The Differential Effects of Malpractice Reform: 
Defensive Medicine in Obstetrics

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Abstract

Despite widespread reports of defensive medicine in surveys of physicians, empirical 
investigations have produced conflicting evidence. This paper models the interactions 
in a health insurance market, predicting that rises in medical malpractice pressure 
have non-monotonic effects on health care spending. Spending rises with malpractice 
pressure until reaching a threshold, and decreases thereafter. This theory is tested by 
estimating the effects of various tort reforms between 1987 and 2001 on the incidence 
of birth by cesarean section. The findings support the predictions of the model. Caps 
on noneconomic damages decrease C-section rates by 3% for mothers with good access 
to care, but increase them by 5% for mothers with poor access. This, as well as a lower 
incidence of late prenatal care and reduced prevalence of birth abnormalities, suggests 
malpractice reform primarily improves access to health care for vulnerable populations, 
and reduces utilization among well-served populations as a secondary effect.

Keywords: Defensive Medicine; Obstetrics; Healthcare Spending.

JEL Codes: I18, H75, K13

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1 Introduction

The existence and importance of defensive medicine practiced by health care providers has been a contentious issue for over forty years. Defensive medicine is the treatment decisions by health care providers made primarily to limit malpractice liability risk, rather than for the medical benefit of patients. Examples include the ordering of unnecessary and costly tests or procedures (“positive” defensive medicine) to forestall any claims of negligence, as well as the avoidance of the patients or procedures (“negative” defensive medicine) likely to result in a malpractice claim. Such behavior, if practiced on a sufficient scale, demonstrates the adverse effects that malpractice liability costs, or “malpractice pressure,” could have on patients’ access to care and the affordability of health insurance.

Surveys conducted in many countries report that various margins of physician behavior are sensitive to malpractice pressure, and that defensive medicine is widely practiced (Bovbjerg et al. 1996; Mello and Kelly 2005; Studdert et al. 2005; Lumalcuri and Hale 2010; Reyes 2010). These findings have led to the passage of various reforms of tort law attempting to reduce providers’ malpractice burden. The goal of these reforms is a reduction in the practice of defensive medicine, thereby making consumers’ health insurance more affordable and improving access to care. On the other hand, there may be unintended negative consequences of these reforms. For example, limiting malpractice risk may induce some physicians to provide a substandard level of care, or cause physicians to recommend aggressive yet lucrative treatment plans in the pursuit of revenue maximization. Therefore, when considering malpractice reform as an option for improving a health care system, it is important to determine the degree to which past reforms were successful in achieving their goals.

Researchers have investigated the practice of defensive medicine and the impact of malpractice reform for over two decades using utilization, spending, and quality data. Unlike physician surveys, however, these studies have produced findings with inconsistent and often conflicting implications. A number of empirical studies have revealed a clear positive relationship between malpractice pressure and health care spending. For example, physicians conduct more births by cesarean section (an expensive procedure widely considered defensive) following either a rise in malpractice premiums (Localio et al. 1993; Dubay et al. 1999; Yang et al. 2009) or facing a malpractice lawsuit (Grant and McInnes 2004; Shurtz 2013). Diagnostic and medical imaging procedures tend to be positively affected by malpractice pressure (Kessler and McClellan 2002; Baicker et al. 2007), suggesting the practice of positive defensive medicine. Tort reforms have been successful in reducing Medicare spending
(Kessler and McClellan 1996, 2002; Lakdawalla and Seabury 2012) as well as various other measures of health care utilization (Moriya 2010; Cotet 2012; Frakes 2012; Chen and Yang 2014; Avraham and Schanzenbach 2015). The findings of several other studies, however, indicate that the effect of malpractice pressure on health care spending is negative. Contrary to the studies mentioned above, Tussing and Wojtowycz (1992); Currie and MacLeod (2008); Shurtz (2014) all find increased provision of cesarean sections as malpractice pressure decreases. Medicare spending, as well, appears to increase in some cases following malpractice reform (Paik et al. 2012). Finally, there are other investigations that did not uncover any statistically significant relationship between malpractice pressure and health care spending (Baldwin et al. 1995; Baicker and Chandra 2005; Hellinger and Encinosa 2006; Congressional Budget Office 2006; Baicker et al. 2007; Kim 2007; Sloan and Shadle 2009). Overall this shows the lack of a clear message from the empirical literature, which has left interested parties deadlocked in the discussion of malpractice reform as a viable policy option for improving health care systems.

While several articles have already noted the inconsistent messages in the empirical defensive medicine literature (Helland and Showalter 2009; Avraham and Schanzenbach 2010; Reyes 2010; Cotet 2012), an explanation for these conflicts has been lacking. It could be that differing studies tend to uncover either positive or negative defensive medicine, both of which may have different implications for health care spending. While plausible, this does not explain why defensive medicine would be positive in one case and negative in another, nor does it help researchers or policymakers predict the effects of changes in the malpractice environment. The theoretical analysis in Montanera (2015) offers an explanation for the aforementioned empirical findings. It shows that the practice of defensive medicine can result in complex relationships between malpractice pressure and health care spending, which may vary qualitatively depending on the circumstances. However, some ambiguity remains in its predictions, which makes empirical tests of the model difficult. Without such an empirical test, it is unknown whether this complexity can explain the inconsistencies in the empirical literature.

In this study, we develop a special case of the model in Montanera (2015) that yields clear, unambiguous, and testable predicted effects of malpractice pressure on health care spending. This model shows that defensive medicine (both positive and negative) results in non-monotonic effects of malpractice pressure on health care spending. Specifically, health care spending rises initially with malpractice pressure. These effects are positive up to a threshold, after which any further increases in pressure produce negative effects. Intuitively,
as a result of defensive medicine, access to care becomes more expensive as malpractice pressure rises. At least initially, consumers are willing to bear the added expense in order to maintain access (for example, without excessive wait times), resulting in increased health care spending. We define this type of outcome as a “full-access equilibrium”. Eventually, however, this willingness to pay becomes exhausted and consumers instead demand cheaper, lower-quality health insurance with poorer access to care, or may simply opt out of the market altogether. We define this as a “limited-access equilibrium.” In this way, for a given individual or homogenous group, the theory predicts that defensive medicine creates non-monotonic effects of malpractice pressure on health care spending and quality: initially positive before becoming negative.

Informed by the model, this study proceeds with an investigation of a non-monotonic relationship between malpractice pressure and health care spending. This is done by estimating the effects of various state-level tort reforms on C-section rates in the United States between the years of 1989 and 2001. Tort reforms passed during this specific period represent the best source of plausibly exogenous changes in malpractice pressure [Kessler and McClellan (1996, 2002); Dubay et al. (2001); Currie and MacLeod (2008)]. Data was drawn from two sources: the Vital Statistics Natality Birth Data, provided by the National Center for Health Statistics (NCHS)\(^1\), and tort reforms by state-month-year provided by W. Bentley MacLeod through the Institute for Quantitative Social Science Dataverse Network (IQSS Dataverse Network) of Harvard University. The empirical strategy is designed to investigate for non-monotonic effects on health care spending, even though a continuous measure of malpractice pressure is unavailable. It does so by sorting observations into “full-access” and “limited-access” sub-samples and regressing separately. Full- and limited-access designation is determined by whether or not the mother’s prenatal care began on time during the first trimester.

The results of the empirical investigation are consistent with the model’s predicted non-monotonic effects of malpractice reform. For example, caps on noneconomic damages (which reduce malpractice pressure) result in a contemporaneous 5% increase in the provision of cesarean section for limited-access births. According to the theory, this is the result of decreased negative defensive medicine, and thus improved access, among mothers with poor access to care. Over a two-year period, however, those same caps result in a 3.4% decrease in cesarean sections among full-access births. The theory predicts that this is due to reduced positive defensive medicine in the treatment of mothers with good access to care. Since

\(^1\)Available through the National Bureau of Economic Research (NBER) website.
revenue maximization by physicians may also cause differential effects of malpractice reform (Shurtz 2014; Avraham and Schanzenbach 2015), further tests are conducted to determine whether or not changes in birth outcomes following malpractice reform are consistent with improvements in access. Over the whole sample, results show a decreased incidence of late prenatal care and a greater number of prenatal care visits as a result of malpractice reform. Furthermore, when focussing on limited-access mothers, the reforms result in large percentage reductions in fetal alcohol syndrome and newborn anemia; two birth abnormalities connected to behavioral and environmental factors. We interpret this as evidence of increased access to primary care and preventative services, and thus the increased utilization due to reduced negative defensive medicine rather than revenue maximization.

