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How Does Proactive Disclosure of Medical Error Affect Settlement, Suit, and the Accuracy of Compensation and Deterrence?

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Abstract

The current system of resolving allegations of medical malpractice neither reliably compensates injured patients nor reliably deters negligence on the part of providers.

Recently, a few hospitals have begun experimenting with a change from a policy of categorically denying fault and refusing payment to a policy of routinely and fully disclosing all unexpected adverse events to patients, even admitting fault if warranted, and offering a financial settlement. These providers effectively move from a reactive strategy of responding to plaintiffs' demands for compensation to a proactive strategy of always preempting plaintiffs' demands by offering to settle.

I model this change in policy as a change from a game of screening for negligence by plaintiffs to a game of signaling negligence by defendants. I show that while the plaintiff's compensation is more, the defendant's expected payment is less in the signaling equilibrium than in the screening equilibrium.

Signaling will yield both more accurate deterrence and more accurate compensation than screening when the plaintiff's litigation cost is very small relative to the defendant's litigation cost. When the parties' relative litigation costs are reversed, screening will be more accurate.

Keywords: early offers, medical malpractice litigation, settlement, screening, signaling.

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1 Introduction

Patient safety has become an increasingly important issue in health policy and closely related to the debate over improving the quality of medical care. Medical errors that go undetected and uncompensated are costly to patients and meritless claims of medical negligence are costly to providers. It is widely acknowledged that the current medical malpractice system neither reliably compensates patients whose care was deficient nor does it protect providers against unjustified claims. The inadequacy of and dissatisfaction with the current adversarial medical malpractice system have motivated the search for new approaches. One such approach to the medical malpractice crisis is the concept of transparency, including the full disclosure of medical error.

While "few health care organizations question the imperative to be honest and forthcoming with patients following an injury," (Leape and Berwick 2005) estimates suggest that less than 1% of the more than 1 million preventable adverse events occurring each year in the United States are disclosed to the patient (Mazor, Simon, and Gurwitz 2004). The routine disclosure of medical errors represents a significant departure from current practice (Gibson and Singh 2003) of "deny and defend". Open disclosure helps health care providers and the organization learn about problems associated with their processes and systems of health care delivery, prompting practice improvements thereby reducing the potential for harm to subsequent patients (Leape, Bates, Cullen, Cooper, Demonaco, Gallivan, Hallisey, Ives, Laird, Laffel, et al. 1995) and enhancing the overall safety and fidelity of the medical system.

Disclosing medical errors is warranted out of respect for the patient's autonomy, upholding his or her right "to make informed decisions about subsequent treatment" (Levinson and Gallagher 2007) and "to seek appropriate restitution or recompense." (Hebert, Levin, and Robertson 2001). Despite the potential benefits and growing recognition, medical error disclosure and compensation programs remain rare. A recent survey named only 8 healthcare organizations in the United States that have integrated error disclosure processes into their care-giving protocols (Shapiro 2008). Although patients and providers favor the disclosure of medical errors in principle (Gallagher, Waterman, Ebers, Fraser, and Levinson 2003), a 2002 survey found that "fear of medical malpractice litigation was ... the most commonly cited institutional barrier to developing and implementing disclosure policies" (Lamb, Studdert, Bohmer, Berwick, and Brennan 2003). The reluctance of healthcare organizations to adopt disclosure policies is perhaps not surprising, given that, to date, "no published research ... has formally evaluated, with strict methodological rigor, the effect of disclosure on litigation" (Studdert, Mello, Gawande, and Brennan 2007).

Experience of Existing Error Disclosure Programs

Recently, a few provider organizations have begun experimenting with routine, early, open, and direct disclosure of unexpected adverse events to patients - even before the patient files a complaint or a demand for compensation.

As a practical matter, reports based on actuarial data suggest that aggressive full disclosure programs foster patient trust and satisfaction (Kraman and Hamm (1999); Hickson, Federspiel, Pichert, Miller, Gauld-Jaeger, and Bost (2002); Duclos, Eichler, Taylor, Quintela, Main, Pace, and Staton (2005); Boothman (2006b); Clinton and Obama (2006)). Perhaps the best-known study of an existing error disclosure program compared the complexityadjusted workload in 1996 and malpractice payments made in 1990-1996 at the Veteran Affairs (VA) Medical Center in Lexington, KY to 35 other VA hospitals. Some VA hospitals with similar workload had fewer claims and lower payments than the Lexington VA, calling into question the authors' assertion that "extreme honesty may be the best policy" (Kraman and Hamm 1999). The experience of the Lexington VA may not generalize readily to nongovernmental hospitals, however, as "[f]ederal and private employment in the health care industry differ in several important ways" (Kraman and Hamm 1999), including the payer and demographic characteristics of the patients they typically treat and the protection of government health care practitioners from personal liability. Perhaps more importantly, the study of the Lexington VA was limited by the unavailability of pre-implementation data. Thus, it could not assess how much the policy affected claims and payments.

On the other hand, pre- and post-implementation data were available in a study examining the effect of the error disclosure program adopted at the University of Michigan Health System (UMHS). From 2001 to 2005 claims at UMHS dropped from 262 to 114 and "reserves on medical malpractice claims dropped by more than two thirds." (Boothman, Blackwell, Campbell Jr, Commiskey, and Anderson 2009). While suggestive, these results are limited by the lack of controlling for "... other factors that influence litigation rates ... over time" (Gallagher, Studdert, and Levinson 2007).

Extrapolation from Expert Assessments of Hypothetical Disclosures

Studdert, Mello, Gawande, Brennan, and Wang (2007) used simulation methods to assess the likely consequences of error disclosure and concluded that the adoption of an error disclosure policy would double claim volume and costs of compensation. While useful to isolate the important role of the transition probabilities, this study is predicated on assumptions and the simulation is only as true as its assumptions are. While the Lexington VA Medical Center and UMHS data reflect observed patient behavior in response to error disclosure, the simulation study relied on predictions of patient behavior in hypothetical scenarios. The survey also did not specify "whether an apology or compensation was offered." As the UMHS program includes both an apology and offers of compensation, the contrast between the decline in claims and payments reported by UMHS and the increase predicted by the simulation study suggests that these features may affect claims and payments when errors are disclosed.

Disclosure research has reached a critical juncture. Currently, the literature on the effects of disclosure on malpractice is scarce. The paucity of evidence is conflicting and suffers from a lack of controls for alternative explanations to trends in litigation rates and is thus of little use to policy-makers and practitioners seeking to assess the likely impact of a wider adoption of error disclosure programs. The present study proposes to examine the effectiveness of a comprehensive full disclosure with rapid remediation (FDRR) program implemented at a large, urban, academic affiliated medical center in the mid-western United States. The research addresses a critical barrier in the more widespread adoption of medical-error disclosure programs, namely that other organizations won't look at these programs for fear it may trigger a wave of lawsuits.

2 Full Disclosure with Rapid Remediation at the University of Illinois

We study the lawsuits filed against a large, urban, tertiary-care academic medical center in the Midwestern United States before and after it implemented a medical error disclosure policy in April 2006. The shift to a proactive policy of telling patients openly and immediately that an adverse outcome had occurred marked a sharp departure from the medical center's earlier, reactive risk management strategy of "denying and defending" categorically all claims of negligent care regardless of merit. As a large, urban, tertiary-care academic medical center located on the near West Side of Chicago, the University of Illinois Medical Center at Chicago (UIMCC) treats a large share of the inner-city's low-income and minority groups, many of whom struggle with low levels of literacy and language proficiency. Of the approximately 20,000 patients discharged per year from the Medical Center, more than 40% are admitted through the Emergency Department, and about half are either uninsured or on Public Aid. More than a quarter of patients seek care related to pregnancy, childbirth, and neonatal care, exposing the medical center to potentially very large lawsuits in cases of unanticipated adverse outcomes. Other high-risk procedures, such as organ transplantation surgeries, including an average of 100 kidney transplants annually, are also performed at the medical center every year. Moreover, the medical center is located in a jurisdiction considered to be among the most plaintiff-friendly counties in the United States, thus exacerbating the medical center's exposure to professional liability claims.

In April 2006, UIMCC adopted a novel, proactive strategy for managing its professional liability and instituted a Medical Error Full Disclosure with Rapid Remediation (FDRR) program which consists of the following core components (McDonald, Helmchen, Smith, Centomani, Gunderson, Mayer, and Chamberlin forthcoming):

Event Report: UIMCC staff can report any adverse event anonymously online or via telephone.

Error Investigation: A Rapid Error Investigation Team (REIT) determines if the patient suffered any quantifiable psychological or physical injury as a result of medical error. If the REIT determines that the patient suffered harm, further investigation determines whether the standard of care was breached and whether that breach resulted in injury.

Patient Communication Consult Service $PCCS$**:** If the adverse event was not the result of medical error, UIMCC's personnel communicate that to the patient and family. If necessary, a family conference is convened to explain the hospital's findings. Crucially, the liaison will emphasize that the medical injury was not due to substandard care. If, in the rare situation, the patient or family expresses a threat to sue they are referred to claims management personnel while being informed the UIMCC will defend appropriate care vigorously.

Full Disclosure with Rapid Remediation: If the adverse event was the result of a clear medical error, the UIMCC discloses the error to the patient, apologizes, and offers to remedy the error through continued medical management and, if deemed necessary, financial compensation.

