of disclosure laws and payments to physicians. First, we use multiple regression in a cross-sectional framework and assess whether our estimates change significantly with the inclusion of controls that may be correlated with both the laws and the payments. Our second approach employs a differences-in-differences panel framework to control for unobserved differences that are fixed within states. In both analyses, we find that state-mandated public disclosure of pharmaceutical payments to physicians is associated with lower statewide average payments per physician but higher payments among the subset of physicians with industry relationships. The quantitative estimates across all payments and for each payment category are similar, which reduces the concern that our results are due to omitted variables, though we cannot completely rule out that possibility.

For one state—Massachusetts—existing state-mandated disclosures first became publicly available during our sample period, which allowed for separate analyses of the association between disclosure laws and public visibility of disclosed data while the administrative cost of reporting data remained fixed for pharmaceutical companies. We use the date the data became publicly visible as the treatment date for two reasons. First, this allows disentangling the behavioral response by physicians to mandatory disclosure from the behavioral response by industry to the costs of complying with mandatory disclosure. Second, we lack data covering the period before the date the state-mandated disclosure data began to be collected. The results corroborate the cross-sectional finding. While the number of payments to physicians decreases, the average amount of payments increases among physicians who accepted payments. This suggests that the public visibility of the disclosed data, rather than the disclosure

itself, is the primary mechanism behind our findings. This is further corroborated by the fact that in our analysis states with weak disclosure laws are indistinguishable from states with no disclosure laws.

The rest of the paper proceeds as follows. Section 2 presents the theory that provides the intuition for the potential effects of mandatory disclosure on the disclosed activity. Section 3 describes the data. Section 4 explains the empirical strategy and threats to the validity of the identification strategy. Section 5 presents the results. Section 6 discusses the findings and concludes.

2. THEORY

This section seeks to understand why disclosure laws may have behavioral effects. Many papers model expert advisors, but models of mandatory disclosure are scarce. The following is a simple theory for the potential impact of disclosure laws on physician payments. First, payments to physicians are predicted to increase after mandatory disclosure because of the reputational cost to physicians of having their industry-physician relationships made public. Second, physicians receiving low payments drop out with mandatory disclosure because it is not worth it to the pharmaceutical companies to continue paying them. We illustrate the intuition in a two-type model and a full model with continuous types in Online Appendix OA. The model contributes to a large, primarily informal, mandatory-disclosure literature in law.

In brief, suppose each physician can be categorized according to a certain number of ways in which he or she may increase pharmaceutical sales. For example, some physicians may be more successful at conducting clinical research that advances marketing claims or finds additional indications for a particular drug. Other physicians may be more effective at presenting the results of clinical research to colleagues and affecting their peers' prescribing behaviors. Some physicians may simply be more behaviorally responsive to payments in their prescribing patterns. The pharmaceutical company's objective, for a given physician type, is to maximize its return from payments. Payments for effective physicians will be higher than payments for less effective physicians.

Now consider the effect of disclosure. We assume that a disclosure law increases the cost of each physician for the pharmaceutical company. Disclosure effectively makes physicians more reluctant to accept payments. The reputational cost of accepting payments is passed on to the

pharmaceutical company, which then must make higher individual payments to achieve the same effect with a particular physician. Mandatory disclosure has two effects. First, it increases payments to the paid physicians, because for a given physician's effort, the payment to the physician increases. Second, it increases the cutoff threshold for physicians' effectiveness. The pharmaceutical company will choose not to pay physicians who are less effective than this cutoff. So mandatory disclosure causes low payments to drop out.

3. DATA

We identified payments to physicians between 2009 and 2011 using public disclosures from 12 pharmaceutical companies. The combined revenue of the companies represents 42 percent of US market revenue in 2011.[1] Two companies made payment data available voluntarily, and data from the remaining 10 companies became available through legal action—typically as a result of legal settlements with the US Department of Justice.[2] The data were collated and provided by a nonprofit journalism organization, ProPublica. We conducted several validation checks of the data. First, we validated the database with data obtained directly from seven pharmaceutical companies. ProPublica assembled data on payments to physicians from 12 pharmaceutical companies between the third quarter of 2009 and the fourth quarter of 2011. This compilation is important because historical data are not easily obtainable from all pharmaceutical companies directly. For example, some companies remove data from their website at the end of each quarter or year. We partially validate the quality of the ProPublica data by comparing them with data obtained directly from Eli Lilly for payments made to physicians during 2010. We find a match of greater than or equal to 97.5 percent for the number of physicians and total amount of payments in each category and overall. Similarly high match rates were found for AstraZeneca payments made in 2010, GlaxoSmithKline payments made in quarters 2–4 of 2009, Johnson & Johnson payments made in 2010, Merck payments made from quarter 3 of 2009 to quarter 4 of 2010, Valeant payments made in quarters 1–3 of 2010, and Viiv payments made in 2010.[3] Other data were not

1. Table A1 reports information on these companies' payments to physicians.

2. Table A2 summarizes the conditions for each pharmaceutical company disclosing the payments.

3. Online Appendix OB presents a full discussion of the validity of our data.

reported in a quarterly or yearly time frame available for comparison. When we exclude voluntarily disclosed data in robustness checks of our specifications, the results are similar.

Our data contain 579,652 payments made from quarter 3 of 2009 to quarter 2 of 2011. We exclude 707 payments for which an individual recipient could not be identified. A total of 316,622 physicians and $316 million in payments are represented in our data. Each payment includes the name of the pharmaceutical company providing payment, name and city of the physician receiving payment, date, amount, and category of payment (consulting, speaking, research, meals, travel and/or lodging, items, other, or a combination of these categories). We cannot verify whether pharmaceutical companies assigned the most relevant payment category to transactions, as contract terms are typically private and may include the provision of promotional or marketing support (Steinbrook 2009).