2 The Model

This section develops a model in order to derive unambiguous and testable predicted effects of malpractice pressure on health care spending. The model considers three decision makers: (i) a continuum of identical consumers of measure 1, (ii) a continuum of identical physicians of measure \( D < 1 \), and (iii) a single managed care organization (MCO) operating in a fully contested health insurance market. Consumers purchase health insurance policies from the MCO, which must in turn enter into contracts with physicians to procure services on behalf of policyholders. Each identical consumer is endowed with income \( m \) and holds preferences over consumption \( (y) \) and health status \( (H) \) according to the utility function \( U(y, H) \), which is subject to the Inada conditions. A healthy consumer enjoys health status \( H_1 \) while an ill consumer suffers a strictly lower status, \( H_2 \). Prior to health status being determined, each consumer has the chance to purchase health insurance. Illness occurs with probability \( q \), but in the case of illness, a consumer has a chance to recover the higher health status if the consumer is insured. Therefore, in purchasing health insurance, the consumer gives up some consumption in exchange for the chance of recovery in the event of illness.

We assume that the consumer’s utility function is additively separable, which makes consumers’ marginal utility of consumption independent of health status. This assumes away interactions found in the empirical literature, which indicates that health and consumption tend to be compliments (Levy and Nir 2012; Finkelstein et al. 2013). Where this is true, an

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2 This section presents justifications for primarily those assumptions departing from the more general model in Montanera (2015). It does not attempt to repeat the justification for every modeling assumption made in the general model, to which readers seeking additional detail are referred.

3 This is the central departure of this model from that in Montanera (2015).
individual facing a negative health shock would find consumption less valuable. This effect may be reasonably assumed away in the simplified model specifically because this is a market for health insurance, where insurance policies tend to cover entire households. While one individual may devalue their own consumption upon falling ill, other uses of income (rent, tuition, etc.) would likely remain important for the rest of the household. The impact of this assumption is revisited in the Equilibrium section.

Health insurance is purchased from a single MCO. Health insurance consists of a policy price ($\tau$) and a probability of recovery ($Q$). Given that consumers are identical ex ante, and because the market is fully contested, the only insurance policy \(\{Q, \tau\} \) the MCO can offer in equilibrium is that which maximizes expected consumer utility ($EU$) subject to a zero-profit constraint. The probability of recovery depends on the health care services procured by the MCO from physicians. The MCO does this by setting a contract for services, the expenses of which are financed using revenue from the sale of insurance policies. Under the contract, each physician receives a payment ($w$) for each consumer on the physician’s caseload, as well as a stock of resources ($s$) to divide and allocate across each case. Resources are procured at a marginal cost of $c$, which is constant.

Physicians are risk-neutral income maximizers. Taking as given the contract \(\{w, s\} \) set by the MCO, each physician then chooses the size of his caseload ($n$) and the quantity of resources ($t_i$) to devote to each patient $i$ as “treatment”, where the total amount of treatment across the physician’s caseload cannot exceed the available stock of resources ($s$). A patient receiving treatment $t_i$ receives a favorable outcome (recovering from $H_2$ to $H_1$) with probability $1 - \rho(t_i)$ but suffers an adverse outcome (remaining with $H_2$) with probability $\rho(t_i)$. The function $\rho(t)$ is strictly positive, decreasing, continuous, and strictly convex. Furthermore, assume that the adverse outcome occurs with probability 1 when no treatment is provided (meaning $\rho(0) = 1$), but approaches zero as treatment increases. These all imply that physicians can reduce the probability of an adverse outcome, but cannot eliminate it entirely. Assume that each patient on the physician’s caseload carries an uninsurable expected malpractice liability cost of $g(t_i, P)$, where $P$ is a parameter representing malpractice pressure. As a functional form assumption, further assume that $g(t_i, P) = \rho(t_i)P$, meaning that expected liability cost is proportional to the probability of an adverse outcome. Given that patients are identical and $\rho(t)$ is strictly convex, the physician’s total liability costs are lowest when resources are evenly distributed ($t_i = \frac{s}{n}$), so the physician’s income-maximizing caseload $n^*(w, s, P)$ is the solution to:
\[
\max_n \left\{ wn - np\left(\frac{s}{n}\right) P \right\}
\]

Intuitively, while expanding the caseload allows a physician to increase revenues, it also increases the exposure to expected malpractice liability costs. This is both because the greater number of patients increases the number of potential claims, but also because the physician’s available resources become more thinly spread over the larger caseload. An increase in malpractice pressure \(P\) increases both the total liability exposure as well as the marginal cost of expanding his caseload, inducing the physician to choose a smaller caseload and focus available resources on a smaller group of patients. An increase in either \(w\) or \(s\) has the opposite effect, meaning the MCO must use the contract \(\{w, s\}\) to overcome these liability concerns in order to procure physicians’ services.

The solution to the physician’s problem ultimately determines the quality and cost of the health insurance policy offered, and so this must be accounted for in the MCO’s problem. The total size of caseloads opened across all physicians is \(Dn^*\), while the total number of ill consumers is \(q\). Since the number of patients treated cannot exceed the number of ill consumers, and assuming an even distribution of patients across physicians, the actual number of patients treated by each physician is \(\tilde{n} = \frac{n}{\min\{n^*(w, s, P), \frac{q}{D}\}}\). Given the assumptions of the model, an ill consumer’s successful recovery is the result of two events. First, the consumer must be taken on as part of a physician’s caseload. This occurs with probability \(\frac{D\tilde{n}}{q}\), which serves as the level of “access” provided to the ill consumer through the health insurance policy. Second, conditional on gaining access, the patient’s treatment is successful with probability \(1 - \rho(\frac{s}{\tilde{n}})\). Therefore, the unconditional probability that a given ill consumer recovers through their health insurance policy is \(\tilde{Q} = \frac{D\tilde{n}}{q}(1 - \rho(\frac{s}{\tilde{n}}))\).

In procuring these services, the MCO must make total payments of \(Dw\tilde{n}\) to physicians and bear the total cost \(Dcs\) in procured resources. Therefore, the MCO’s problem is:

\[
\max_{w, s} \left\{ EU = \left(1 - q + q\tilde{Q}\right) U(m - \tau, H_1) + \left(q - q\tilde{Q}\right) U(m - \tau, H_2) \right\}
\]

\[
s.t. \quad \tau = Dw\tilde{n} + Dcs
\]
By adjusting the contract \( \{w, s\} \), the MCO can procure the physician services that ultimately provide policyholders with a chance at recovery. Procuring more of these services is costly, requiring the MCO to set greater policy prices in order to break even, and leaving consumers with a smaller share of income remaining for consumption. The MCO thus faces the tradeoff between consumption and the probability of recovery on behalf of patients.

3 Equilibrium

Equilibrium is defined as, for a given set of model parameters, \( i \) a decision rule \( n^*(w, s, P) \) solving the physician’s problem and \( ii \) a contract \( \{w^*, s^*\} \) solving the MCO’s problem. Let \( \tilde{n}^*, \tilde{t}^*, \tau^* \), and \( \tilde{Q}^* \) respectively be the caseloads, treatment, policy price, and probability of recovery that result from these equilibrium variables. For a given set of parameters, let \( \bar{\tau} \) be the minimum policy price required to finance an optimal contract where all ill consumers are accepted onto a physician’s caseload \( (D\tilde{n}(w^*, s^*, q, D, P) = q) \).

Definition 1. Define a full-access equilibrium as any equilibrium such that \( \tau^* > \bar{\tau} \) and \( \tilde{n}^* = \frac{q}{D} \).

Definition 2. Define a limited-access equilibrium as any equilibrium such that \( \tau^* \leq \bar{\tau} \).