Patient Decides Whether to File Claim: The process concludes when the patient either accepts the UIMCC's management of the adverse event and in return waives the right to sue (if UIMCC provides compensation beyond waiving out-of-pocket charges) or decides to sue.

Process Improvement: The root cause analysis (RCA) of the incident and the effectiveness of the UIMCC's FDRR process build the evidence base for clinical process improvements to enhance future patient safety and quality of care and to better manage the UIMCC's malpractice liability.

The medical error disclosure process at UIMCC is distinctive from other published programs in that it is aims to be:

i proactive: the medical staff and hospital administrators will engage in these process components before being prompted by a claim or lawsuit filed by the patient

ii routine: all process components will be followed every time anyone reports an incident.

In designing its error disclosure process, UIMCC followed the same principles that had guided the design of the policy at the University of Michigan Health System (Boothman 2006a):

1. "We will seek to compensate quickly and fairly when our unreasonable medical care causes patient injuries."
2. "We will defend our staff and institution vigorously when our care was reasonable and/or when we did not cause a patient injury."
3. "We will seek to learn from our mistakes and our patients' experiences."

More than merely saying "I'm sorry", medical error disclosure is commonly operationalized by adherence to the Five "R"s of Apology (Woods 2004) by the provider vis-à-vis the patient:

Recognition: an acknowledgment that an unexpected adverse outcome has arisen in the course of treatment;

Regret: an expression of empathy by the provider for the loss and harm suffered by the patient;

Responsibility: the acceptance by the medical staff that their actions and decisions may have contributed to the unexpected adverse outcome and that they have a duty to mitigate the resulting harm;

Remedy: the pledge not only to relieve medically, if possible, and financially, if necessary, the harm and loss suffered by the patient but also to learn from the incident in order to prevent it from occurring again;

Remain Engaged: the assurance by the medical staff and hospital administrators that they will not abandon the patient until all questions arising out of the adverse outcome have been resolved to the full satisfaction of the patient.

3 Optimal Voluntary Disclosure of Medical Errors

Medical error disclosure gives patients access to information that they might wish to consider in choosing among courses of subsequent treatment after an adverse outcome but also in choosing whether to file a lawsuit against the provider. As detailed information about the cause of the adverse outcome might be costly or impossible for them to obtain otherwise, medical error disclosure reduces the cost that patients and their advocates incur when preparing to sue the provider for professional liability. As most patients who sustain medical injury never sue, mostly because they are uncertain about the circumstances that led to the adverse outcome, many physicians and hospital administrators are afraid that voluntarily disclosing medical errors to patients will remove this informational barrier and trigger a costly wave of additional lawsuits and payments.

While error disclosure may strengthen patients' ability to sue, it may also weaken their resolve to do so. By openly discussing the adverse event with patients, the provider makes it unnecessary for patients to sue in order to learn whether their care was negligent. By building a reputation for vigorously defending appropriate care, the provider makes it unattractive to sue for patients who sustained an injury despite appropriate care. When care was clearly inappropriate, the provider may pair the error disclosure with an apology and a carefully calibrated offer of financial compensation and thus make it again unattractive for patients to sue. While out-of-court settlements without error disclosure are common, the value of fully disclosing all known circumstances surrounding the adverse event lies in helping patients and their legal representatives to align their estimates of a trial outcome with those of the provider and will therefore aid in reaching a rapid settlement out-of-court.

By obviating the need to sue in order to obtain an apology, an explanation of the circumstances that led to the adverse outcome, and a commitment from the provider to indemnify the patient, a policy of routine and proactive disclosure of unanticipated adverse outcomes might reduce the frequency of lawsuits, especially those without merit. The purpose of this paper is to assess theoretically and empirically whether medical error disclosure leads to a net increase or decrease in claims and payments.

There are additional benefits and risks of proactively and routinely disclosing medical errors to patients, which will be addressed in future research. Patients avoid the legal fees of bringing a suit and the uncertainty and waiting time associated with obtaining a verdict. Providers avoid the cost of legal defense against actual suits and the cost of defensive medicine aimed at improving their defense in potential suits. Moreover, disclosure can often facilitate closure, not only for the patients and their friends and family but also for the medical professionals involved in adverse outcomes, who frequently prefer the opportunity of an open and honest conversation with the patient and co-workers to the restrictions on disclosure often imposed by professional liability insurers. From a perspective of economic efficiency, medical error disclosure can improve the accuracy with which instances of negligent care translate into financial repercussions for the provider, both by raising the payout in case of negligence and by lowering it in case of no negligence, thus raising the prospect that providers of medical services will undertake those and only those efforts whose resulting reduction in the probability of negligent care is cost-justified.

For all its potential benefits, disclosing medical errors may engender the adverse self-selection of patients whose indemnity demands will be disproportionately high if they learn that negligence on the part of the provider played a role in their adverse treatment outcome. Similarly, it is not clear whether and what reputational effects medical error disclosure generates for the provider. Will patients who learn that their provider was negligent revise their assessment of the provider's quality of care or of the provider's honesty?

3.1 Setup

After each episode of care, the defendant (doctor) D and plaintiff (patient) P both observe severity W of the injury.

Before the case goes to trial, the parties have an opportunity to settle it. In this case, the defendant pays the plaintiff the settlement amount S, both parties avoid litigation costs, and the case is closed.

If a settlement is not reached, the plaintiff can either drop the suit, in which case the defendant pays the plaintiff 0, or the plaintiff can take the defendant to court, in which case the court determines the defendant's degree of liability q, the defendant pays the plaintiff qW and incurs litigation cost C_d, and the plaintiff receives from the defendant qW and incurs litigation cost C_p.

Note that the plaintiff can obtain at least $\mathrm{E}[q]W - C_p$ by always going to court. The analysis will be restricted to cases W that "have merit" in that $\mathrm{E}[q]W - C_p > 0$. Otherwise, the game would have a trivial Nash equilibrium, in which the defendant always refuses any strictly positive settlement demand and the plaintiff never sues. [2]

Both parties are assumed to be risk-neutral so that expected payouts can be interpreted as expected utility. [3]

3.1.1 Outcomes

In the following, I compare four models of dispute resolution that vary in their assumptions about the symmetry and uncertainty of the information that parties have about the degree of liability q that the court will assign to the defendant if the case proceeds to trial.

For each model and each realization q, I derive

- the equilibrium settlement, denoted $S(q)$, and
- the equilibrium probability of trial $\theta(q)$.

By taking expectations over q, I compute the following outcomes, which are all observable in principle:

- the **expected probability of trial**, $\mathrm{E}[\theta(q)]$,
- the **expected probability of settlement**, $1 - \mathrm{E}[\theta(q)]$,

[2] "Thus the contingency fee system gives plaintiffs' lawyers a strong incentive to screen prospective plaintiffs and to accept only cases having sufficiently high expected value" (Farber and White 1991)

[3] the parties' differential degrees of risk aversion can be represented by the parties' litigation costs C_d and C_p, which are then interpreted as containing a risk premium. refer to the Milgrom representation of risk aversion

- the **expected settlement**, $\frac{\mathrm{E}[(1-\theta(q))S(q)]}{\mathrm{E}[(1-\theta(q))]}$,
- the **expected award**, $\frac{\mathrm{E}[\theta(q)qW]}{\mathrm{E}[\theta(q)]}$,

For each party, I compute the expected payoff:

- the **defendant's expected payment** is
$$\mathrm{E}\left[\pi_d(q)\right] = \mathrm{E}\left[(1-\theta)\,S + \theta\,(qW + C_d)\right] = \mathrm{E}\left[(1-\theta)\right]\frac{\mathrm{E}\left[(1-\theta)\,S\right]}{\mathrm{E}\left[(1-\theta)\right]} + \mathrm{E}\left[\theta\right]\left(\frac{\mathrm{E}\left[\theta qW\right]}{\mathrm{E}\left[\theta\right]} + C_d\right)$$
- and the **plaintiff's expected compensation** is
$$\mathrm{E}\left[\pi_p(q)\right] = \mathrm{E}\left[(1-\theta)\,S + \theta\,(qW - C_p)\right] = \mathrm{E}\left[(1-\theta)\right]\frac{\mathrm{E}\left[(1-\theta)\,S\right]}{\mathrm{E}\left[(1-\theta)\right]} + \mathrm{E}\left[\theta\right]\left(\frac{\mathrm{E}\left[\theta qW\right]}{\mathrm{E}\left[\theta\right]} - C_p\right)$$

In addition to the expected probability of trial, which may be privately efficient but is socially inefficient because it forces both parties to incur litigation costs C_d and C_p respectively, I can assess

- the **accuracy of deterrence** by computing its mean squared error, E[(socially optimal payment - actual payment)^2] $= \mathrm{E}\left[(qW - \pi_d(q))^2\right]$
- the **accuracy of compensation** by computing its mean squared error, E[(socially optimal compensation - actual compensation)^2] $= \mathrm{E}\left[(qW - \pi_p(q))^2\right]$.

The objective of the following analysis is to compare these outcomes across models (cf. (Daughety and Reinganum 1993)).

3.2 Symmetric Information

As a benchmark, assume at first that both parties can predict q with equal accuracy. In this case, the defendant is prepared to settle for at most the amount (gross of litigation costs) he expects to pay if the case proceeds to trial, $\mathrm{E}[q]W + C_d$, and the plaintiff is prepared to settle for no less than the amount (net of litigation costs) she expects to obtain if the case proceeds to trial, $\mathrm{E}[q]W - C_p$.