If a payment range is specified (for example, $10,001–$20,000), we use the average reported payment within that range. Most companies reported data at the annual level, so we generated equivalent data for the remaining companies by summing the payments by year. We created physician identifiers based on the same name (first, last, and middle) and city appearing in multiple disclosure records. For a match across payment records, we required the same first and last name and either the same middle name (or initial) or city; no other data were available for the match. Various governmental and nonprofit organizations provided data on statewide health and socioeconomic conditions.[4]

We classify state disclosure laws as strong if states required payments to physicians to be publicly available and weak if states required payments to physicians to be reported to the state but not the general public; we label them "none" if states did not require reporting of payments to physicians. Table 1 summarizes the dates of passage of laws and categorizes the strength of disclosure laws by state. In Massachusetts, payments from drug companies and medical device makers to health care providers were required to be disclosed to the general public. In Minnesota, payments of over $100 from wholesale drug manufacturers to practitioners were required to be generally disclosed to the public. In Vermont, payments from prescription drug companies to health care providers were required to be disclosed to the general public. In Massachusetts, the data

4. These variables and their sources are in Online Appendix OC.

Table 1. States Mandating Disclosure of Pharmaceutical Company Payments to Physicians

	Effective Date	Information Disclosed	Restrictions on Access	Source
Public reporting (strong):				
Massachusetts	July 2009	Payments from drug companies and medical device makers to health care providers	None; first publicly released in November 2010	Mass. Gen. Laws Ann., ch. 111N, sec. 6
Minnesota	January 1997	Payments of >$100 from wholesale drug manufacturers to practitioners	Generally public but some information is subject to trade secret and other restrictions	Minn. Stat., sec. 151.461 (2006)
Vermont	June 2002	Payments from prescription drug companies to health care providers	None	Vt. Stat. Ann. tit. 18, secs. 4631–32
No public reporting (weak):				
West Virginia	April 2009	Payments of $100 from drug companies to health care providers for advertising prescription drugs	Confidential	W. Va. Code R., sec. 206-1-3
District of Columbia	July 2004	Payments for seminars, informational programs, trips, and travel; food, entertainment, or gifts valued at >$25; or anything provided to a health-care professional for less than market value	Confidential except for aggregate data	D.C. Code, secs. 48-833.01–09

Maine	January 2006	Payments for seminars, informational programs, trips, and travel; food, entertainment, or gifts valued at >$25; or anything provided to a health care professional for less than market value	Confidential except for aggregate data	Me. Rev. Stat. Ann. tit. 22, sec. 2681.5.A
California	January 2005	Pharmaceutical companies must self-impose an annual limit on marketing expenses to health care professionals	No disclosure requirement	Cal. Health & Safety Code, secs. 119400–02
No disclosure laws:[a]				
Ohio	Proposed bill	Proposed bill would require pharmaceutical manufacturers to submit annual reports listing gifts to physicians who are authorized to prescribe drugs	Not specified	S. 79, 129th Gen. Assemb., Reg. Sess. (Ohio 2011/12)
Federal	March 2013	All payments and transfers of value; preempts state laws that are similar or weaker	None	42 U.S.C. 1320a–7h

[a] Analyzed as part of the no-disclosure group, but noteworthy.

became publicly searchable on a website in November 2010. For Minnesota and Vermont, the data can be requested from the state attorney general offices. In West Virginia, payments above $100 from drug companies to health care providers, for the purpose of advertising prescription drugs, were disclosed to the state. In Maine and the District of Columbia, payments for seminars, informational programs, trips and travel, food, entertainment, or gifts valued at more than $25 and anything provided to a health care professional for less than market value were required to be disclosed. In California, pharmaceutical companies were required to self-impose an annual limit on marketing expenses to health care professionals. In West Virginia, the District of Columbia, Maine, and California, any payment data disclosed were kept confidential.

3.1. Outcomes

The main dependent variable is the log of average payments per year,[5] calculated as the total amount paid to all physicians in a state each year (statewide payments) divided by the number of physicians with active licenses in each state (number of active physicians). In additional tests, we examine the share of statewide payments in each category and number of physicians accepting any payment. We also analyze annual payments to individual physicians among the subset of physicians who accepted at least one payment (paid physicians) and the distribution of payments above and below $1,000 and $100—the limit on industry gifts to physicians suggested by both the American Medical Association (AMA) (1991, 2000) and the Pharmaceutical Research and Manufacturers of America (2008).

3.2. Potential Confounders

The release of national data by pharmaceutical companies due to legal settlements was unlikely to have been predicted at the time physicians received payments. However, there may be potential confounders that influence the interest of pharmaceutical companies in associating with physicians in these states. These potential confounders broadly divide into factors associated with supply and demand for payments. Supply factors may stem from pharmaceutical companies interested in physicians in states with a larger elderly population (reflecting a bigger market share for prescription drugs) or with more health insurance, wealth, or edu-

5. We use logs because the distribution of payments is more reflective of lognormal rather than normal distribution.

cation (where patients can afford prescription medications). Dense populations, more physicians with active licenses, or more nurses with active licenses may make pharmaceutical associations more effective, for example, through more interaction with other physicians on a regular basis, whether casual or at well-attended speaking engagements. Demand for payments derives from physicians who, earning a lower income or residing in states with a higher cost of living, may have greater interest in supplementing income with payments from pharmaceutical companies. We obtain cost-of-living data, average wages of physicians, median household income, and the proportion of individuals with health insurance from the US Departments of Labor and Commerce. We measure population density and the proportions of individuals under 18 years of age (who may demand different medications), 65 or older, and with at least a high school education from the US Census Bureau. The Kaiser Family Foundation provided data on the average number of retail prescriptions per person that were filled at pharmacies in 2011. The AMA and American Hospital Association provided data on the number of physicians and nurses in each state with active licenses, respectively.