The distinction of equilibrium type by level of access is important as it concerns the MCO’s best use of the additional funds it received from an increase in the policy price. In the MCO’s problem, there are constant returns from increasing caseloads and diminishing returns from increasing treatment. As long as access is less than full, the MCO’s best use of an additional dollar of funding is to induce physicians to increase caseloads, while holding treatment constant. This holds until the caseloads taken on by all physicians \( (Dn) \) equals the number of ill consumers \( (q) \), at which point any increase in caseloads would go unfilled and thus be ineffective. Therefore, once full access is achieved, the MCO’s best use of an additional dollar of funding is to procure additional resources in order to increase treatment.

Given certain technical assumptions on the convexity of \( \rho(t) \) and the initial effectiveness of treatment in reducing liability costs (Assumptions 1 and 2 from Appendix A), then the following existence and uniqueness result holds:

Proposition 1. Given Assumptions 1 and 2 then there exists a unique equilibrium that is either a full-access or limited-access equilibrium.
The proof for existence and uniqueness is the same as in Montanera (2015). It shows that there is a unique \( \{n, t\} \) that maximizes the probability of recovery \( \tilde{Q} \) for a given level of available funding \( (\tau) \). This unique \( \{n, t\} \) can be substituted into the MCO’s problem, which can then be solved with respect to \( \tau \). This yields the following first order condition:

\[ q \cdot \frac{\partial \tilde{Q}}{\partial \tau} \Delta U = MU_y \tag{1} \]

where \( \Delta U = U(m - \tau, H_1) - U(m - \tau, H_2) \) is an ill consumer’s benefit from recovery and \( MU_y \) is the marginal utility of consumption\(^4\). This shows that the optimal policy price \( (\tau^*) \), which is also equilibrium health care spending due to the unit-measure of consumers, balances the increased consumer utility brought on by greater chances of recovery with the lost utility of foregone consumption. If the optimal policy price is sufficiently large \( (\tau^* > \bar{\tau}) \), then the result is a full-access equilibrium, and a limited-access equilibrium otherwise. From (1), and by the Implicit Function Theorem, the following comparative static reveals how equilibrium health care spending changes with malpractice pressure:

\[ \frac{\partial \tau^*}{\partial P} = \frac{-q \Delta U \frac{\partial^2 \tilde{Q}}{\partial \tau \partial P}}{q \Delta U \frac{\partial^2 \tilde{Q}}{\partial \tau^2} - \frac{\partial MU_y}{\partial \tau}} \tag{2} \]

The denominator on the right side of (2) is always negative, meaning that the sign of the comparative static is determined by \( \frac{\partial^2 \tilde{Q}}{\partial \tau \partial P} \). Because \( \frac{\partial \tilde{Q}}{\partial \tau} \) is the increased probability of recovery that the MCO is able to procure with a marginal increase in funds, the term \( \frac{\partial^2 \tilde{Q}}{\partial \tau \partial P} \) is best interpreted as impact of malpractice pressure on the effectiveness of an additional dollar of funding.

**Proposition 2.** If malpractice pressure \( P' \) results in a full-access equilibrium, then \( \frac{\partial \tau^*}{\partial P} > 0 \).

The proof of Proposition 2 is presented in Appendix B. In any full-access equilibrium, the term \( \frac{\partial^2 \tilde{Q}}{\partial \tau \partial P} \) is positive. Intuitively, rising malpractice pressure makes full access more expensive. Maintaining full access at a given level of funding requires that the MCO reallocate funds from procuring resources to increasing physician payments. This lowers the level of treatment, and since treatment is subject to diminishing returns, a marginal effectiveness of treatment increases. As resources become more effective while the cost is constant, the rise in malpractice pressure makes an increase in resources more cost-effective. This induces the

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\(^4\Delta U \) is independent of \( y \) and \( MU_y \) is independent of \( H \) as a result of the additive separability assumption on the utility function.
MCO to raise additional funds in order to procure more resources, which in turn raises the price of health insurance and thus health care spending.

**Proposition 3.** If malpractice pressure $P'$ results in a limited-access equilibrium, then:

i) $\frac{\partial \tau^*}{\partial P} < 0$

ii) $\frac{\partial \tilde{n}^*}{\partial P} < 0$

iii) Any $P > P'$ also results in a limited-access equilibrium.

The proof of Proposition 3 is presented in Appendix C. It shows that the effect of malpractice pressure on health care spending in the limited-access equilibrium is the opposite of that in the full-access equilibrium. The reason for this difference is that, as long as access is limited, the MCO’s best use of the marginal unit of funding is to increase access. Just as in the other equilibrium, however, a rise in malpractice pressure makes physicians more wary of increasing caseloads, and thus makes access more expensive. This reduces the cost-effectiveness of increased caseloads, thus making the marginal unit of funds less effective at increasing the probability of recovery (i.e. $\frac{\partial^2 \hat{Q}}{\partial \tau \partial P}$ is negative.). Therefore, unlike in the full-access equilibrium, the MCO is induced to forego the marginal unit of funding, thus lowering the price of health insurance and health care spending. With access becoming more expensive to procure, and less funds becoming available to the MCO, equilibrium access must decrease. This means that, as malpractice pressure rises, equilibrium cannot return to full-access once it crosses into limited-access. Therefore, for a given set of model parameters, the greatest level of malpractice pressure producing a full-access equilibrium ($\bar{P}$) is a threshold. The model thus predicts that the effect of malpractice pressure on equilibrium health care spending is non-monotonic, positive up until a threshold level of pressure is reached, and negative thereafter.

\[5\] Without the assumption of additive separability in the utility function, a second term would appear in the numerator of $2$. This term would be the effect of the increase in malpractice pressure, which lowers expected health status for a given level of health care spending, on $MU_y$. If present, this term would reinforce the effect of malpractice pressure on spending in one equilibrium type, but confound it in the other. Which equilibrium type (full- or limited-access) would be confounded depends on the sign of the term.
4 Data and Methods

Figure 1 illustrates both the analytical results as well as the identification strategy for an empirical investigation of the model’s predictions. The figure displays the predicted levels of access to care and health care spending at different levels of malpractice pressure. Intuitively, at low levels of malpractice pressure, access to care is relatively inexpensive. Physicians are not overly concerned with the prospect of a malpractice lawsuit, and so are willing to provide care to many patients at low levels of reimbursement. When access is so inexpensive, consumers are willing to pay for health insurance policies that provide excellent access to care; for example, without excessive wait times or travel distances to willing providers. As malpractice pressure rises, however, physicians become more wary of lawsuits, and require greater financial reimbursement in order to provide the same level of access. At least initially, consumers are willing to bear the added expense, resulting in increased health care spending, in order to maintain a high level of access. If malpractice pressure continues to rise, however, this willingness to pay eventually becomes exhausted. Consumers instead demand cheaper health insurance with poorer access to care, or may simply opt out of the market altogether.

Figure 1: Effects of Rising Medical Malpractice Pressure

(a) Effects on Access to Health Care

(b) Effects on Health Care Spending

The most accepted exogenous measure of malpractice pressure is the presence of state-level tort reforms (Kessler and McClellan, 1996; Dubay et al., 2001). The passage or withdrawal of these reforms may be interpreted as a discrete change in the malpractice pressure, but does not the level of pressure to which an individual or population is exposed. This complicates the estimation of a potential non-monotonic relationship between health care spending and malpractice pressure because it is not known which observations fall on either side of the threshold $\bar{P}$. To solve this problem, we use the model’s predictions on consumer
access to health care. Taking both panels of Figure 1 together, it is clear that rising malpractice pressure has a positive effect on the health care spending of those patients enjoying good access to care, while a negative effect is experienced by patients with poor access. Therefore, estimation of the non-monotonic relationship would be allowed, even with a discrete measure of malpractice pressure, as long as the observations in the data could be separated into full-access and limited-access groups, and then estimated separately.

We consider the effects of four tort reforms: caps on punitive damages, caps on noneconomic damages, collateral source rule reform, and joint-and-several liability rule reform. Data on tort reforms by state-month-year is provided by W. Bentley MacLeod through the Institute for Quantitative Social Science Dataverse Network (IQSS Dataverse Network) of Harvard University. The Congressional Budget Office report, “The Effects of Tort Reform: Evidence from the States” provides the following descriptions of these reforms:

- **Punitive damages**: Damages awarded in addition to compensatory (economic and noneconomic) damages to punish a defendant for willful and wanton conduct.