As long as litigation costs are nonnegative, both parties will prefer to settle and the case will never proceed to trial: $\theta^s(q) = 0\ \forall q$.

Nash bargaining will lead both parties to split equally total litigation costs, which represent the savings from reaching a settlement and thus avoiding litigation so that the plaintiff's compensation is given by:

$$\pi_p^s = S^s = \mathrm{E}[q|I]W - C_p + \frac{C_p + C_d}{2} = \mathrm{E}[q|I]W + \frac{C_d - C_p}{2}$$

and the defendant's payment [4] is given by:

$$\pi_d^s = S^s = \mathrm{E}[q|I]W + C_d - \frac{C_p + C_d}{2} = \mathrm{E}[q|I]W + \frac{C_d - C_p}{2}.$$

where $\mathrm{E}[q|I]$ is the expected value of q, given the parties' identical information after the episode of care but before trial.

[4] As in all configurations of the game the defendant's payoff is nonpositive, I refer to his payoff as "payment" and report the absolute value of the defendant's payoff.

3.2.1 Perfect Information – Both Parties Can Predict q

If both parties can predict perfectly the degree of liability q that the court will assign to the defendant, $\mathrm{E}[q|I] = q$ and they always settle for

$$S^{per} = qW + \frac{C_d - C_p}{2} = \pi_p^{per} = \pi_d^{per}$$

and the observable features of the model in this case are:

- the **expected probability of trial**, $\mathrm{E}\left[\theta^{per}\right] = 0$,
- the **expected probability of settlement**, $1 - \mathrm{E}\left[\theta^{per}\right] = 1$,
- the **expected settlement**,

$$\frac{\mathrm{E}\left[\left(1-\theta^{per}\right) S^{per}\right]}{\mathrm{E}\left[\left(1-\theta^{per}\right)\right]} = \mathrm{E}\left[qW + \frac{C_d - C_p}{2}\right] = \frac{W + C_d - C_p}{2},$$

- the **expected award** is not defined because all cases are settled.

The **defendant's expected payment** is:

$$\mathrm{E}\left[\pi_d^{per}\right] = \mathrm{E}\left[\left(1-\theta^{per}\right) S^{per} + \theta^{per}\left(qW + C_d\right)\right] = \frac{W + C_d - C_p}{2} = \frac{W}{2} + C_d - \frac{C_p + C_d}{2}$$

where $W/2 + C_d$ is the highest expected payment the defendant will make, namely if every case proceeds to trial, and $(C_p + C_d)/2$ is the defendant's benefit of settling the case (the defendant and the plaintiff split equally total litigation costs).

The **plaintiff's expected compensation** is:

$$\mathrm{E}\left[\pi_p^{per}\right] = \mathrm{E}\left[\left(1-\theta^{per}\right) S^{per} + \theta^{per}\left(qW - C_p\right)\right] = \frac{W + C_d - C_p}{2} = \frac{W}{2} - C_p + \frac{C_p + C_d}{2}$$

where $W/2 - C_p$ is the lowest expected payment the plaintiff will receive, namely if every case proceeds to trial.

Finally, the **accuracy of deterrence** equals the **accuracy of compensation** and is

$$\mathrm{E}\left[\left(qW - \pi_i^{per}\right)^2\right] \;=\; \mathrm{E}\left[\left(qW - \left(qW + \frac{C_d - C_p}{2}\right)\right)^2\right] \;=\; \frac{\left(C_d - C_p\right)^2}{4} \qquad i = d, p.$$

Thus, the only source of distortion even in the case of symmetric and perfect information about q is an asymmetry in parties' litigation costs. Even though the plaintiff will never sue the defendant, Nash bargaining ensures that the party with the lower cost can appropriate a larger share of the total litigation savings than the party with higher litigation cost.

3.2.2 Imperfect Information – Neither Party Can Predict q

If neither party can predict q perfectly, both parties will use a probability distribution of q to guide their choices. If information is symmetric, both parties' probability distributions must be identical. Specifically, both parties assume that q is uniformly distributed on the unit interval: $q \sim U_{[0,1]}$. [5]

As $\mathrm{E}[q|I] = 1/2$, the parties always settle for

$$S^{imp} = \frac{W + C_d - C_p}{2} = \pi_p^{imp} = \pi_d^{imp}.$$

and the observable features of the model in this case are identical to those in the case of perfect information.

The parties' expected payoffs are also identical to those in the case of perfect information:

$$\mathrm{E}\left[\pi_d^{imp}\right] = \frac{W + C_d - C_p}{2} = \frac{W}{2} + C_d - \frac{C_p + C_d}{2}$$

and

$$\mathrm{E}\left[\pi_p^{imp}\right] = \frac{W + C_d - C_p}{2} = \frac{W}{2} - C_p + \frac{C_p + C_d}{2}$$

As in the case of perfect information, the **accuracy of deterrence** equals the **accuracy of compensation** but both are larger than in the case of perfect information:

$$\begin{aligned}
\mathrm{E}\left[\left(qW - \pi_i^{imp}\right)^2\right] &= \mathrm{E}\left[(qW)^2 - 2qW\frac{W + C_d - C_p}{2} + \frac{(W + C_d - C_p)^2}{4}\right] \\
&= \frac{W^2}{3} - \frac{W^2}{2} - W\frac{C_d - C_p}{2} + \frac{W^2}{4} + W\frac{C_d - C_p}{2} + \frac{(C_d - C_p)^2}{4} \\
&= \frac{W^2}{12} + \frac{(C_d - C_p)^2}{4} \qquad i = d, p.
\end{aligned}$$

As in the perfect information case, any asymmetry in parties' litigation costs will prevent both compensation and deterrence to match their socially optimal values. In addition, the severity of the injury W, which determines the magnitude of any award at trial, constitutes a second source of distortion. To see why note that W determines the variance of the payment that should be made and received, qW:

$$\mathrm{E}\left[\left(qW - \frac{W}{2}\right)^2\right] = \mathrm{E}\left[q^2 - q + \frac{1}{4}\right]W^2 = \left[\frac{1}{3} - \frac{1}{2} + \frac{1}{4}\right]W^2 = \frac{W^2}{12}$$

When information is perfect, any variation in the actual payment is matched one-for-one by a commensurate variation in the socially payment. When information is imperfect, on the other hand, the payment that *is* made and received does not vary with qW. Thus, an increase in the variance of qW magnifies, on average, the error between the actual and the socially optimal payments.

[5] The distribution of q will depend on the type of care received by the patient as well as the nature and severity of the patient's injury, all of which are assumed to be perfectly observable by both parties. The uniform distribution was chosen for tractability.

3.3 Asymmetric Information

While the defendant can predict perfectly the degree of liability q that the court will assign, the plaintiff is uncertain about q and only knows its probability distribution. As before, assume that q is uniformly distributed on the unit interval: $q \sim U_{[0,1]}$.

3.3.1 Screening

In the screening model, the plaintiff moves first by demanding a settlement S from the defendant.[6] As shown in Figure 1, the defendant can either accept the demand, in which case the two parties' payoffs are $(-S, S)$ and the game is over, or reject the demand, in which case the plaintiff must decide whether to litigate or give up and drop her demand. If the plaintiff decides to litigate [7], payoffs are $(-qW - C_d, qW - C_p)$; if the plaintiff drops her demand, payoffs are $(0, 0)$.

The defendant's problem

The defendant will reject the plaintiff's settlement demand S if it exceeds his expected payment (inclusive of litigation costs) $p[qW + C_d]$:

$$r(S,p) = \begin{cases} 0 & \text{if } S < p[qW + C_d] \;\Leftrightarrow\; q > \frac{S/p - C_d}{W} \\ \in [0,1] & \text{if } q = \frac{S/p - C_d}{W} \\ 1 & \text{if } q < \frac{S/p - C_d}{W} \end{cases}$$

where r denotes the defendant's probability of rejecting S and p denotes the plaintiff's probability of litigating after the defendant has rejected S.