In robustness checks, we use sparse models to assist in the selection of controls (Belloni et al. 2012; Belloni, Chernozhukov, and Hansen 2014). Controlling for a large set of variables is desirable from the standpoint of mitigating potential biases underlying the interpretation of the disclosure law coefficient. The downside is that controlling for too many variables may make estimates become less precise. Researchers are faced with a trade-off between the precision of the estimate and the plausibility of the conditional exogeneity assumption. By including additional controls in the specification, we make the conditional exogeneity assumption more plausible. At the same time, the precision of estimates is potentially reduced. The double-selection method by the least absolute shrinkage and selection operator method (LASSO) offers a rigorous approach to achieving a balance between exogeneity and precision (Belloni et al. 2012; Belloni, Chernozhukov, and Hansen 2014).[6]

Formally, LASSO modifies ordinary least squares by minimizing the sum of squared errors subject to the sum of the absolute value of all coefficients being less than a constant. This constraint tends to set some coefficients to exactly 0, which reduces the model's complexity by identify-

6. Tables OD1 and OD5 report the results using the least absolute shrinkage and selection operator method (LASSO) to select potential confounders, and the result of this selection is reported in Table OD6.

ing only the most important variables. Estimation proceeds in two steps. First, LASSO selects the control variables that predict the strength of the disclosure law. This step helps to ensure robustness by finding control variables that are strongly related to the treatment and thus potentially important confounds. Next, LASSO selects control variables that are predictive of payments. This step helps to ensure that important elements are included in the equation, helps keep the residual variance small, and intuitively provides an additional chance to find important confounds. We use in LASSO a set of potential confounding factors constructed from the original controls and, as standard practice, all two-way interactions between any two controls.[7] The original controls plus LASSO-selected control variables are then included as independent variables.[8] However, LASSO is not a perfect solution to omitted-variables bias: the cross-sectional regressions can still be misleading to the extent that important confounding factors are left out of the feature set, hence the need for a differences-in-differences approach to complement the cross-sectional approach.

4. ESTIMATION FRAMEWORK

4.1. Cross-Sectional Specification

Our multiple regression model uses the following framework:

$$\log(Y_{st}) = \beta_0 + \beta_1 \text{Law}_{st} + \beta_2 \text{Year}_t + \beta_3 \boldsymbol{X}_{st} + \varepsilon_{st}, \quad (1)$$

where Y_{st} is the ratio of the sum of all payments received over the number of active physicians in state s in year t.[9] The dummy variables Law_{st} indicate the strength of disclosure laws in state s in year t (strong, weak, or none, the omitted category), Year_t is a dummy for each year in our sample, and $\boldsymbol{X}_{st}$ is a set of state and year controls, including the share

7. For additional description of and motivation for the LASSO variables, see Cohen and Chen (2010).

8. We also include the share of payments from each pharmaceutical company by value and by count and the share of payments in each payment category by value and by count. However, all results at the state and physician level and at various thresholds are robust to dropping control variables for the share of payments from each company and the share of payments for each category of payment. In fact, the relationships become larger and more statistically significant.

9. We specify payments in logs because we reject the hypothesis that payments in nonlog terms are normally distributed using the one-sample Kolmogorov-Smirnov test against the theoretical distribution.

of payments from each company, the share of payments in each category, and health and socioeconomic controls as described above. We use heteroskedasticity-robust Huber-White standard errors or standard errors clustered at the state level.

For alternative specifications, we also examine the following:

$$\log(Y_{ist}) = \beta_0 + \beta_1 \text{Law}_{st} + \beta_2 \text{Year}_t + \beta_3 \boldsymbol{X}_{st} + \varepsilon_{ist}, \quad (2)$$

where Y_{ist} is the sum of all payments received by physician i in state s in year t, and the right-hand-side variables have the same notation as the aggregate version. When we analyze payments above or below cutoffs like \$1,000 and \$100, we check the robustness of the results to implementing truncated regressions.[10] Finally, for the third specification, we examine the following:

$$\log(Y_{cst}) = \beta_0 + \beta_1 \text{Law}_{st} + \beta_2 \text{Year}_t + \beta_3 \boldsymbol{X}_{st} + \varepsilon_{cst}, \quad (3)$$

where Y_{cst} is the sum of category c payments received divided by the sum of all payments in state s and year t.

4.2. Differences-in-Differences Specification

Massachusetts offers a special setting to study what happens after public visibility of disclosed data while the administrative cost of reporting data remains fixed for pharmaceutical companies. This is possible because existing state-mandated disclosures first became publicly available during our sample period. Analyzing public visibility in a differences-in-differences framework helps discriminate between physicians' response to mandatory disclosure and the industry's response to the costs of compliance.

For the differences-in-differences specification, we use the following framework:

$$\log(Y_{st}) = \beta_0 + \beta_1 \mathbf{1}_{\text{M}} + \beta_2 \mathbf{1}_{\text{M}} \text{Post}_t + \beta_3 \text{Year}_t + \beta_4 \boldsymbol{X}_{st} + \varepsilon_{st}, \quad (4)$$

where Y_{st} is the sum of all payments over the number of active physicians in state s in year t, $\mathbf{1}_{\text{M}}$ is an indicator variable for the state of Massachusetts, Post_t is an indicator variable for years after Massachusetts public disclosure, Year_t and $\boldsymbol{X}_{st}$ are as defined before, and the year fixed effects

10. To reduce the impact of outliers, we also replace the top .5 percent of payments with the 99.5th percentile. We vary this parameter between the top .5 percent and 2.5 percent, with similar results. Results are robust to eliminating payments reported in ranges.

absorb the postdisclosure dummy. Standard errors are clustered at the state level. As an alternative specification, we also consider

$$\log(Y_{ist}) = \beta_0 + \beta_1 \mathbf{1}_M + \beta_2 \mathbf{1}_M \text{Post}_t + \beta_3 \text{Year}_t + \beta_4 \boldsymbol{X}_{st} + \varepsilon_{ist}, \quad (5)$$

where Y_{ist} is the sum of all payments received by physician i in state s in year t, and the right-hand-side variables have the same notation as the aggregate version.