- **Noneconomic damages**: Damages payable for items other than monetary losses, such as pain and suffering. The term technically includes punitive damages, but those are typically discussed separately.

- **Collateral-source payments**: Amounts that a plaintiff recovers from sources other than the defendant, such as the plaintiff’s own insurance. Under the collateral-source rule, that compensation from other sources may not be admitted as evidence at trial.

- **Joint-and-several liability**: Liability in which each liable party is individually responsible for the entire obligation. Under joint-and-several liability, a plaintiff may choose to seek full damages from all, some, or any one of the parties alleged to have committed the injury. In most cases, a defendant who pays damages may seek reimbursement from nonpaying parties. (Congressional Budget Office 2004)

Delivery by cesarean section is associated with defensive behavior since it is an expensive alternative to vaginal birth (Dubay et al., 1999; Chen and Yang, 2014; Shurtz, 2014) and is widely believed among physicians to reduce the complications most likely to result in malpractice claims (Yang et al., 2009). For this reason, the incidence of birth by cesarean section is used here as a proxy for health care spending. Data on the use of cesarean section comes from the Vital Statistics Natality Birth Data, provided by the NBER. This certificate information covers all births occurring between 1989 and 2001 in 26 U.S. states that passed
or rescinded any of four tort reforms between the years of 1987 and 2001, from which a 15 percent sample is drawn. The states used in the analysis are presented in Table 1.

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Notes: The “†” indicates that state only appears in Lag 1 and Lag 2 samples. The “‡” indicates that state only appears in Lag 2 sample.

Notice that natality data covers the years 1989-2001 while the tort reform data goes back two years earlier. This is to allow for tort reforms to affect cesarean rates with a lag of up to two years. It is possible that the physicians or the patients respond gradually to the changes in tort laws over a number of years, as is suggested in Dubay et al. (1999). While the model presented in Section 2 is static and thus lacks a time dimension, these lagged effects may exist in practice, and so the empirical application allows for more gradual effects of tort reform.

The empirical analysis is restricted to births in counties with a population of at least 100,000. The reason is that the model developed in this study assumes a fixed measure of physicians, which effectively makes physicians immobile. In less-populated counties, likely without many physicians, the movement of even a small number physicians can cause significant changes to the physician-to-patient ratio. By focussing the analysis on counties with larger populations and presumably greater numbers of physicians, this ratio is likely to be more stable and thus more closely resemble the conditions assumed in the model.

Since access to care is predictive of the qualitative effect of a change in malpractice pressure on health care spending, the strategy for testing the non-monotonic relationship using a discrete measure of malpractice pressure consists of two steps. First, each birth is sorted into full- and limited-access groups. Second, we estimate monotonic relationships separately for each group. The second-step estimations utilize the specification from Currie.

Montanera (2012) shows that physician mobility can be a source of bias in the effects of malpractice pressure on health care spending, and so focusing in large counties would help in reducing this bias.
and MacLeod (2008) as follows:

\[(3) \quad C_{i,m,y} = \beta_0 + \text{TR}_{s,m,(y-k)} \beta_1 + x_{i,m,y}' \beta_2 + \delta_y + \eta_m + \gamma_c + \theta_s \times t + \varepsilon_{i,m,y}\]

where \(C_{i,m,y}\) is an indicator variable for whether or not cesarean section was the method of delivery use with mother \(i\) at month \(m\) during year \(y\). In particular, we define \(C_{i,m,y} = 1\) if cesarean section was the method of delivery, and \(C_{i,m,y} = 0\) if it was a vaginal birth. The vector \(\text{TR}_{s,m,y}\) includes four dummy variables each corresponding to each of the four tort reforms considered in this study at state \(s\) on month \(m\) during year \(y\). The following conditions define the values of the dummy variables:

- \(PDC_{s,m,y} = 1\{\text{state } s \text{ at time } (m, y) \text{ has a cap on punitive damages}\}\)
- \(NEC_{s,m,y} = 1\{\text{state } s \text{ at time } (m, y) \text{ has a cap on noneconomic damages}\}\)
- \(CSR_{s,m,y} = 1\{\text{state } s \text{ at time } (m, y) \text{ allows payments from private sources as evidence in trials}\}\)
- \(JSL_{s,m,y} = 1\{\text{state } s \text{ at time } (m, y) \text{ requires parties to be responsible for at least 50% of the harm}\}\)

Note that the specification in (3) allows for the estimation of lagged effects, with \(k = 1, 2\) representing one- and two-year lags, respectively. Since each specification is restricted to states experiencing a change in at least one tort reform variable, estimating lagged effects allows additional states to be included in the analysis. Table 1 indicates which states appear in the No-Lag sample, Lag 1 sample, and Lag 2 sample. The vector \(x_{i,m,y}\) contains the following control variables: a dummy for child gender, a dummy for multiple birth, dummies for mother Hispanic, African American or other race, dummies for each parity from 1 to 4 and more than 5, dummies for mother’s education (less than high school, high school, some college, college or more), dummies for mothers’s age (19-24, 25-34, 35 or more). Finally, \(\delta_y\) are year effects, \(\eta_m\) month effects, \(\gamma_c\) county effects, and \(\theta_s \times t\) is a state-specific linear time trend.

The first step in the empirical test requires sorting births into full- and limited-access groups. Since “access” is a latent variable in the model developed in Section 2, in the estimation uses proxies for this variable. For each birth, the Vital Statistics Natality Birth Data lists the trimester in which prenatal care was initiated, if at all. Borrowing from Dubay et al. (2001), prenatal care initiated during the first trimester is considered timely, while initiation in second or third trimesters, or not at all, is considered untimely. Assuming that

\[\text{Additional proxies to the one examined here, including the Kessner Index for adequacy as well as others, can be found in Cano-Urbina and Montanera (2015).}\]
timely prenatal care is in the best interests of the mother and infant, untimely initiation is
taken as an indicator of the mother’s poor access to prenatal care. Therefore, those mothers
with timely initiation of prenatal care are sorted into the full-access group, and those with
untimely care into the limited-access group.

Table 2 presents summary statistics. Note that limited-access births are relatively less
likely to be conducted by cesarean section. These births also correspond, on average, to
mothers who are younger, less educated, and more likely to be black or Hispanic. This
indicates that affordability is a likely a significant barrier to access. Similarly, in Table 3,
full- and limited-access groups’ exposure to each tort reform is relatively equal. This does
not mean that each group is affected by each tort reform in the same way, but at least rules
out any bias in the results due to an imbalance in the shares of treated observations.

5 Results

Currie and MacLeod (2008) present a model predicting the effect of each tort reform on
malpractice pressure. Caps on either punitive or noneconomic damages limit the direct
liability costs of jury awards and, by lowering the expected payoff of a lawsuit, potentially
the indirect costs through reduced frequency of lawsuits. For this reason, the passage of
either type of damage cap is considered a reduction in malpractice pressure. CSR reform
allows courts to consider other sources of income to a plaintiff stemming from a medical
injury when determining damages. As far as these other sources would lessen the need for
additional damages to make the plaintiff whole, CSR reform is also considered a reduction
in malpractice pressure. The final tort reform examined here, JSL reform, is considered
an increase in malpractice pressure. This is because these reforms involve changes to the
threshold level of responsibility for injury a party must hold before being potentially liable for
damages. Without a threshold, a physician could face a malpractice claim over negligence
that was primarily another party’s doing. Installing a threshold of 50% or higher would
result in a greater dependence of a physician’s total malpractice liability on that physician’s
own decisions. As this could increase the incentive for defensive behavior, setting such a
high threshold is considered an increase in malpractice pressure. The withdrawal of any of
these reforms is assumed to have the opposite effect.