The plaintiff's problem

Given the defendant's decision rule, a rejection of the plaintiff's demand S allows the plaintiff to update her expectation of the true degree of liability as follows:

$$\mathrm{E}\left[q \,|\text{defendant has rejected } S\right] = \mathrm{E}\left[q \,\middle|\, q \leq \frac{\frac{S}{p} - C_d}{W}\right] = \frac{\frac{S}{p} - C_d}{2W} \quad \text{for} \quad \frac{S}{p} > C_d$$

Given the defendant's rejection function $r(S,p)$, the plaintiff chooses the settlement demand S and the litigation probability p that maximize her expected compensation net of

[6] This model follows closely Nalebuff (1987)

[7] I roll trial and pretrial discovery into one step (Farber and White (1991)). Both in the screening model and in the signaling model, the key feature of the model is the plaintiff's decision to take the case to trial, i.e. to trade off a certain settlement (after the defendant has moved) against the uncertain benefit of trial (net of litigation costs, assumed to be certain in this model).

litigation costs:

$$\max_{S,p} \; [1-r(S,p)]S + r(S,p)p\left[\mathrm{E}\left[q\,|\text{defendant has rejected } S\right]W - C_p\right]$$
$$= [1-r(S,p)]S + r(S,p)p\left[\frac{S/p - C_d}{2} - C_p\right]$$

$$\text{s.t.} \quad S \geq 0 \quad \text{and} \quad p \in [0,1] \quad \text{and} \quad \frac{S}{p} > C_d$$

To find the settlement demand S and litigation probability p that solve this problem, suppose first that $S \geq C_d + 2C_p$. Then

$$\mathrm{E}[q|\text{defendant has rejected } S]W - C_p = \frac{S/p - C_d}{2} - C_p \geq 0 \quad \forall p$$

so that the plaintiff will always find it optimal to sue after the defendant has rejected her settlement demand, i.e. $p^{scr} = 1$. To find the exact optimal value for S when $p = 1$, note that as the plaintiff will never demand more than what the defendant would pay if he were fully liable, $S \leq W + C_d$, so that $r(S,p) = \frac{S/p - C_d}{W}$ and the plaintiff's problem is now:

$$\max_{S,p=1} \; \frac{W - S + C_d}{W}S + \frac{S - C_d}{W}\left[\frac{S - C_d}{2} - C_p\right]$$

$$\text{s.t.} \quad S \geq C_d + 2C_p$$

The Kuhn-Tucker conditions are:

$$\left[-S + W - (S - C_d) + \frac{S - C_d}{2} - C_p + \frac{S - C_d}{2}\right] \Big/ W \leq 0 \Leftrightarrow W - C_p \leq S$$

and

$$S \geq C_d + 2C_p.$$

By complementary slackness, the two Kuhn-Tucker conditions imply:

$$S^* = \max\left\{W - C_p, C_d + 2C_p\right\}$$

Assume that $W - C_p > C_d + 2C_p$, so that for a given realization q, the settlement demand is

$$S^*(q) = W - C_p \quad \forall S \geq C_d + 2C_p.$$

The plaintiff always demands the maximum amount she would obtain (net of litigation costs) if the defendant were fully liable.

Now assume that $C_d < S \leq C_d + 2C_p$, so that $\exists p \in [0,1]$ s.t. $S = p(C_d + 2C_p)$, so that $\frac{S/p - C_d}{2} - C_p = 0$, i.e. the plaintiff is indifferent between litigating and giving up after the defendant has rejected her demand S, and the defendant rejects S with probability $\frac{2C_p}{W}$, which is in $[0,1]$ by assumption that the case has merit. Thus, the plaintiff now solves:

$$\max_{S} \frac{W-2C_p}{W} S$$

$$\text{s.t.} \quad S \leq C_d + 2C_p$$

which yields $S^* = C_d + 2C_p$. But we showed above that whenever $S \geq C_d + 2C_p$, $S^* = W - C_p$. Thus,

$$S^*(q) = W - C_p \quad \forall S > C_d.$$

Finally, consider $S \leq C_d$. In this case, there is a Nash equilibrium, in which the plaintiff threatens to sue with certainty should the defendant reject her settlement demand, i.e. $p = 1$. Given $p = 1$, any settlement demand $S \leq C_d$ is less than the defendant's expected payment even in case of no liability, $q = 0$. Thus, the defendant will always accept. Given that the defendant always accepts, $p = 1$ is an equilibrium strategy. Thus, $(S^* = C_d, p = 1)$ is a second local maximum of the plaintiff's objective function.

I show below that "the plaintiff will always prefer to make larger offers, which have a risk of being rejected, provided that the expected court award is greater than the total litigation costs." (Nalebuff (1987)) Thus,

$$S^{scr}(q) = W - C_p$$

Note that in the screening game the settlement demand S^{scr} cannot vary with q because the plaintiff does not know q.

For a given realization q, the equilibrium probability of trial is:

$$\theta^{scr}(q) = \begin{cases} 0 & \text{if } q \geq \frac{S^{scr}/p^{scr} - C_d}{W} = \frac{W-(C_p+C_d)}{W} \\ 1 & \text{if } q < \frac{W-(C_p+C_d)}{W} \end{cases}$$

The higher total litigation costs, the smaller the probability of trial (the greater the incentive to settle). Note that plaintiff's and defendant's litigation costs are perfect substitutes in that only total litigation costs determine the probability of trial.

Equilibrium Outcomes

Given the equilibrium settlement $S^{scr}(q)$ and the equilibrium probability of trial $\theta^{scr}(q)$, the following outcomes, which are all observable in principle, can be computed:

- the **expected probability of trial**, $\mathrm{E}\left[\theta^{scr}(q)\right] = \frac{W-(C_p+C_d)}{W}$,
- the **expected probability of settlement**, $1 - \mathrm{E}\left[\theta^{scr}(q)\right] = \frac{C_p+C_d}{W}$,
- the **expected settlement**, $\frac{\mathrm{E}[(1-\theta^{scr})S^{scr}]}{\mathrm{E}[(1-\theta^{scr})]} = W - C_p$, and
- the **expected award**

$$\frac{\mathrm{E}\left[\theta^{scr} q W\right]}{\mathrm{E}\left[\theta^{scr}\right]} = \frac{\frac{W-(C_p+C_d)}{2W}\left[\mathrm{E}[q|q < \frac{W-(C_p+C_d)}{W}]W\right]}{\frac{W-(C_p+C_d)}{2W}} = \frac{W-(C_p+C_d)}{2}.$$

The **defendant's expected payment** is

$$\begin{aligned}
\mathrm{E}\left[\pi_d^{scr}(q)\right] &= \frac{C_p + C_d}{W}[W - C_p] \;+\; \frac{W - (C_p + C_d)}{W}\left\{\frac{W - (C_p + C_d)}{2} + C_d\right\} \\
&= \frac{C_p + C_d}{W}[W - C_p] \;+\; \frac{W - (C_p + C_d)}{W}\left\{W - C_p - \left[\frac{W - (C_p + C_d)}{2}\right]\right\} \\
&= W - C_p - \frac{[W - (C_p + C_d)]^2}{2W} \\
&= W - C_p - \frac{W^2 - 2W(C_p + C_d) + (C_p + C_d)^2}{2W} \\
&= \frac{W}{2} + C_d - \frac{(C_p + C_d)^2}{2W}
\end{aligned}$$

where $\frac{(C_p+C_d)^2}{2W}$ is the defendant's share of total litigation costs that are saved when the parties settle. In particular,

$$\frac{(C_p + C_d)^2}{2W} = \frac{(C_p + C_d)}{W}\frac{(C_p + C_d)}{2},$$

where the first factor is the probability of settling the case and the second factor is half the savings in the total / social cost of litigation. Note that by assumption the first factor is always between zero and one so that even the defendant fares better with symmetric information than with asymmetric information.

The **plaintiff's expected compensation** is

$$\begin{aligned}
\mathrm{E}\left[\pi_p^{scr}(q)\right] &= \frac{C_p + C_d}{W}[W - C_p] \;+\; \frac{W - (C_p + C_d)}{W}\left\{\frac{W - (C_p + C_d)}{2} - C_p\right\} \\
&= \frac{C_p + C_d}{W}[W - C_p] \;+\; \frac{W - (C_p + C_d)}{W}\left\{W - C_p - \left[\frac{W + (C_p + C_d)}{2}\right]\right\} \\
&= W - C_p - \frac{W^2 - (C_p + C_d)^2}{2W} \\
&= \frac{W}{2} - C_p + \frac{(C_p + C_d)^2}{2W}
\end{aligned}$$

where $W/2 - C_p$ is the minimum expected compensation the plaintiff can guarantee herself by always litigating and $(C_p + C_d)^2/2W$ is the "bonus" for settling instead of litigating. First note that

$$\frac{W}{2} - C_p + \frac{(C_p + C_d)^2}{2W} > C_d$$

because we're assuming $W - C_p > C_d$, i.e. the plaintiff will always demand $W - C_p$ even at the risk that the defendant will reject the demand and the plaintiff only gets an expected compensation of $[W - C_p - C_d]/2 - C_p$.

To compute the accuracies of deterrence and compensation, note first that they can be decomposed as follows:

$$\begin{aligned}
\mathrm{E}\left[(qW-\pi)^2\right] &= \mathrm{E}\left[q^2W^2\right] + \mathrm{E}\left[\pi^2\right] - \mathrm{E}\left[2qW\pi\right] \\
&= \mathrm{E}\left[q^2W^2\right] - \mathrm{E}\left[qW\right]^2 + \mathrm{E}\left[\pi^2\right] - \mathrm{E}\left[\pi\right]^2 + \mathrm{E}\left[qW\right]^2 + \mathrm{E}\left[\pi\right]^2 - \mathrm{E}\left[2qW\pi\right] \\
&= \mathrm{V}\left[qW\right] + \mathrm{V}\left[\pi\right] + \mathrm{E}\left[qW\right]^2 + \mathrm{E}\left[\pi\right]^2 - 2\mathrm{E}\left[qW\right]\mathrm{E}\left[\pi\right] + 2\mathrm{E}\left[qW\right]\mathrm{E}\left[\pi\right] - \mathrm{E}\left[2qW\pi\right] \\
&= \mathrm{V}\left[qW\right] + \mathrm{V}\left[\pi\right] + \left(\mathrm{E}\left[qW\right] - \mathrm{E}\left[\pi\right]\right)^2 - 2\mathrm{Cov}\left[qW, \pi\right]
\end{aligned}$$

That is, the mean squared error of the socially optimal payoff and the actual payoff can be expressed as the sum of their variances and the squared deviation of their means minus twice their covariance.