To assess the validity of our estimates, we use randomization inference: we rerun the regressions, reassigning the indicator variable to another state. We report whether the true β_2 falls outside the 90 or 95 percent range of placebo β_2 estimates. There are no pretrend data to assess parallel pretrends before the data were revealed online because most of the data are yearly. In Online Appendix OE, we employ a synthetic control model and report point estimates similar to the main estimates.

5. RESULTS

5.1. Cross-Sectional Association between Disclosure Laws and Payments: State-Level Analysis

We preview our results with mean statistics and distributional visualizations before moving to the regression analyses. First, we look at differences in payments for states with strong, weak, or no disclosure laws. We compare the magnitude and category of payments according to disclosure status. Table 2 presents summary statistics. Among active physicians, 11 percent in strong-disclosure states accepted payments, versus 37 percent and 42 percent of physicians in states with weak and no disclosure laws, respectively. Among the 316,622 physicians[11] who accepted payments across the United States, the average annual payment was $1,377 (SD = $6,694).[12] Table 2 also displays the average payments per physician in the states. It shows that statewide payments per physician are $221 in strong-disclosure states, $334 in weak-disclosure states, and $411 in nondisclosure states. Speaking fees constitute the largest share across all categories and states. Strong-disclosure states have lower average payments for speaking and for other categories (which include meals) and higher payments for consulting. Physicians in strong-disclosure states also had proportionately larger average payments for consulting. The absolute payment amount for research activities is larger in strong-disclosure

11. The physician total of 316,622 = 6,689 + 38,209 + 271,724 from Table 2.
12. This is the weighted average from Table 2.

Table 2. Summary Statistics for Pharmaceutical Company Payments to Physicians, 2009–11

Variable	Strong Laws	Weak Laws	No Laws
States	3	4	44
Active physicians[a]	43,820	109,041	646,630
Paid physicians	6,689	38,209	271,724
Payments	11,039	69,759	498,147
Physicians accepting any payment/active physicians[b]	10.73	36.56	42.31
Average annual statewide payments/active physicians:			
Consulting	33.52	15.92	18.91
Speaking	130.34	233.09	255.71
Research	30.91	35.30	68.49
Other categories	26.08	50.09	68.34
Total	220.85	334.40	411.45
Average annual payments/physicians who accepted any payment:			
Consulting	1,046.49	314.79	282.96
Speaking	3,692.35	2,909.10	2,855.72
Research	1,030.37	150.26	207.20
Other categories	354.05	466.93	470.89
Total	2,436.35	1,466.84	1,340.24
Share of statewide payments:			
Consulting	15.38	5.79	5.05
Speaking	53.59	64.28	61.74
Research	22.23	13.94	18.92
Other categories	8.80	15.99	14.29
Share of payments by year:			
2009	7.32	3.49	3.59
2010	64.33	60.95	61.65
2011	28.35	35.56	34.75
Statewide variables:			
Real income per capita[a]	29,781	29,095	26,782
Average physician wage	194,797	190,758	188,748
Cost of living index	115.32	121.33	102.86
Population $<$ 18 years (%)	21.99	21.59	24.25
Population $\geq$ 65 years (%)	13.59	13.58	13.05
$\geq$High school education (%)	90.84	85.24	87.12
Health insurance (%)	76.96	68.28	71.11
Prescriptions filled at retail pharmacies (person/year)	12.23	13.15	12.14
Population density (1,000s/square mile)	249.10	2,298.41	162.06
Physicians with active licenses	14,607	27,260	14,696
Nurses with active licenses	43,933	67,815	45,775

[a] For 2010.

[b] Average per state.

states. Similar patterns are also present in terms of proportional distributions of payments.

Figure 1*A* shows the density of annual payments by strength of disclosure law (observations are at the physician-year level). The density lines for states with no disclosure laws and for states with weak disclosure laws indicate that in both groups, 90 percent of the annual payments to paid physicians are below $1,000 (this can be seen clearly from the cumulative density plot in Figure OD1). Figure 1*B* shows that in strong-disclosure states (Massachusetts, Minnesota, and Vermont) 81 percent of the physicians were paid less than $1,000 annually. Massachusetts—the state with the most recent implementation of a strong disclosure law—exhibits the lowest proportion of paid physicians receiving payments greater than $1,000 and diverges least from weak and nondisclosure states in this regard. States under strong disclosure laws for longer periods of time have higher proportions of highly paid physicians. The distributions are significantly different at $P = .001$.

Figure 1*A* and 1*B* present a separate study of the $100 cutoff. The disclosure obligations in one strong-disclosure state (Minnesota) and one weak-disclosure state (West Virginia) required payments of over $100 to be reported to the public or state attorney general offices. However, litigation settlements obliged all payments to be reported. Figure 1*A* shows that up to 60 percent of annual physician payments are less than $100 in Minnesota (this can be seen clearly from the cumulative density plot in Figure OD1), which is in between the percentage share for the other two strong-disclosure states (Massachusetts and Vermont); this is suggestive evidence that the administrative burden of reporting is not a significant determinant of the payments. In other words, to the extent that the administrative burdens surrounding payments in excess of $100 and the lack of administrative burdens for payments under $100 means that payments under $100 should be more common (than in states without disclosure obligations), this is not apparent from comparing Minnesota with Massachusetts (which has a greater share of payments under $100). Figure 1*B* presents another interesting feature of the data at the discontinuity. (Since Figure 1*A* uses an Epanechnikov kernel to smooth the data, Figure 1*B* presents only the data for values from $98 to $102.) There is a discontinuity in payments for Minnesota at $100, with 18 payments of $99 and three payments of $100. In contrast, for nondisclosure states, the number of payments varies smoothly around $100, with 2,806 payments of $99 and 2,260 payments of $100. Moreover, the distribution