Table 4 shows the effects of the four tort reforms separately for full- and limited-access
births. The first two columns present the contemporaneous effects of tort reforms on the
the likelihood of a C-section, that is estimating the specification in Eq. 3. The results
Table 2: Summary Statistics (Percentages)

<table>
<thead>
<tr>
<th></th>
<th>Full Access</th>
<th>Limited Access</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utilization:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-Section</td>
<td>22.71</td>
<td>17.73</td>
</tr>
<tr>
<td>Forceps</td>
<td>4.16</td>
<td>2.92</td>
</tr>
<tr>
<td>Amniocentesis</td>
<td>3.19</td>
<td>1.41</td>
</tr>
<tr>
<td><strong>Quality:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fetal Alcohol Syndrome</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Newborn Anemia</td>
<td>0.12</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>Demographics:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male Child</td>
<td>51.11</td>
<td>51.38</td>
</tr>
<tr>
<td>Multiple Birth</td>
<td>2.88</td>
<td>2.10</td>
</tr>
<tr>
<td>Mother Hispanic</td>
<td>14.97</td>
<td>27.24</td>
</tr>
<tr>
<td>Mother Black</td>
<td>16.08</td>
<td>30.30</td>
</tr>
<tr>
<td>Mother Other Race</td>
<td>3.25</td>
<td>3.36</td>
</tr>
<tr>
<td>Mother Married</td>
<td>74.31</td>
<td>43.99</td>
</tr>
<tr>
<td><strong>Mother’s Age:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 – 18</td>
<td>6.11</td>
<td>16.94</td>
</tr>
<tr>
<td>19 – 24</td>
<td>26.16</td>
<td>40.93</td>
</tr>
<tr>
<td>25 – 34</td>
<td>55.41</td>
<td>34.97</td>
</tr>
<tr>
<td>35+</td>
<td>12.33</td>
<td>7.17</td>
</tr>
<tr>
<td><strong>Mother’s Education:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 12</td>
<td>16.83</td>
<td>43.29</td>
</tr>
<tr>
<td>12</td>
<td>33.06</td>
<td>36.06</td>
</tr>
<tr>
<td>13 – 15</td>
<td>23.33</td>
<td>14.18</td>
</tr>
<tr>
<td>16+</td>
<td>26.78</td>
<td>6.47</td>
</tr>
<tr>
<td><strong>Parity:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>41.88</td>
<td>36.63</td>
</tr>
<tr>
<td>2</td>
<td>33.41</td>
<td>28.14</td>
</tr>
<tr>
<td>3</td>
<td>16.01</td>
<td>18.01</td>
</tr>
<tr>
<td>4</td>
<td>5.60</td>
<td>9.02</td>
</tr>
<tr>
<td>5+</td>
<td>3.09</td>
<td>8.21</td>
</tr>
<tr>
<td><strong>No of obs</strong></td>
<td>2,153,090</td>
<td>517,311</td>
</tr>
</tbody>
</table>

*Notes: Descriptive statistics using the 26 states listed in Table 1. The samples for full and limited access correspond to the samples used in the Lag 2 regressions which also contain the observations from the Lag 1 and No Lag regressions.*
Table 3: Tort Reforms (Percentages)

<table>
<thead>
<tr>
<th></th>
<th>Full Access</th>
<th>Limited Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any NE cap</td>
<td>63.43</td>
<td>65.68</td>
</tr>
<tr>
<td>Any PD cap</td>
<td>30.70</td>
<td>28.93</td>
</tr>
<tr>
<td>JSL Reform</td>
<td>48.60</td>
<td>48.16</td>
</tr>
<tr>
<td>CSR Reform</td>
<td>44.30</td>
<td>45.31</td>
</tr>
<tr>
<td>No of obs</td>
<td>2,153,090</td>
<td>517,311</td>
</tr>
</tbody>
</table>

Notes: Descriptive statistics using the tort reforms from years 1987 to 2001 implemented in the 26 states listed in Table 1. The samples for full and limited access correspond to the samples used in the Lag 2 regressions which also contain the observations from the Lag 1 and No Lag regressions.

Indicate that limited-access mothers experience the immediate effects of tort reforms, with only noneconomic damages cap and JSL reform having a significant effect. According to the estimates, reducing the level of malpractice pressure by introducing a noneconomic damages cap results in an increase in the probability of using a C-section as the method of delivery. Similarly, increasing the level of malpractice pressure by introducing a JSL reform is associated with a decrease in the probability of a C-section. Notice that these results are in line with the Proposition 3 since, in a limited-access equilibrium, malpractice pressure is negatively correlated with health care spending, which is precisely the result found in the second column of Table 4.

As explained in Section 4, tort reforms may have lagged effects, and so additional specifications of Eq. (3) are estimated for one- and two-year lagged reforms. The results for one-year lags are similar to the contemporaneous effects, and in an effort to be concise, these results are left out of Table 4. The estimates from a two-year lagged reforms are presented in the last two columns of Table 4. The results indicate that full-access mothers primarily experience the effects of tort reform two years after the reform takes place, with noneconomic damages cap and CSR reform having significant effects. The estimates suggest that reducing the level of malpractice pressure by introducing a noneconomic damages cap or CSR reform results in a decrease in the probability of a C-section. This is the same positive effect on health care spending predicted to occur in a full-access equilibrium due to increasing malpractice pressure. Therefore, once again, the direction of the effects is consistent with the predictions of the model developed in Section 2.

As the model in Section 2 is static, it offers no explanation for why the predicted effect of malpractice pressure on health care spending is delayed for full-access mothers. According to
Table 4: Effects of Tort Reforms on C-Section: By Trimester

<table>
<thead>
<tr>
<th></th>
<th>No Lag</th>
<th>Lag 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Access</td>
<td>Limited Access</td>
</tr>
<tr>
<td>Any PD cap</td>
<td>0.2153</td>
<td>0.5401</td>
</tr>
<tr>
<td></td>
<td>(0.2137)</td>
<td>(0.4124)</td>
</tr>
<tr>
<td>Any NE cap</td>
<td>-0.0583</td>
<td>0.8935***</td>
</tr>
<tr>
<td></td>
<td>(0.3506)</td>
<td>(0.2114)</td>
</tr>
<tr>
<td>JSL Reform</td>
<td>-0.0351</td>
<td>-1.4625***</td>
</tr>
<tr>
<td></td>
<td>(0.2729)</td>
<td>(0.3067)</td>
</tr>
<tr>
<td>CSR Reform</td>
<td>0.7800*</td>
<td>-0.3351</td>
</tr>
<tr>
<td></td>
<td>(0.3853)</td>
<td>(0.5155)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.0454</td>
<td>0.0435</td>
</tr>
<tr>
<td>No of obs</td>
<td>1,712,239</td>
<td>404,049</td>
</tr>
</tbody>
</table>

Notes: Standard errors corrected for state-of-occurrence clustering are in parenthesis. The dependent variable is a dummy equal to one if the delivery method was a C-section and zero if it was a vaginal birth. All coefficient estimates and standard errors are multiplied by 100. All specifications control for child gender, multiple births, mother race (Hispanic, Black, or other race), parity from 1 to 4 and 5+, mother’s education (<12, 12, 13-15, 16+ years), mother’s age (19-24, 25-34, 35+ years), state-of-occurrence-specific time trends, as well as year, month, and county of occurrence.

*Significant at 10%, **Significant at 5%, ***Significant at 1%.

the model, under reduced malpractice pressure from tort reform, physicians do not require as much compensation for providing the same level of physician services. In the real world, this reduced compensation could be delivered in the form of reduced fees per C-section (which cannot be determined with the available data) or more stringent conditions on approving C-section in marginal cases. Therefore, the reduced C-sections performed on full-access mothers are the result of reduced positive defensive medicine. As a physician’s decisions are evaluated against a standard of due care in matters of malpractice, and unnecessary C-sections could become the standard under high malpractice pressure, there may be reluctance to deviate too far below that standard immediately following tort reform. The delayed effect may thus reflect the impact of tort reform on the actual standard of care, which would evolve slowly if individual physicians gradually make incremental adjustments to their treatment decisions.

Taken within the context of the model developed in this paper, the results from Table 4 suggest that the increased C-sections following pressure-reducing tort reforms are the result of more affordable health insurance becoming available to mothers with poor access to care, that is the limited-access subsample. This is a different interpretation from that found in the literature. Both Currie and MacLeod (2008) and Shurtz (2014), studying the field of obstetrics, interpret the increase in C-sections as revenue maximization; physicians taking
advantage of a more lenient malpractice environment by performing unnecessary C-sections. While the incentive to gain revenue surely exists, it is unlikely to be held in check by the fear of liability. Over this period, many more malpractice claims in obstetrics (31% vs. 3%) are associated with delayed or nonperformance of C-section rather than unnecessary performance (Kravitz et al., 1991). Furthermore, if the additional C-sections were the result of revenue maximization, the likely targets would be mothers with excellent access to care and generous health insurance, that is the full-access sample. As the evidence shows, however, the additional C-sections were performed on mothers with poor access to care. This suggests that the additional C-sections following tort reform are more due to reduced negative defensive medicine than revenue maximization.