The **accuracy of deterrence** is

$$\begin{aligned}
\mathrm{E}\left[(qW-\pi_d^{scr})^2\right] &= \frac{W-(C_p+C_d)}{W}\mathrm{E}_{\neg q*}\left[(qW-qW-C_d)^2\right] \\
&\quad + \frac{(C_p+C_d)}{W}\left[\mathrm{V}_{q*}\left[qW\right] + \mathrm{V}_{q*}\left[S^{scr}\right] + \left(\mathrm{E}_{q*}\left[qW\right] - \mathrm{E}_{q*}\left[S^{scr}\right]\right)^2 - 2\mathrm{Cov}_{q*}\left[qW, S^{scr}\right]\right] \\
&= \frac{W-(C_p+C_d)}{W}C_d^2 \\
&\quad + \frac{(C_p+C_d)}{W}\left[\frac{(C_p+C_d)^2}{12} + 0 + \left(W - \frac{C_p+C_d}{2} - W + C_p\right)^2 - 0\right] \\
&= \frac{W-(C_p+C_d)}{W}C_d^2 + \frac{(C_p+C_d)}{W}\left[\frac{(C_p+C_d)^2}{12} + \frac{(C_p-C_d)^2}{4}\right]
\end{aligned}$$

where $q* \in \left(\frac{W-(C_p+C_d)}{W}, 1\right)$.

This is a convex combination of the accuracy loss when a trial can be avoided, $\frac{(C_p+C_d)^2}{12} + \frac{(C_p-C_d)^2}{4}$, which is incurred with probability $\frac{C_p+C_d}{W}$, and the loss when a trial cannot be avoided, C_d^2, which is incurred with probability $\frac{W-(C_p+C_d)}{W}$.

The **accuracy of compensation** is

$$\begin{aligned}
\mathrm{E}\left[\left(qW-\pi_p^{scr}\right)^2\right] &= \frac{W-(C_p+C_d)}{W}\mathrm{E}_{\neg q*}\left[(qW-qW+C_p)^2\right] \\
&+\frac{(C_p+C_d)}{W}\left[\mathrm{V}_{q*}\left[qW\right]+\mathrm{V}_{q*}\left[S^{scr}\right]+\left(\mathrm{E}_{q*}\left[qW\right]-\mathrm{E}_{q*}\left[S^{scr}\right]\right)^2-2\mathrm{Cov}_{q*}\left[qW,S^{scr}\right]\right] \\
&= \frac{W-(C_p+C_d)}{W}C_p^2 \\
&+\frac{(C_p+C_d)}{W}\left[\frac{(C_p+C_d)^2}{12}+0+\left(W-\frac{C_p+C_d}{2}-W+C_p\right)^2-0\right] \\
&= \frac{W-(C_p+C_d)}{W}C_p^2+\frac{(C_p+C_d)}{W}\left[\frac{(C_p+C_d)^2}{12}+\frac{(C_p-C_d)^2}{4}\right]
\end{aligned}$$

3.3.2 Signaling

In the signaling model, the defendant moves first by offering a settlement amount S to the plaintiff.[8] As shown in Figure 2, the plaintiff can either accept the offer, in which case the two parties' payoffs are $(-S, S)$, or reject the offer, in which case the suit proceeds to trial and payoffs are $(-qW-C_d, qW-C_p)$.

The plaintiff's problem

The plaintiff uses the defendant's settlement offer S to update her expectation about the defendant's true liability, $E[q|S]$, and accepts S if it exceeds the expected compensation (net of litigation costs) of going to trial, $\mathrm{E}\left[q|S\right]W-C_p$:

$$\alpha(S)=\begin{cases} 0 & \text{if } S<\mathrm{E}\left[q|S\right]W-C_p \\ \in[0,1] & \text{if } S=\mathrm{E}\left[q|S\right]W-C_p \\ 1 & \text{if } S>\mathrm{E}\left[q|S\right]W-C_p \end{cases}$$

where $\alpha(S)$ denotes the probability that the plaintiff accepts the defendant's offer S.

The defendant's problem

Given the plaintiff's acceptance function $\alpha(S)$, for each liability q, the defendant chooses the settlement offer S that minimizes his expected payment to the plaintiff gross of litigation costs:

$$\begin{aligned}
&\max_S\ -\alpha(S)S-\left[1-\alpha(S)\right]\left[qW+C_d\right]=-\left[qW+C_d\right]+\alpha(S)\left[qW+C_d-S\right] \\
&\text{s.t.}\quad S\geq 0
\end{aligned}$$

[8]This model follows closely (Spier 2006).

The Kuhn-Tucker conditions for this problem are:

$$\alpha'(S)[qW + C_d - S] - \alpha(S) \leq 0$$

and

$$S \geq 0$$

and complementary slackness is

$$[\alpha'(S)[qW + C_d - S] - \alpha(S)]\, S = 0.$$

Thus, for any interior solution, $S > 0$, the first Kuhn-Tucker condition holds as an equality and represents a first-order differential equation:

$$\alpha'(S)[qW + C_d - S] - \alpha(S) = 0$$

Note that any solution to this differential equation, $\alpha^*(S)$, can only depend on the defendant's offer S but not on the defendant's true liability q because q is not observed by the plaintiff. This implies that S must be of the form $S = qW - k \Leftrightarrow k = qW - S$, where k is a constant to be determined: [9]

$$\alpha'(S)[k + C_d] - \alpha(S) = 0 \quad \Leftrightarrow \quad \alpha'(S) = \frac{\alpha(S)}{k + C_d}$$

which has the solution:

$$\alpha(S) = A \exp\left(\frac{S}{k + C_d}\right)$$

To determine A, note that the plaintiff will always accept if offered $W - C_p$, i.e. the amount she would obtain, net of litigation costs, if the defendant were fully liable because she can never do better by proceeding to trial:

$$\alpha(W - C_p) = A \exp\left(\frac{W - C_p}{k + C_d}\right) = 1 \;\Leftrightarrow\; A = \exp\left(-\frac{W - C_p}{k + C_d}\right)$$

so that

$$\alpha(S) = \exp\left(\frac{S - (W - C_p)}{k + C_d}\right)$$

The plaintiff's optimal acceptance probability is increasing in the defendant's settlement offer S. This counteracts the defendant's inclination to low-ball his offer. Intuitively, by threatening to take the case to trial more often when the defendant's offers a small settlement, the plaintiff imposes a greater cost on the defendant for misleadingly low-balling his offer.

Equilibrium

[9] There is another, degenerate solution to this first-order differential equation that is independent of q, namely $\alpha^*(S) = 0$. Note, however, that this solution cannot be optimal: if the defendant offers the highest possible award net of litigation costs that the plaintiff could hope to obtain at trial, $S = qW - C_d$, the plaintiff would do better accepting than rejecting the offer.

We solve for k by noting that for $\alpha(S)$ to be in $(0,1)$, we require that the plaintiff be indifferent between settling and going to trial: $S = \mathrm{E}\left[q|S\right]W - C_p$. As $S = qW - k$ is a bijection, the plaintiff can infer with perfect accuracy from the offer S the defendant's true liability $E[q|S] = q = (S+k)/W$, so that $S = \mathrm{E}\left[q|S\right]W - C_p = S + k^* - C_p \Leftrightarrow k^* = C_p$.

Thus, the **equilibrium settlement** for a given realization q is

$$S^{sig}(q) = qW - C_p$$

and the **equilibrium acceptance probability** for a given realization q is

$$\alpha^*(S^{sig}(q)) = \exp\left(\frac{S^{sig}(q) - (W - C_p)}{k^* + C_d}\right) = \exp\left(\frac{qW - C_p - (W - C_p)}{C_p + C_d}\right) = \exp\left(\frac{qW - W}{C_p + C_d}\right),$$

which is convex in q, ranges from $1/\exp\left(\frac{W}{C_p+C_d}\right) < 1/2$ for $q = 0$ to 1 for $q = 1$, and implies the **equilibrium probability of trial**

$$\theta^{sig}(q) = 1 - \alpha^*(S^{sig}(q)) = 1 - \exp\left(\frac{qW - W}{C_p + C_d}\right)$$

The **expected probability of settlement** is:

$$\begin{aligned}
\mathrm{E}\left[1 - \theta^{sig}(q)\right] &= \mathrm{E}\left[\exp\left(\frac{qW - W}{C_p + C_d}\right)\right] \\
&= \frac{C_p + C_d}{W}\exp\left(\frac{qW - W}{C_p + C_d}\right)\Bigg|_0^1 \\
&= \frac{C_p + C_d}{W}\left[1 - \frac{1}{\exp\left(\frac{W}{C_p+C_d}\right)}\right]
\end{aligned}$$

and the **expected probability of trial** is:

$$\begin{aligned}
\mathrm{E}\left[\theta^{sig}(q)\right] &= 1 - \frac{C_p + C_d}{W}\left[1 - \frac{1}{\exp\left(\frac{W}{C_p+C_d}\right)}\right] \\
&= \frac{W - (C_p + C_d)}{W} + \frac{C_p + C_d}{W}\frac{1}{\exp\left(\frac{W}{C_p+C_d}\right)}
\end{aligned}$$

The **plaintiff's expected compensation** is:

$$\mathrm{E}[\pi_p^{sig}(q)] = \mathrm{E}\left[\left(1 - \theta^{sig}\right)S^{sig} + \theta^{sig}[qW - C_p]\right] = \mathrm{E}\left[qW - C_p\right] = \frac{W}{2} - C_p$$