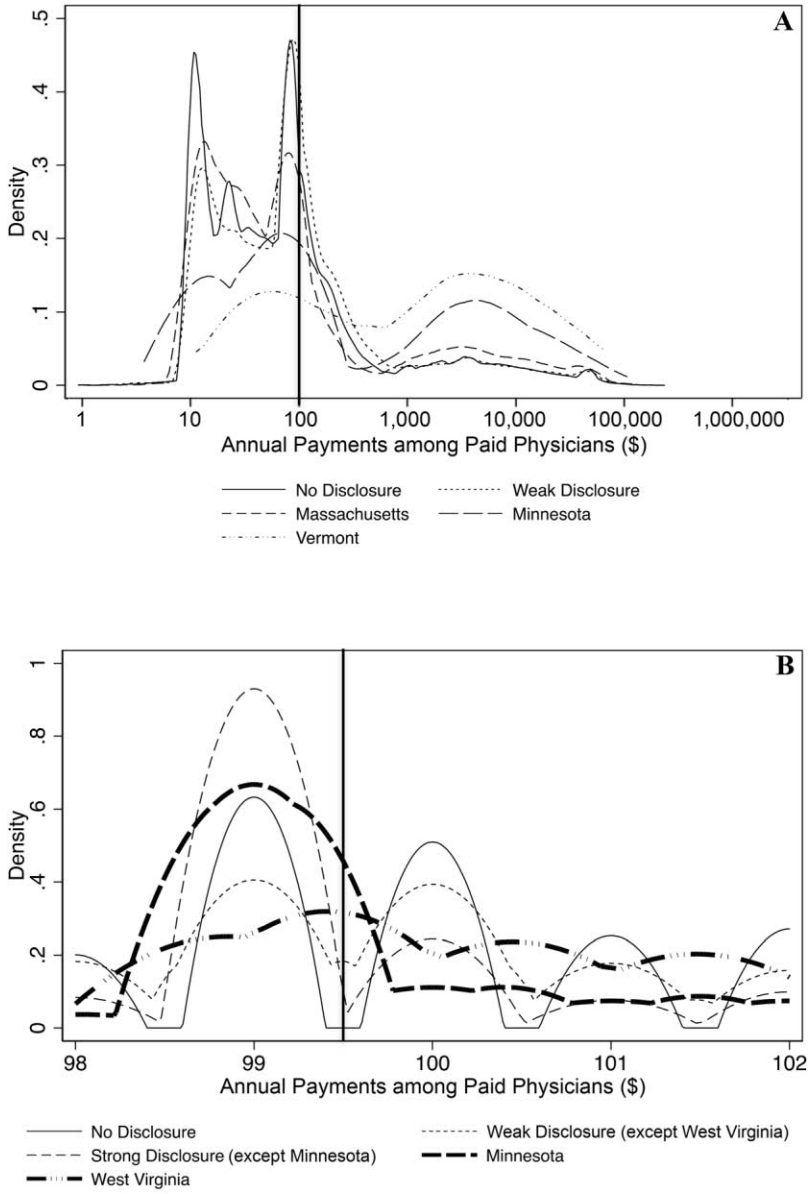

Figure 1. Density of payments to physicians who accept payments, 2009–11. *A,* Disclosures for all states; *B,* comparison of strong-disclosure states.

for West Virginia is similar to the distribution of payments for nondisclosure states, with 23 payments of $99 and 16 payments of $100. This difference in discontinuity supports the view that disclosure affects the reputational costs to physicians, who would discontinuously experience this cost at $100 and only in strong-disclosure states.

Table 3 presents multiple regression models to relate physician payments to the presence of strong, weak, or no disclosure laws, controlling for the pharmaceutical company providing payment, category of payment, year, and controls described above. In column 1, the unit of analysis is the state-year, with 153 observations across 3 years. Adjusted for all controls, statewide payments per physician are 49 percent lower in strong-disclosure states than in nondisclosure states. Statewide payments are not significantly lower in weak-disclosure states than in nondisclosure states. Both of these results are consistent with regression models that include different sets of potential confounds.[13]

Using multiple regression models, we also estimate the relationship between disclosure laws and the share of payments in each category and the relationship between disclosure laws and the number of physicians receiving payments. Compared with total payments per category in nondisclosure states, adjusted for all controls, the share of total payments per category in strong-disclosure states is as follows: 10.5 percent lower share for speaking ($P < .005$), 3.1 percent lower share for meals ($P < .05$), and 9.4 percent higher share for consulting ($P < .001$).[14] Weak-disclosure states have, in contrast, a 2.8 percent higher share of payments for meals and a 2.1 percent lower share of payments for consulting than in nondisclosure states ($P = .05$ for both). A χ^2-test of differences between payment categories by strength of disclosure laws is significant ($P < .001$).

5.2. Cross-Sectional Association between Disclosure Laws and Payments: Physician-Level Analysis

Next we analyze the association between disclosure laws and payments received by physicians at the individual (rather than state) level. The unit of analysis is the physician-year. Table 3, column 2, considers the subset of physicians who accepted any payment from pharmaceutical companies. In strong-disclosure states, annual payments among those physicians are 10.1 percent higher than in nondisclosure states. This result is robust

13. Table OD1 displays a sequence of models in which control variables are gradually added to assess sensitivity of the main results.