To investigate for whether or not malpractice reform improves access to care, particularly for vulnerable populations, this study proceeds by estimating Equation 3 using two access proxies as the dependent variable. The most obvious proxy is that which was used to separate full- and limited-access sub-samples: a dummy variable equal to 1 if prenatal care was timely (initiated in the first trimester) and 0 if initiated afterward or not at all. The first two columns of Table 5 presents these results. In order to filter out births where prenatal care was already late at the time of a tort reform, only the 1- and 2-year lagged specifications are included in the table. Consistent with the predictions of the model, punitive and noneconomic damage caps increases the likelihood that a mother’s prenatal care was timely, while JSL reform decreases it. The third and fourth columns of Table 5 repeat the estimation using the number of prenatal care visits as the dependent variable. These results reveal the same pattern. Therefore, to the extent that these are good proxies for the latent access variable, reduced malpractice pressure through damage caps improves access to care on average over the entire sample. Increases in malpractice pressure through JSL reform have the opposite effect. Both of these findings are consistent with tort reform resulting in reduced negative defensive medicine.

In order to determine whether access improvements are primarily realized by limited-access mothers, the final specification estimates Equation 3 using access-sensitive health outcomes. That is, we can investigate whether or not access to care improves for mothers who regularly face access barriers, by estimating the specification in (3) using the presence of specific birth abnormalities as the dependent variables. Two such abnormalities listed in the Natality Birth Data are fetal alcohol syndrome and newborn anemia. Both of these abnormalities can be caused by behavioral and environmental risk factors during the pregnancy. For example, newborn anemia can be caused by a lack of iron, exposure to certain drugs, or
Table 5: Effects of Tort Reforms on Access Measures

<table>
<thead>
<tr>
<th></th>
<th>On-Time Prenatal Care</th>
<th></th>
<th>Number of Prenatal Visits</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lag 1</td>
<td>Lag 2</td>
<td>Lag 1</td>
<td>Lag 2</td>
</tr>
<tr>
<td>Any PD cap</td>
<td>0.5973</td>
<td>0.9360**</td>
<td>-0.0062</td>
<td>0.0752</td>
</tr>
<tr>
<td></td>
<td>(0.6061)</td>
<td>(0.3604)</td>
<td>(0.0979)</td>
<td>(0.0662)</td>
</tr>
<tr>
<td>Any NE cap</td>
<td>0.3473</td>
<td>0.9947**</td>
<td>0.1439</td>
<td>0.1505*</td>
</tr>
<tr>
<td></td>
<td>(0.4079)</td>
<td>(0.3725)</td>
<td>(0.0916)</td>
<td>(0.0854)</td>
</tr>
<tr>
<td>JSL Reform</td>
<td>-0.9926**</td>
<td>-0.8269</td>
<td>-0.1771**</td>
<td>-0.1225*</td>
</tr>
<tr>
<td></td>
<td>(0.4090)</td>
<td>(0.5099)</td>
<td>(0.0834)</td>
<td>(0.0684)</td>
</tr>
<tr>
<td>CSR Reform</td>
<td>0.0172</td>
<td>-0.2857</td>
<td>0.1086</td>
<td>0.0205</td>
</tr>
<tr>
<td></td>
<td>(0.9262)</td>
<td>(0.9125)</td>
<td>(0.0822)</td>
<td>(0.0926)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.1496</td>
<td>0.1488</td>
<td>0.1439</td>
<td>0.1431</td>
</tr>
<tr>
<td>No of obs</td>
<td>2,514,192</td>
<td>2,700,476</td>
<td>2,481,261</td>
<td>2,665,428</td>
</tr>
</tbody>
</table>

Notes: Standard errors corrected for state-of-occurrence clustering are in parenthesis. The dependent variable is a dummy equal to one if Forceps obstetric procedure was utilized and zero if not. Coefficient estimates and standard errors for On-Time Prenatal Care are multiplied by 100. All specifications control for child gender, multiple births, mother race (Hispanic, Black, or other race), parity from 1 to 4 and 5+, mother’s education (<12, 12, 13-15, 16+ years), mother’s age (19-24, 25-34, 35+ years), state-of-occurrence-specific time trends, as well as year, month, and county of occurrence.

*Significant at 10%, **Significant at 5%, ***Significant at 1%.

infections acquired before birth. To the extent that regular primary care can mitigate these risk factors, a reduction in the incidence of these abnormalities in limited-access mothers following tort reform may indicate improved access to care. Furthermore, since mitigation of these abnormalities is largely achieved by prevention, it is unlikely that any additional services provided are done to maximize revenue.

The results for these birth abnormalities are presented in Tables 6 and 7. The passage of noneconomic damage caps is associated with a significant percentage decrease in the prevalence of fetal alcohol syndrome. JSL reform has the opposite effect, though it is delayed. Although this classification of full-access mothers also appears to enjoy an immediate reduction in fetal alcohol syndrome, the effect for limited-access mothers is both twice as great and also more persistent. A similar pattern is observed in the effects on newborn anemia, particularly for the immediate effects of tort reform, where JSL increases in importance. Furthermore, there is a positive and highly significant effect on newborn anemia in full-access births two years following the passage of non-economic damage caps. It is unclear whether or not the increase in this abnormality among these births is linked to any changes in the care these mothers receive. Taken together, Tables 6 and 7 indicate that pressure-reducing
Table 6: Effects of Tort Reforms on Fetal Alcohol Syndrome: By Trimester

<table>
<thead>
<tr>
<th></th>
<th>Full Access</th>
<th>Limited Access</th>
<th>Full Access</th>
<th>Limited Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any PD cap</td>
<td>0.0012</td>
<td>-0.0088</td>
<td>0.0030</td>
<td>0.0125</td>
</tr>
<tr>
<td></td>
<td>(0.0035)</td>
<td>(0.0103)</td>
<td>(0.0034)</td>
<td>(0.0097)</td>
</tr>
<tr>
<td>Any NE cap</td>
<td>-0.0091***</td>
<td>-0.0247**</td>
<td>-0.0040</td>
<td>-0.0120*</td>
</tr>
<tr>
<td></td>
<td>(0.0028)</td>
<td>(0.0091)</td>
<td>(0.0026)</td>
<td>(0.0065)</td>
</tr>
<tr>
<td>JSL Reform</td>
<td>0.0011</td>
<td>0.0050</td>
<td>0.0056</td>
<td>0.0146**</td>
</tr>
<tr>
<td></td>
<td>(0.0022)</td>
<td>(0.0101)</td>
<td>(0.0042)</td>
<td>(0.0059)</td>
</tr>
<tr>
<td>CSR Reform</td>
<td>0.0020</td>
<td>0.0119</td>
<td>-0.0073</td>
<td>0.0154</td>
</tr>
<tr>
<td></td>
<td>(0.0023)</td>
<td>(0.0177)</td>
<td>(0.0071)</td>
<td>(0.0184)</td>
</tr>
<tr>
<td>Lag 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any PD cap</td>
<td>-0.0008</td>
<td>0.0003</td>
<td>-0.0030</td>
<td>0.0012</td>
</tr>
<tr>
<td></td>
<td>(0.0103)</td>
<td>(0.0034)</td>
<td>(0.0097)</td>
<td>(0.0030)</td>
</tr>
<tr>
<td>Any NE cap</td>
<td>-0.0247**</td>
<td>0.0003</td>
<td>-0.0120*</td>
<td>0.0146**</td>
</tr>
<tr>
<td></td>
<td>(0.0091)</td>
<td>(0.0026)</td>
<td>(0.0065)</td>
<td>(0.0059)</td>
</tr>
<tr>
<td>JSL Reform</td>
<td>0.0119</td>
<td>0.0050</td>
<td>-0.0073</td>
<td>0.0154</td>
</tr>
<tr>
<td></td>
<td>(0.0101)</td>
<td>(0.0042)</td>
<td>(0.0071)</td>
<td>(0.0184)</td>
</tr>
<tr>
<td>CSR Reform</td>
<td>0.0119</td>
<td>0.0050</td>
<td>-0.0073</td>
<td>0.0154</td>
</tr>
<tr>
<td></td>
<td>(0.0177)</td>
<td>(0.0071)</td>
<td>(0.0184)</td>
<td>(0.0154)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.0003</td>
<td>0.0003</td>
<td>0.0003</td>
<td>0.0009</td>
</tr>
<tr>
<td>No of obs</td>
<td>1,625,263</td>
<td>385,488</td>
<td>2,067,676</td>
<td>499,222</td>
</tr>
</tbody>
</table>