For a given q, the defendant's payment is:

$$\begin{aligned}\pi_d^{sig}(q) &= (1-\theta^{sig})S^{sig} + \theta^{sig}\left[qW + C_d\right] \\ &= S^{sig} + \theta^{sig}\left[qW + C_d - S^{sig}\right] \\ &= qW - C_p + \left[1 - \exp\left(\frac{qW - W}{C_p + C_d}\right)\right][C_p + C_d] \\ &= qW + C_d - \exp\left(\frac{qW - W}{C_p + C_d}\right)[C_p + C_d]\end{aligned}$$

so that the **defendant's expected payment** is

$$\begin{aligned}\mathrm{E}[\pi_d^{sig}(q)] &= \mathrm{E}\left[qW + C_d - \exp\left(\frac{qW - W}{C_p + C_d}\right)[C_p + C_d]\right] \\ &= \frac{W}{2} + C_d \; - \; \frac{C_p + C_d}{W}\left[1 - \frac{1}{\exp\left(\frac{W}{C_p + C_d}\right)}\right][C_d + C_p]\end{aligned}$$

The **accuracy of deterrence** is

$$\begin{aligned}\mathrm{E}\left[\left(qW - \pi_d^{sig}(q)\right)^2\right] &= \mathrm{E}\left[\left(qW - qW - C_d + \exp\left(\frac{qW - W}{C_p + C_d}\right)[C_p + C_d]\right)^2\right] \\ &= C_d^2 - 2C_d\mathrm{E}\left[\exp\left(\frac{qW - W}{C_p + C_d}\right)\right][C_p + C_d] + \mathrm{E}\left[\exp\left(\frac{2qW - 2W}{C_p + C_d}\right)\right][C_p + C_d]^2 \\ &= C_d^2 + \frac{[C_p + C_d]^2}{W}\left[1 - \frac{1}{\exp\left(\frac{W}{C_p + C_d}\right)}\right]\left\{\frac{C_p + C_d}{2}\left[1 + \frac{1}{\exp\left(\frac{W}{C_p + C_d}\right)}\right] - 2C_d\right\}\end{aligned}$$

The **accuracy of compensation** is

$$\mathrm{E}\left[\left(qW - \pi_p^{sig}(q)\right)^2\right] \;=\; \mathrm{E}\left[(qW - qW + C_p)^2\right] \;=\; C_p^2$$

3.4 Model Comparisons

The results derived in the previous sections can now be used to compare the equilibrium outcomes of the bargaining games under symmetric and asymmetric information.

3.4.1 Expected Probability of Trial

The expected probability of trial is greater in the signaling model than in the screening model (Table 1):

$$\mathrm{E}\left[\theta^{sym}(q)\right] < \mathrm{E}\left[\theta^{scr}(q)\right] < \mathrm{E}\left[\theta^{sig}(q)\right]$$

The reason is the plaintiff's very high probability of rejecting very low offers and thus forcing a trial and its concavity in q: To deter the defendant from low-balling the offer, the plaintiff must maintain a high probability of trial for the defendant's low offers but reward the defendant for each increase in the offer by reducing the probability of rejection at an increasing rate (Figure 3).

3.4.2 Defendant's Expected Payment

As

$$W > C_p + C_d \Leftrightarrow \exp\left(\frac{W}{C_p + C_d}\right) / \left(\exp\left(\frac{W}{C_p + C_d}\right) - 1\right) < 2$$

by assumption,

$$\mathrm{E}[\pi_d^{sym}(q)] < \mathrm{E}[\pi_d^{sig}(q)] < \mathrm{E}[\pi_d^{scr}(q)].$$

As shown in Table 2, the defendant's expected payment can be decomposed into the payment that the defendant would make if the dispute always proceeded to trial $(W/2 + C_d)$ and the payment *reduction* that is specific to the model assumptions about the distribution of information and the order of moves.

The payment reduction is largest in the case of symmetric information. In fact, when both parties' litigation costs are identical, $C_d = C_p = C$, the defendant's expected payment reduces to $W/2$.

The defendant's expected payment in the signaling and screening models is shown in Figure 4. For the entire range of the defendant's degree of liability q, $\pi_d^{sig}(q) < \pi_d^{scr}(q)$, which in turn implies $\mathrm{E}[\pi_d^{sig}(q)] < \mathrm{E}[\pi_d^{scr}(q)]$. Algebraically, in the screening model, the defendant will pay $qW + C_d$ if $q < \frac{W-(C_p+C_d)}{W}$ and $W - C_p$ otherwise. In the signaling model, the defendant pays the convex combination

$$\begin{aligned}\pi_d^{sig}(q) &= \theta^{sig}(q)\,[qW + C_d] + \left(1 - \theta^{sig}(q)\right)[qW - C_p] \\ &= qW + C_d - \exp\left(\frac{qW - W}{C_p + C_d}\right)[C_p + C_d]\,,\end{aligned}$$

which is never greater than $qW + C_d$. As

$$\pi_d^{sig\,\prime}(q) = W - \frac{W}{C_p + C_d}\exp\left(\frac{qW - W}{C_p + C_d}\right)[C_p + C_d] = W\left[1 - \exp\left(\frac{qW - W}{C_p + C_d}\right)\right] > 0 \qquad \forall q$$

and thus $\pi_d^{sig\,\prime}(1) = 0$, π_d^{sig} will also never be greater than $W - C_p$, thus proving $\mathrm{E}[\pi_d^{sig}(q)] < \mathrm{E}[\pi_d^{scr}(q)]$.

3.4.3 Accuracy of Deterrence

Table 3 compares the accuracy of deterrence, as measured by the mean squared difference between the defendant's socially optimal payment qW and the defendant's actual payment π_d, across models.

The accuracy of deterrence is greatest in the case of symmetric and perfect information. The only possible source of accuracy loss is an asymmetry in parties' litigation costs, which in turn will allow the party with the lower cost to extract some rent from the party with the higher cost.

When information is symmetric but imperfect, the fact that payments will no longer vary with the true degree of liability q introduces another source of accuracy loss.

When information is asymmetric, the accuracy of deterrence in the screening model relative to that in the signaling model will depend on the plaintiff's litigation costs relative to the defendant's litigation costs. In Figure 4, the range of q has been partitioned into two intervals. For values of q in the left interval, the defendant's payment in the signaling equilibrium (solid red line) is closer to the socially optimal payment qW (dotted black line) than the payment in the screening equilibrium (broken blue line) so that for these values deterrence is more accurate in the signaling model than in the screening model. The opposite is true for values of q in the right interval.

Figure 4 also shows that screening will yield more accurate deterrence than signaling when the defendant's litigation cost is zero, $C_d = 0$:

$$\mathrm{E}\left[(qW - \pi_d^{scr})^2\right] = \frac{C_p}{W}\left[\frac{C_p^2}{12} + \frac{C_p^2}{4}\right] = \frac{C_p^3}{3W}$$

and

$$\mathrm{E}\left[\left(qW - \pi_d^{sig}\right)^2\right] = \frac{C_p^2}{W}\left[1 - \frac{1}{\exp\left(\frac{W}{C_p}\right)}\right]\left\{\frac{C_p}{2}\left[1 + \frac{1}{\exp\left(\frac{W}{C_p}\right)}\right]\right\} = \frac{C_p^3}{2W}\left[1 - \frac{1}{\exp\left(\frac{2W}{C_p}\right)}\right]$$

Thus,

$$\mathrm{E}\left[(qW - \pi_d^{scr})^2\right] < \mathrm{E}\left[\left(qW - \pi_d^{sig}\right)^2\right].$$

as long as $2W > \ln 3C_p$, which is implied by the assumption that $W/2 > C_p$.

Similarly, it can be shown that screening will yield *less* accurate deterrence than signaling when the *plaintiff*'s litigation cost is zero, $C_p = 0$.

3.4.4 Plaintiff's Expected Compensation

The plaintiff's expected compensation is largest in the case of symmetric information because the case never goes to trial and thus the two parties can split total litigation costs that they would jointly incur in case of trial.

For the cases of asymmetric information, the ranking is the opposite of Table 2 (Defendant's Expected Payment):

$$\mathrm{E}[\pi_p^{sym}(q)] > \mathrm{E}[\pi_p^{scr}(q)] > \mathrm{E}[\pi_p^{sig}(q)]$$

The plaintiff's expected compensation is smallest in the signaling equilibrium, as it attains the lower bound, namely the plaintiff never obtains more than she would if she always went to trial. The plaintiff's expected compensation is higher in the screening equilibrium because the plaintiff will obtain a settlement payment of $W - C_p$ whenever $q \geq \frac{W-(C_p+C_d)}{W}$ and this settlement payment is evidently higher than the compensation $qW - C_p$ that the plaintiff would obtain in the signaling equilibrium. Figure 5 illustrates this comparison and also shows that it holds for any level of litigation costs and even when litigation costs are not the same for both parties.

3.4.5 Accuracy of Compensation

In the signaling game, the plaintiff's actual compensation $\pi_p = qW - C_p$ falls short of the plaintiff's socially optimal compensation qW by the plaintiff's litigation costs C_p at all levels of q (Figure 5).