14. Table OD2 reports the complete set of regression coefficients.

Table 3. Relationship between Disclosure Laws and Log Annual Payments to Physicians, 2009–11

	Per Active Physician (1)	Among Paid Physicians (2)	Among Physicians Who Accepted > $100 (3)	Among Physicians Who Accepted ≤ $100[a] (4)	Per Active Physician (5)	Among Physicians Who Accepted > $100 (6)	Among Physicians Who Accepted ≤ $100[a] (7)
Strong laws	−.488***	.101*	.543***	−.254***			
	(<.001)	(.0304)	(<.001)	(<.001)			
	[−.716, −.259]	[.0096, .193]	[.411, .675]	[−.260, −.249]			
Weak laws	−.176	−.0880***	.036	−.0613***			
	(.111)	(<.001)	(.34)	(<.001)			
	[−.394, .041]	[−.130, −.0458]	[−.039, .111]	[−.0767, −.0458]			
Massachusetts × After Public Release					−.356***	.691***	−.0686***
					(<.001)	(<.001)	(<.001)
					[−.465, −.247]	[.605, .778]	[−.0846, −.0527]
N	153	425,797	139,019	2,257,059	153	141,736	2,257,059
R^2	.99	.215	.172	.099	.972	.170	.098

Note. Results are adjusted for the company providing payment, category of payment, year, and statewide demographics (household income, average physician wage, cost of living, percentage of the population under 18, percentage of the population 65 or older, percentage of unemployment, percentage with at least a high school education, percentage with health insurance, annual number of prescription drugs filled at pharmacies per person, population density, number of active physicians, and number of active nurses). Results for Massachusetts are differences in payments between Massachusetts and all other states before and after public release of Massachusetts payments and include standard errors clustered at the state level. All other regressions include robust standard errors clustered at the state level. Columns 1 and 5 use state-year and all other columns use physician-year as the unit of analysis. *P*-values are in parentheses; 95 percent confidence intervals are in square brackets.

[a] Include a 0 for physicians who accepted no payments.

* $P < .05$.

** $P < .01$.

*** $P < .001$.

to various sets of controls.[15] Average annual payments among physicians who accepted any payments is $2,436 in strong-disclosure states and $1,340 in nondisclosure states (and $1,467 in weak-disclosure states). In weak-disclosure states, annual payments are 8.8 percent lower ($P < .001$) than in nondisclosure states, but the sign of this association is reversed in specifications with fewer controls.

We evaluate different thresholds for payments to ascertain the parts of the payment distribution that are associated with disclosure laws, which allows us to assess a prediction of the model. The model says that low-payment physicians simply drop out, and high-payment physicians get more money. We use a multiple regression analysis similar to the aggregate approach. The unit of analysis is the physician-year. Some specifications include only physician-years in which a physician received any payments. Other specifications include all active physician-years, assigning $0 to physicians not receiving payments.

Column 3 indicates that, in strong-disclosure states, annual payments among physicians who accepted more than $100 per year are 54 percent higher than in nondisclosure states (unreported). No statistically significant association is observed between strong disclosure laws and the number of physicians who accepted more than $100 per year (unreported). However, in strong-disclosure states, roughly 19 percent of paid physicians accepted payments over $1,000, compared with only 10 percent of physicians in weak-disclosure states and nondisclosure states. States with more recent strong disclosure laws have a smaller percentage of paid physicians accepting payments over $1,000.

No statistically significant association is observed for strong disclosure laws and size of payments among paid physicians who accepted $100 or less per year, but the number of such physicians was 68 percent lower (95 percent confidence interval = [−1.294, −.0588]; $P = .0322$)[16] than in nondisclosure states. Column 4 includes all physicians and indicates that annual payments among physicians who accepted $100 or less per year are 25 percent lower. Payments among physicians who accepted $100 or less per year are significantly different in states with weak versus no disclosure laws, but the significance disappears in the truncated regression with clustering at the state level.[17]

15. Table OD1 sequentially adds controls in models 7–9.

16. Table OD3, which reports additional analyses of the relationship between disclosure laws and distribution of payments to physicians, shows this result in column 2.

17. Table OD5, which reports additional analyses of the relationship between disclosure laws and payments to physicians, shows this result in column 4.

5.3. Differences-in-Differences Association between Disclosure Laws and Payments

One state in our sample, Massachusetts, enacted a strong disclosure law in January 2009 but first publicly released data in November 2010 (Kowalczyk 2010). To examine the impact of this release, we run a differences-in-differences analysis that compares the change in payments in Massachusetts before versus after November 2010 with the change in payments in all other states (none of which altered transparency during this time period). The units of analysis are state-year and physician-year. Column 5 of Table 3 indicates that, following the public release of disclosed payments, payments per physician in Massachusetts decreased 36 percent ($P < .001$) relative to all other states (which did not change their publication of disclosures during that time period). The share of Massachusetts payments declined by 7 percent for speaking and 4 percent for meals but rose 9 percent for research and 1 percent for consulting (for the first three values, $P < .001$; for the last value, $P < .1$).[18] However, because of the large decrease in payments per physician overall, the absolute amount in each of the categories is reduced. When we use randomization inference, reassigning the indicator variable to each of the other states, the estimated decrease for overall payments, meals, and travel is between the 90th and 95th percentiles of the alternative estimates.

Although not statistically significant, the number of Massachusetts physicians receiving any payment and payments of less than $100 declines 34 percent ($P = .112$) and 13 percent ($P = .125$), respectively (unreported). Payments among Massachusetts physicians who accepted more than $100 per year increase 69 percent ($P < .001$), while payments among those who accepted less than $100 per year decrease by 6.9 percent ($P < .001$) (columns 6–7) relative to all other states. When we reassign the indicator variable to each of the other states, the estimated decrease in payments among those who accepted less than $100 per year is between the 90th and 95th percentiles of the alternative estimates.

6. DISCUSSION AND CONCLUSION

Many hope that disclosure policies will result in more evidence-based prescribing decisions, better patient outcomes, and decreases in total expen-

18. The regression analyses of Massachusetts's disclosure law is shown in Table OD4.

ditures on prescription drugs—the fastest growing component of health care costs. However, the interaction of disclosure laws on the mediating channel of industry-physician relationships remains unknown. Online Appendix OA presents a model of the potential impact of disclosure laws on the disclosed activity. These effects have not been previously modeled as far as we are aware, nor have they been empirically examined. The interaction of disclosure laws on the targeted behavior is typically unknowable since data on disclosed activities rarely exist in the absence of disclosure. We bypass this obstacle by utilizing national data released by pharmaceutical companies because of legal settlements unlikely to have been predicted at the time the physicians received payments.