Notes: Standard errors corrected for state-of-occurrence clustering are in parenthesis. The dependent variable is a dummy equal to one if the newborn manifest the fetal alcohol syndrome and zero if not. All coefficient estimates and standard errors are multiplied by 100. All specifications control for child gender, multiple births, mother race (Hispanic, Black, or other race), parity from 1 to 4 and 5+, mother’s education (<12, 12, 13-15, 16+ years), mother’s age (19-24, 25-34, 35+ years), state-of-occurrence-specific time trends, as well as year, month, and county of occurrence.

∗Significant at 10%, **Significant at 5%, ***Significant at 1%.

Malpractice reforms led to reductions in the prevalence of birth abnormalities that can be mitigated to some degree with regular access to care. The fact that these effects were of significantly greater magnitude for limited-access mothers suggests both that tort reform was successful in reducing the practice of negative defensive medicine and that much of the additional care these mothers received was not due to revenue maximization.

6 Conclusion

Contrary to physicians’ assertions that defensive medicine is widely practiced, existing empirical investigations into the subject have uncovered inconsistent and often conflicting findings. Why the same tort reforms increase health care spending in some cases, decrease it in others, and have no effect in still others has been difficult to explain. In this article, we develop a model providing such an explanation; that the practice of defensive medicine results in non-monotonic effects of malpractice reforms on health care spending. Rising malpractice pressure makes access to care more expensive. Health care spending rises as long as there is willingness and ability to bear this expense, but falls once either of these is exhausted. In this way, the estimated effects of tort reform can be qualitatively different depending on the
### Table 7: Effects of Tort Reforms on Newborn Anemia (Hct. < 39/Hgb. < 13): By Trimester

<table>
<thead>
<tr>
<th></th>
<th>Lag 0</th>
<th>Lag 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Access</td>
<td>Limited Access</td>
</tr>
<tr>
<td>Any PD cap</td>
<td>-0.0180</td>
<td>-0.0542</td>
</tr>
<tr>
<td></td>
<td>(0.0165)</td>
<td>(0.0419)</td>
</tr>
<tr>
<td>Any NE cap</td>
<td>-0.0415**</td>
<td>-0.1750***</td>
</tr>
<tr>
<td></td>
<td>(0.0156)</td>
<td>(0.0586)</td>
</tr>
<tr>
<td>JSL Reform</td>
<td>0.0606***</td>
<td>0.2260***</td>
</tr>
<tr>
<td></td>
<td>(0.0219)</td>
<td>(0.0617)</td>
</tr>
<tr>
<td>CSR Reform</td>
<td>0.0389</td>
<td>-0.0405</td>
</tr>
<tr>
<td></td>
<td>(0.0280)</td>
<td>(0.0861)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.0025</td>
<td>0.0068</td>
</tr>
<tr>
<td>No of obs</td>
<td>1,693,801</td>
<td>399,334</td>
</tr>
</tbody>
</table>

Notes: Standard errors corrected for state-of-occurrence clustering are in parenthesis. The dependent variable is a dummy equal to one if the newborn manifest anemia and zero if not. All coefficient estimates and standard errors are multiplied by 100. All specifications control for child gender, multiple births, mother race (Hispanic, Black, or other race), parity from 1 to 4 and 5+, mother’s education (<12, 12, 13-15, 16+ years), mother’s age (19-24, 25-34, 35+ years), state-of-occurrence-specific time trends, as well as year, month, and county of occurrence.

*Significant at 10%, **Significant at 5%, ***Significant at 1%.

The population under investigation. Regardless of characteristics, however, the qualitative effect should be predictable based on the population’s access to health care.

Direct estimation of the non-monotonic relationship becomes complicated by the fact that we only observe changes in malpractice pressure but not a continuous measure of this latent variable. We solve this problem using the predictions from our model and sort births into full-access and limited-access groups according to the timeliness of prenatal care initiation. The findings reveal non-monotonic effects by access to care over a two-year period following tort reform, in a way that is consistent with the predictions of the model. Reductions in malpractice pressure, due to noneconomic damage caps and JSL reform in particular, increase the incidence of birth by cesarean section in mothers with poor access to care by approximately 5%, while decreasing the incidence for mothers with good access to care by approximately 3%.

The findings presented here make several important contributions to the literature. First, the theory and empirical evidence support an explanation for why the empirical literature on defensive medicine has uncovered so many conflicting implications. It is not that defensive medicine is practiced rarely or inconsistently, but that the interplay of positive and negative defensive medicine results in complex relationships between malpractice pressure
and health care spending. For this reason, the empirical literature can uncover seemingly mixed evidence of defensive medicine, even where it is widely practiced. This explanation may help to remove confusion and facilitate policy discussions on the merits of tort reform. Second, the empirical results show that the primary estimated benefit of noneconomic damage caps and JSL reform to consumers is not spending reductions, but improved access to care among vulnerable populations. This is important, not only because access improvements tend to be secondary considerations in policy discussions, but also when interpreting increases in utilization following pressure-reducing tort reforms, which may be mistaken for revenue maximization. Third, this article makes a methodological contribution in the innovative role that access measures play in uncovering the effects of malpractice reform. This creates opportunities to reevaluate the data used in past empirical investigations of defensive medicine using non-monotonic specifications where access measures are available. They further show that evaluating access measures prior to changing the malpractice environment could aid policymakers contemplating tort reform in predicting the qualitative effects on consumers in their jurisdictions.

**APPENDIX**

**A Assumptions in Proposition 1**

Consider the following assumptions.

**Assumption 1.** The function \( \rho(t) \) is such that \( \exists! \, \bar{t} > 0 \) where:

\[
\frac{\partial^2 \rho}{\partial t^2} + t \left( \frac{\partial^3 \rho}{\partial t^3} \right) \begin{cases} 
\geq 0 & \forall \, t \in [0, \bar{t}] ; \\
< 0 & \text{otherwise.}
\end{cases}
\]

**Assumption 2.** The function \( \rho(t) \) and parameters \( \{c, P\} \) are such that:

\[
\exists \, \bar{t} > 0 \text{ where } c\bar{t} = P[1 - \rho(\bar{t}) + \bar{t}\rho'(\bar{t})]
\]

Assumption 1 implies convexity of \( \rho(t) \) and assumption 2 implies effectiveness of treatment in reducing liability costs. Then, consider the following result:

**Lemma 1.** If Assumptions 1 and 2 hold, then in any equilibrium, \( \bar{t}^* \) must be such that:
\[ \frac{\partial^2 \rho}{\partial t^2} + t \left( \frac{\partial^3 \rho}{\partial t^3} \right) < 0 \]