By contrast, in the screening game, this discrepancy C_p only occurs with probability $\frac{W-(C_p+C_d)}{W}$, namely when $q < \frac{W-(C_p+C_d)}{W}$ leads the defendant to reject the plaintiff's settlement demand. For values of q in this interval, screening is as accurate as signaling (Figure 5). When $q \geq \frac{W-(C_p+C_d)}{W}$, which occurs with probability $(C_p+C_d)/W$, the parties settle. *Ceteris paribus*, settlement will improve the accuracy of compensation because litigation costs no longer drive a wedge between the actual and the socially optimal compensation. At the same time, in the screening game settlement will worsen the accuracy of compensation because the settlement amount cannot vary with the true degree of liability q, as the plaintiff does not know q. Table 5 and Figure 5 show that when the parties' litigation costs are the same, these two opposing effects just cancel each other out.

As with the accuracy of deterrence, Figure 5 shows that screening will also yield more accurate compensation than signaling when the defendant's litigation cost is zero, $C_d = 0$:

$$\mathrm{E}\left[\left(qW - \pi_p^{scr}\right)^2\right] = \frac{W - C_p}{W} C_p^2 + \frac{C_p}{W}\left[\frac{C_p^2}{12} + \frac{C_p^2}{4}\right] = C_p^2 - \frac{2}{3W} C_p^3$$

$$\mathrm{E}\left[\left(qW - \pi_p^{sig}\right)^2\right] = C_p^2$$

Similarly, it can be shown that screening will yield *less* accurate deterrence than signaling when the *plaintiff*'s litigation cost is zero, $C_p = 0$.

$$\mathrm{E}\left[\left(qW - \pi_p^{scr}\right)^2\right] = \frac{C_d}{W}\left[\frac{C_d^2}{12} + \frac{C_d^2}{4}\right] = \frac{C_d^3}{3}$$

$$\mathrm{E}\left[\left(qW - \pi_p^{sig}\right)^2\right] = 0$$

4 Conclusion

In the absence of litigation costs, information asymmetries between the plaintiff and the defendant regarding the degree of the defendant's liability would be immaterial, as all disputes could be moved to trial, and the information symmetry restored, costlessly. The dispute resolution mechanism would be perfectly accurate in that defendants' payments would match plaintiffs' receipts, which in turn would reflect the true degree of liability.

When litigation costs are strictly positive, each party will only be prepared to incur its litigation costs if they are justified by a commensurate increase (decrease) in the expected payment to the plaintiff (by the defendant).

In the models described above, each party's private decision to move the dispute to trial imposes externalities on the other party by forcing him or her to incur litigation costs. As I show, when information is asymmetrically distributed, the party moving first exploits this ability to impose costs on the other party to his or her strategic advantage.

Thus, plaintiffs prefer to make settlement demands (screening) to receiving settlement offers (signaling). Defendants prefer to make settlement offers, thus providing a theoretical foundation for switching from a reactive strategy of responding to patient demands to a proactive strategy of preempting patient demands by offering to settle. These results hold for any level of parties' litigation costs and even if litigation costs are not the same for both parties.

Although a comparison of the parties' expected payoffs across models is important for predicting their preferred order of moves, mechanisms to resolve medical malpractice disputes should be judged by their accuracy in compensating patients who were injured due to the provider's negligent care and by their accuracy in imposing financial penalties on negligent providers.

The model shows that screening will yield both more accurate deterrence and more accurate compensation than signaling when the defendant's litigation cost is very small relative to the plaintiff's litigation cost. When the parties' relative litigation costs are reversed, signaling will be more accurate.

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Table 1: Expected Probability of Trial

Model	$\mathrm{E}\left[\theta(q)\right]$
Symmetric	0
Screening	$\frac{W-(C_p+C_d)}{W}$
Signaling	$\frac{W-(C_p+C_d)}{W}+\frac{C_p+C_d}{W}\frac{1}{\exp\left(\frac{W}{C_p+C_d}\right)}$

Table 2: Defendant's Expected Payment

Model	$\mathrm{E}[\pi_d]$
Symmetric	$\frac{W}{2} + C_d - \frac{C_p+C_d}{2}$
Screening	$\frac{W}{2} + C_d - \frac{C_p+C_d}{2}\frac{C_p+C_d}{W}$
Signaling	$\frac{W}{2} + C_d - \frac{C_p+C_d}{\exp\left(\frac{W}{C_p+C_d}\right)/\left(\exp\left(\frac{W}{C_p+C_d}\right)-1\right)}\frac{C_p+C_d}{W}$

Table 3: Accuracy of Deterrence

Model	$\mathrm{E}\left[(qW-\pi_d)^2\right]$
Symmetric, Perfect	$\frac{(C_d-C_p)^2}{4}$
Symmetric, Imperfect	$\frac{(C_d-C_p)^2}{4} + \frac{W^2}{12}$
Screening	$\frac{W-(C_p+C_d)}{W}C_d^2 + \frac{(C_p+C_d)}{W}\left[\frac{(C_p+C_d)^2}{12} + \frac{(C_p-C_d)^2}{4}\right]$
Signaling	$C_d^2 + \frac{[C_p+C_d]^2}{W}\left[1 - \frac{1}{\exp\left(\frac{W}{C_p+C_d}\right)}\right]\left\{\frac{C_p+C_d}{2}\left[1 + \frac{1}{\exp\left(\frac{W}{C_p+C_d}\right)}\right] - 2C_d\right\}$

Table 4: Plaintiff's Expected Compensation

Model	$\mathrm{E}[\pi_p]$
Symmetric	$\frac{W}{2} - C_p + \frac{C_p+C_d}{2}$
Screening	$\frac{W}{2} - C_p + \frac{C_p+C_d}{2}\frac{C_p+C_d}{W}$
Signaling	$\frac{W}{2} - C_p$

Table 5: Accuracy of Compensation

Model	$\mathrm{E}\left[(qW - \pi_p)^2\right]$
Symmetric, Perfect	$\frac{(C_d-C_p)^2}{4}$
Symmetric, Imperfect	$\frac{(C_d-C_p)^2}{4} + \frac{W^2}{12}$
Screening	$\frac{W-(C_p+C_d)}{W}C_p^2 + \frac{(C_p+C_d)}{W}\left[\frac{(C_p+C_d)^2}{12} + \frac{(C_p-C_d)^2}{4}\right]$
Signaling	C_p^2

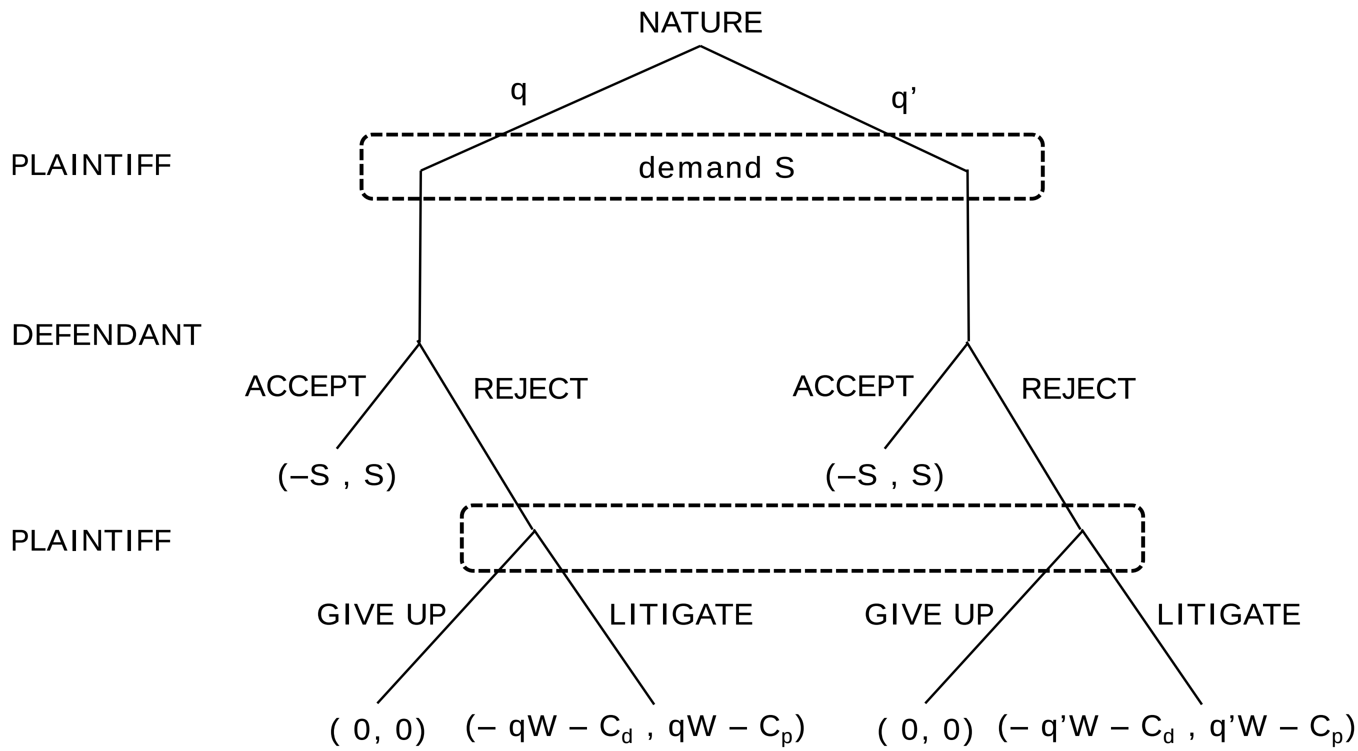

Figure 1: The Screening Game. The defendant's payoffs are listed first. Broken lines represent information sets.