Our first main result is that strong disclosure laws are associated with a 49 percent lower statewide annual average of payments to physicians and a 74 percent lower proportion of physicians receiving payments. These decreases might be considered an intended result of disclosure legislation. However, among physicians who accepted any payment, annual payments were 10 percent higher in strong-disclosure states, and payments were 54 percent higher among physicians who accepted more than $100 per year.

Physicians in strong-disclosure states received proportionately smaller payments for speaking and for meals and larger payments for consulting. The absolute payment amount for research activities is larger in strong-disclosure states. These observations suggest that rather than stigmatize industry-physician research relationships, public disclosure of payments may instead encourage explicit and formal delineation of industry-physician relationships around consulting, research, and development activities.

Our second main result is that little association is observed between payments to physicians and disclosure laws that do not mandate disclosure of payments to the public. This finding may explain the limited effects of disclosure laws in West Virginia and Maine on prescribing behavior in two drug classes observed in a recent study (Pham-Kanter, Alexander, and Nair 2012). The disclosure requirements in the Affordable Care Act, however, are more similar to the strong disclosure laws in our study.

Our results shed light on whether the interaction of disclosure laws and the targeted behavior is mediated through administrative costs imposed on industry or through physicians' willingness to accept payments. (Our model highlights the reputational cost to physicians of having their

industry-physician relationships made public.) Two considerations suggest that administrative costs imposed on industry are the lesser of the two mechanisms in our results. First, strong and weak disclosure impose similar administrative costs. Second, the changes observed in Massachusetts after the public release of disclosures are similar to the smaller payments noted for strong-disclosure states. In addition, the categories of payments shifted in the same way—more in consulting and research and less in speaking and meals in strong-disclosure states—for both cross-sectional and longitudinal variation. These results suggest that the reduction of incidental payments is due to decreased willingness among physicians to accept payments and that the cost of compliance with disclosure requirements does not significantly reduce industry's willingness to maintain payment relationships with physicians. Moreover, to the extent that weak disclosure laws can theoretically have other behavioral effects, such as expressive or moral effects that can be reflected in payments, we do not observe them in the data.

Our third main result is that higher payments for paid physicians are observed when physician payments are publicly visible. This result is consistent with physician-level factors such as compensation demanded for increased public visibility and associated reputational costs (Sigworth, Nettleman, and Cohen 2001) or a compensation race driven by physicians demanding more for their contracts, the availability of information about colleagues' compensation, and being underpaid (Preker et al. 2007) or having a sense of entitlement (Lichter 2008). The observed changes may be due to a compositional shift in the physicians receiving payments or a change in payments within physicians. When we include physician fixed effects, which utilize doctors' predisclosure payment receipts, strong disclosure is associated with higher payments per physician, but the association is not statistically significant at conventional levels. Therefore, some of the differences may be due to composition effects or treatment effects. It is possible that in some instances physicians who previously received large payments began receiving larger payments, and in other instances new physicians began receiving the larger payments.

Potential limitations are that we have data from only 12 pharmaceutical companies, and to some extent the analysis relies on the assumption that the variation in laws is uncorrelated with variation in sampling; however, the 12 companies include seven of the 10 largest firms in the US market, which makes their activities relevant even if they are not repre-

sentative of smaller pharmaceutical firms.[19] Lower payments per physician in strong-disclosure states are observed for each of the 12 companies regardless of its size. This alleviates the concern that sampling factors are associated with the identifying variation if the same pattern holds for each company. We also compare the distribution of payments by companies in the ProPublica database and companies not in the ProPublica database using data from Massachusetts. A Wilcoxon-Mann-Whitney test for significant differences in distributions indicates that the two distributions are not significantly different ($P = .20$).

Despite potential confounders that limit the ability to make causal statements, our results are similar using both cross-sectional and longitudinal variation. We examine the experience of Massachusetts before and after the state publicly released data on pharmaceutical company payments to physicians. We employ advanced statistical techniques for strengthening cross-sectional studies by using LASSO, a sparse model, to select control variables predictive of the strength of disclosure laws and control variables predictive of payments. Results are similar in Figure 1, which uses raw data, and multiple regressions that include controls.

Finally, although we conduct our regression analysis for differences between small and large amounts at $100, other cutoffs besides $100 do not change the findings. In strong-disclosure states, there are fewer small payments even at other cutoffs. We also do not observe payments under $100 to be more common in states with administrative burdens to disclose payments in excess of $100 (Minnesota) compared with disclosure states without the $100 cutoff (Massachusetts), which is further suggestive that the administrative burden of reporting is not a significant determinant of the payments. Notably, comparing two states with the same $100 disclosure requirement cutoff, the drop-off in payments after $99 is sharp for the strong-disclosure state (Minnesota) but not the weak-disclosure state (West Virginia). The difference-in-discontinuity model also supports the view that disclosure affects the reputational costs to physicians, who would discontinuously experience this cost at $100 and only in strong-disclosure states.

19. Analysis of the entire pharmaceutical company industry is the subject of European Research Council–funded work by one of the authors using data from the Affordable Care Act–mandated industry-wide disclosure.

APPENDIX: ADDITIONAL TABLES

Table A1. Pharmaceutical Companies in the Data, May 2012

Company	Revenue	Market Capitalization
Allergan	5.42	29.37
AstraZeneca	33.59	56.25
Cephalon[a]	18.31	43.08
Eli Lilly	24.29	47.86
EMD Serono[b]	N.A.	N.A.
GlaxoSmithKline	43.93	117.82
Johnson & Johnson	65.03	179.03
Merck	48.05	119.79
Novartis	58.57	151.26
Pfizer	67.43	171.7
Valeant	2.46	16.79
ViiV[c]	N.A.	N.A.
Total	367.08	932.95
Size of market	869.85	2,090.00
Market share	42.2	44.6

Note. Revenues are in billions of dollars as of 2011. Market capitalization is in billions of dollars as of May 2, 2012. N.A. = not available.