**Proof.** See [Montanera (2015)]

### B Proof of Proposition 2

From the physician’s problem, the unique payment \((w)\) producing full access \((n^* = \frac{q}{D})\) for a given level of resources \((s)\) is:

\[
 w = \omega(s; \frac{q}{D}, P) = P \left[ \rho \left( \frac{Ds}{q} \right) - \left( \frac{Ds}{q} \right) \rho' \left( \frac{Ds}{q} \right) \right].
\]

where \(\rho'(.)\) is the first derivative of \(\rho(.)\), \(\frac{\partial \omega}{\partial P} > 0\), and \(\frac{\partial \omega}{\partial s} < 0\). Substituting \(\omega(s; \frac{q}{D}, P)\) into the MCO’s problem and solving with respect to \(s\) yields the following necessary condition:

\[
\frac{\left( -\frac{\partial \omega}{\partial t} \right)}{c - Pt \left( \frac{\partial^2 \rho}{\partial t^2} \right)} = \frac{MU_y}{\Delta U},
\]

implying that \(c - Pt \left( \frac{\partial^2 \rho}{\partial t^2} \right) > 0\). Substituting \(\omega(s; \frac{q}{D}, P)\) into the MCO’s budget constraint reveals the unique level of resources that produces full access for a given policy price \((\tau)\)

\[
s = \sigma \left( \tau; \frac{q}{D}, P \right) \quad s.t. \quad \tau = q\omega \left[ \sigma \left( \tau; \frac{q}{D}, P \right); \frac{q}{D}, P \right] + Dc\sigma \left( \tau; \frac{q}{D}, P \right).
\]

where,
\[
\frac{\partial \sigma}{\partial P} = -\left( \frac{q}{D} \right) \left( \frac{\partial \omega}{\partial P} \right) < 0
\]
\[
\frac{\partial \sigma}{\partial \tau} = D^{-1} \left[ c - Pt \left( \frac{\partial^2 \rho}{\partial \tau^2} \right) \right] > 0
\]
\[
\frac{\partial^2 \sigma}{\partial \tau^2} = P \left( \frac{D^2}{q} \right) \left[ \frac{\partial^2 \rho}{\partial \tau^2} + t \left( \frac{\partial^3 \rho}{\partial \tau^3} \right) \right] < 0 \quad \text{(By Lemma 1)}
\]
\[
\frac{\partial^2 \sigma}{\partial \tau \partial P} = q^{-1} \left[ c - P \sigma \frac{\partial^2 \rho}{\partial \tau^2} \right]^{-2} \cdot \left[ \sigma \frac{\partial^2 \rho}{\partial \tau^2} + P \frac{\partial \sigma}{\partial P} \left( \frac{\partial^2 \rho}{\partial \tau^2} + t \frac{\partial^3 \rho}{\partial \tau^3} \right) \right] > 0 \quad \text{(By Lemma 1)}
\]

Substituting \( \omega(.) \) and \( \sigma(.) \) into the MCO’s problem and solving with respect to \( \tau \) yields the following first-order condition:

\[
q \left( \frac{\partial Q}{\partial \tau} \right) \Delta U = MU_y
\]

and the comparative static:

\[
\frac{\partial \tau^*}{\partial P} = \frac{-q \Delta U \frac{\partial^2 Q}{\partial \tau \partial P}}{q \Delta U \frac{\partial^2 Q}{\partial \tau^2} - \frac{\partial MU_y}{\partial \tau}}.
\]

Since \( \frac{\partial MU_y}{\partial \tau} > 0 \), the sign of \( \frac{\partial \tau^*}{\partial P} \) depends on the signs of \( \frac{\partial^2 Q}{\partial \tau \partial P} \) and \( \frac{\partial^2 Q}{\partial \tau^2} \). Since:

\[
\frac{\partial^2 Q}{\partial \tau \partial P} = - \left( \frac{D}{q} \right) \left[ \frac{\partial^2 \rho}{\partial \tau^2} \left( \frac{D}{q} \right) \frac{\partial \sigma}{\partial \tau} \frac{\partial \sigma}{\partial P} + \frac{\partial \rho}{\partial t} \left( \frac{\partial^2 \sigma}{\partial \tau \partial P} \right) \right] > 0
\]

\[
\frac{\partial^2 Q}{\partial \tau^2} = - \left( \frac{D}{q} \right) \left[ \frac{\partial^2 \rho}{\partial \tau^2} \left( \frac{D}{q} \right) \left( \frac{\partial \sigma}{\partial \tau} \right)^2 + \frac{\partial \rho}{\partial t} \left( \frac{\partial^2 \sigma}{\partial \tau^2} \right) \right] < 0
\]

Therefore, \( \frac{\partial \tau^*}{\partial P} \) unambiguously positive.

\section*{C \ Proof of Proposition 3}

Proposition 3: If malpractice pressure \( P' \) results in a limited-access equilibrium, then:
\begin{align*}
\text{i) } & \frac{\partial \tau^*}{\partial P} < 0 \\
\text{ii) } & \frac{\partial \tilde{n}^*}{\partial P} < 0 \\
\text{iii) } & \text{Any } P > P' \text{ also results in a limited-access equilibrium.}
\end{align*}

Proof. Solving the MCO’s problem with respect to \( w \) and \( s \) yields the following first-order conditions:

\begin{align*}
(4) & \quad q \cdot \Delta U \cdot \frac{\partial \tilde{Q}}{\partial w} = MU_y \frac{\partial \tau}{\partial w} \\
(5) & \quad q \cdot \Delta U \cdot \frac{\partial \tilde{Q}}{\partial s} = MU_y \frac{\partial \tau}{\partial s} \\
& \quad \tau = Dw\tilde{n} + Dcs
\end{align*}

Combining Conditions [4] and [5] and substituting in the solution to the physician’s problem \( \{n^*(w, s, P) \text{ s.t. } \frac{w}{P} = \rho - t\frac{\partial \rho}{\partial t}\} \) yields the following necessary condition:

\begin{equation}
\frac{1 - \rho}{w + ct} = \frac{-\frac{\partial \rho}{\partial t}}{c - P\frac{\partial^2 \rho}{\partial t^2}},
\end{equation}

to which there is a unique \( \{w^*, t^*\} = \{w^*(c, P), t^*(c, P)\} \) that depend only on \( c \) and \( P \) \cite{Montanera2015}. This means, from the solution to physician’s problem:

\begin{equation}
\frac{\partial w^*}{\partial P} = \frac{w}{P} - Pt\frac{\partial^2 \rho}{\partial t^2} \frac{\partial t^*}{\partial P}
\end{equation}

and that resources \((s)\) can be expressed as a function \( s = \psi(\tau, c, P) \) such that:

\[ \tau = Dw^*n^*[w^*, \psi(\tau, c, P), P] + Dc\psi(\tau, c, P) \]

Since Condition [6] must hold in equilibrium, \( \psi(\tau, c, P) \) is affected by \( \tau \) and \( P \) as follows:
\[
\frac{\partial \psi}{\partial \tau} = \frac{t}{D(w + ct)} > 0,
\]
\[
\frac{\partial \psi}{\partial P} = \left( \frac{n}{1 - \rho} \right) \left[ \left( 1 - \frac{w}{P} \right) \frac{\partial \tau^*}{\partial P} - t \left( \frac{1 - \rho}{w + ct} \right) \frac{w}{P} \right]
\]

Similar to Proposition 2, the insurer’s problem can be written in terms of \( w^* \) and \( \psi(\tau, c, P) \), with \( \tau \) being the choice variable. Solving yields the same first order condition and resulting comparative static as in Proposition 2:

\[
\frac{\partial \tau^*}{\partial P} = \frac{-q\Delta U \frac{\partial^2 \hat{Q}}{\partial \tau \partial P}}{q\Delta U \frac{\partial^2 \hat{Q}}{\partial \tau^2} - \frac{\partial \mu U}{\partial \tau}}.
\]

but where \( \frac{\partial \hat{Q}}{\partial \tau} = \frac{1}{q} \left( \frac{1 - \rho}{w + ct} \right) > 0 \) and \( \frac{\partial^2 \hat{Q}}{\partial \tau^2} = 0 \). The denominator remains unambiguously negative, so the sign of \( \frac{\partial \tau^*}{\partial P} \) will be determined by the sign of \( \frac{\partial^2 \hat{Q}}{\partial \tau \partial P} \). Conditions 6 and 7 provide the sign:

\[
\frac{\partial^2 \hat{Q}}{\partial \tau \partial P} = -\left( \frac{1}{q} \right) \left[ \left( 1 - \rho \right) \frac{w}{(w + ct)^2} \right] < 0
\]

Therefore, \( \frac{\partial \tau^*}{\partial P} \) unambiguously negative. By Corollaries 5a and 5b of Montanera (2015), if \( \frac{\partial \tau^*}{\partial P} \), then \( \frac{\partial \hat{n}^*}{\partial P} < 0 \) and if \( P' \) results in a limited-access equilibrium, then all \( P > P' \) also result in limited-access equilibrium.

**References**