[a] Data are for Teva, which acquired Cephalon in 2011.

[b] Private company; data are not available.

[c] Owned by GlaxoSmithKline and Pfizer.

Table A2. Categories of Payments Reported by Companies Currently Disclosing Payments to Physicians

Company	Payments	Disclosure Reason	Effective Date	Expiration Date	Source
Allergan	Phase 1: payments for speaking, meals, and advisory boards of the sales, marketing, and medical affairs divisions; phase 2: all payments and transfers of value	Legal settlement for alleged off-label marketing and illegal payments to physicians to induce prescriptions	Phase 1: September 1, 2010; phase 2: September 1, 2011	August 30, 2015	Settlement Agreement, *United States ex rel. Lang v. Allergan, Inc.*, No. 1:07-cv-1288-WSD (N.D. Ga. 2010)
AstraZeneca	Phase 1: speaker fees; phase 2: payments for consulting, speaking, meals, travel, research, certain educational items, royalties and license fees, and ownership and investment interests when made directly or indirectly by AstraZeneca's US business	Legal settlement for alleged off-label marketing and illegal payments to physicians to induce prescriptions	Phase 1: August 31, 2010; phase 2: August 31, 2011	April 27, 2015	Settlement Agreement, *United States ex rel. Wetta v. AstraZeneca Corporation*, No. 04-3479 (E.D. Pa. 2010)
Cephalon[a]	Phase 1: payments for speaking, meals, and advisory boards of the sales, marketing, and medical affairs divisions; phase 2: all payments and transfers of value	Legal settlement for alleged off-label marketing	Phase 1: January 31, 2010; phase 2: March 31, 2011	September 26, 2013	US Department of Justice (2008)

Eli Lilly	Phase 1: payments for speaking, meals, and advisory boards of the sales, marketing, and medical affairs divisions; phase 2: all payments and transfers of value	Guilty plea in criminal lawsuit and settlement in civil lawsuit for alleged off-label marketing	Phase 1: August 1, 2009; phase 2: August 1, 2010	January 14, 2014	Settlement Agreement, *United States of America ex rel. Rudolph v. Eli Lilly and Co.*, No. 03-943 (E.D. Pa. 2009)
EMD Serono	All payments and transfers of value	Legal settlement for alleged illegal payments to physicians to induce prescriptions	July 1, 2011	April 20, 2015	Settlement Agreement, *United States ex rel. Amato v. Serono Laboratories*, No. 1:05-cv-03457-RDB (D. Md. Loc. Adm. 2005)
GlaxoSmithKline	Phase 1: payments for consulting and speaking; phase 2: added payments for clinical research to lead investigators	Voluntary	Phase 1: April 1, 2009; phase 2: January 1, 2010	None	GlaxoSmithKline, Commitment to Transparency and Access (https://web.archive.org/web/20130224005512/http://us.gsk.com/html/responsibility/transparency-access.html)

Table A2. *continued*

Company	Payments	Disclosure Reason	Effective Date	Expiration Date	Source
Johnson & Johnson	All payments and transfers of value from Johnson & Johnson's US businesses	Voluntary	June 30, 2010	None	Johnson & Johnson, Transparency in Our Business Activities (https://web.archive.org/web/20130225110316/http://www.jnj.com/connect/about-jnj/our-citizenship/transparency-in-our-business-activities)
Merck	Phase 1: payments for speaking; phase 2: all payments and transfers of value	Phase 1: voluntary; phase 2: legal settlement for alleged off-label marketing	Phase 1: September 1, 2009; phase 2: June 1, 2012	November 22, 2016	Settlement Agreement, *United States v. Merck Corp.*, No. 11-cr-10384-PBS (D. Mass. 2011)
Novartis	Phase 1: payments for speaking; phase 2: all payments and transfers of value, except for research, development, and clinical investigations; phase 3: all payments and transfers of value	Legal settlement for alleged illegal marketing and remuneration to physicians to induce prescriptions	Phase 1: March 31, 2011; phase 2: March 1, 2012; phase 3: March 1, 2013	September 29, 2015	Settlement Agreement, *United States ex rel. Austin and Montgomery v. Novartis Pharmaceuticals Corp.*, No. 8:03-cv-1551-T-30-TGW (M.D. Fla. 2011)

Pfizer	All payments and transfers of value	Guilty plea for misbranding Bextra and legal settlement for alleged illegal payments to physicians to induce prescriptions	March 31, 2010	August 31, 2014	Settlement Agreement, *United States ex rel. Collins v. Pfizer, Inc.*, No. 04-11780-DPW (D. Mass. 2009)
Valeant	All payments and transfers of value	Guilty plea to violation of US anti-kickback statute and legal settlement for alleged illegal payments to physicians to induce prescriptions	April 30, 2010	September 11, 2014	Valeant Pharmaceuticals Int'l, Quarterly Report Pursuant to Section 13 or 15(d) of the Securities and Exchange Act of 1934 (Form 10-Q), September 30, 2010
ViiV	Speaking and consulting fees to lead investigators; includes payments from Pfizer and GlaxoSmithKline, which own ViiV	Part of Pfizer settlement	January 1, 2010	August 31, 2014	ViiV Healthcare, Payment to US Healthcare Professionals for Research and Development Activity (https://web.archive.org/web/20130211061446/http://www.viivhealthcare.com/about-us/corporate-ethics/payments-to-healthcare-professionals.aspx?sc_lang=en)

[a] Acquired by Teva in 2011.

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