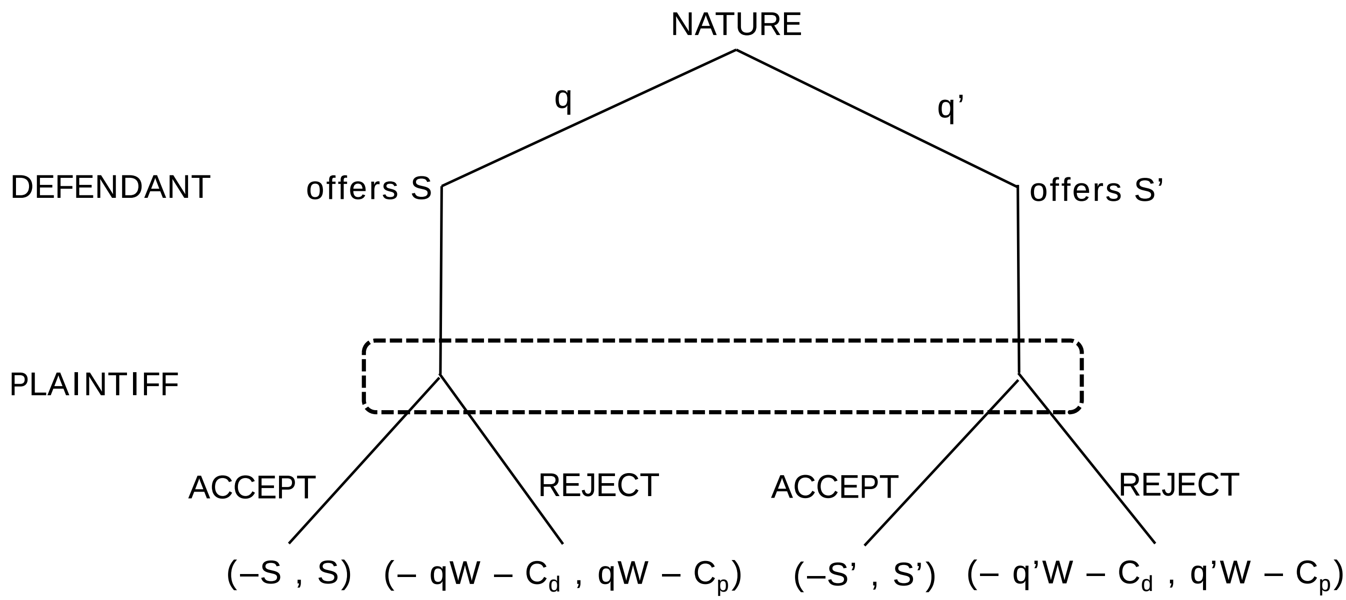

Figure 2: The Signaling Game. The defendant's payoffs are listed first.

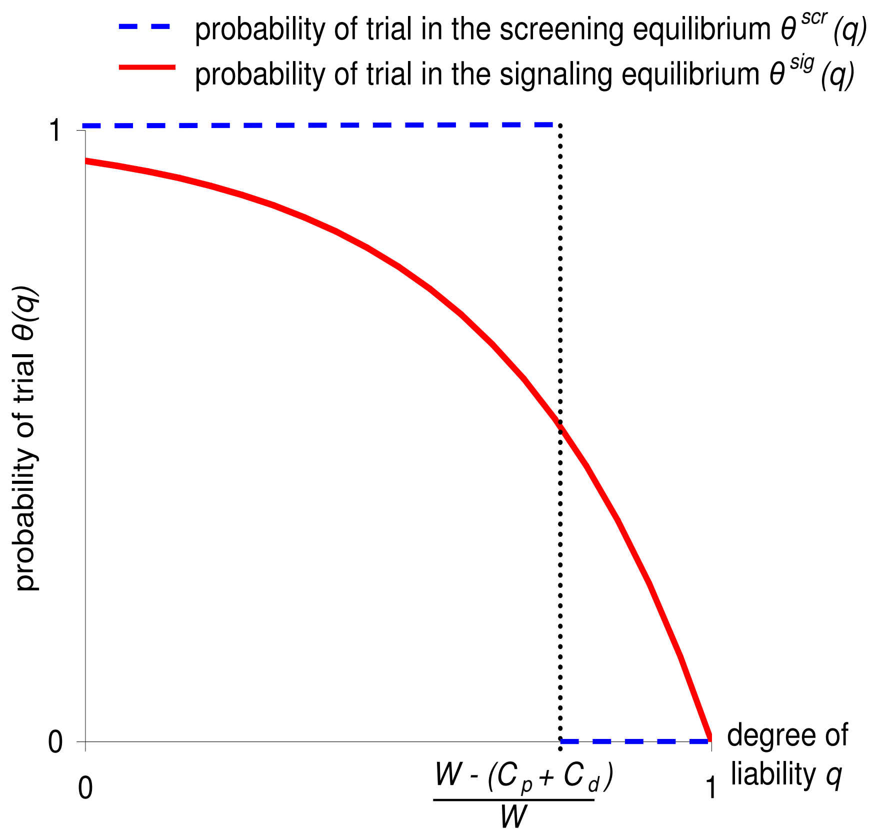

Figure 3: The Probability of Trial $\theta(q)$ as a Function of the Defendant's Degree of Liability q in the Signaling and Screening Games.

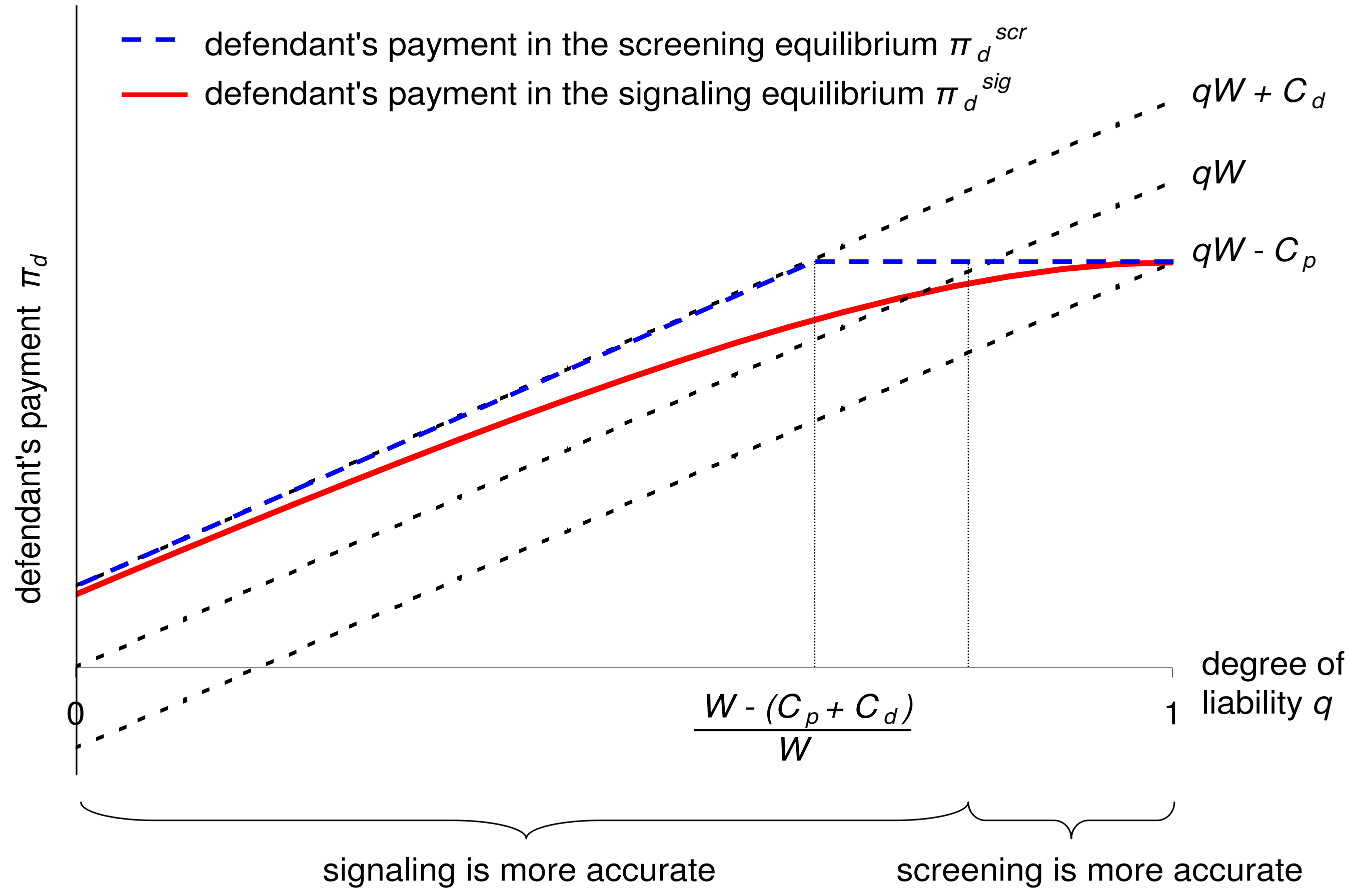

Figure 4: The Defendant's Payment $\pi_d(q)$ as a Function of the Defendant's Degree of Liability q in the Signaling and Screening Games.

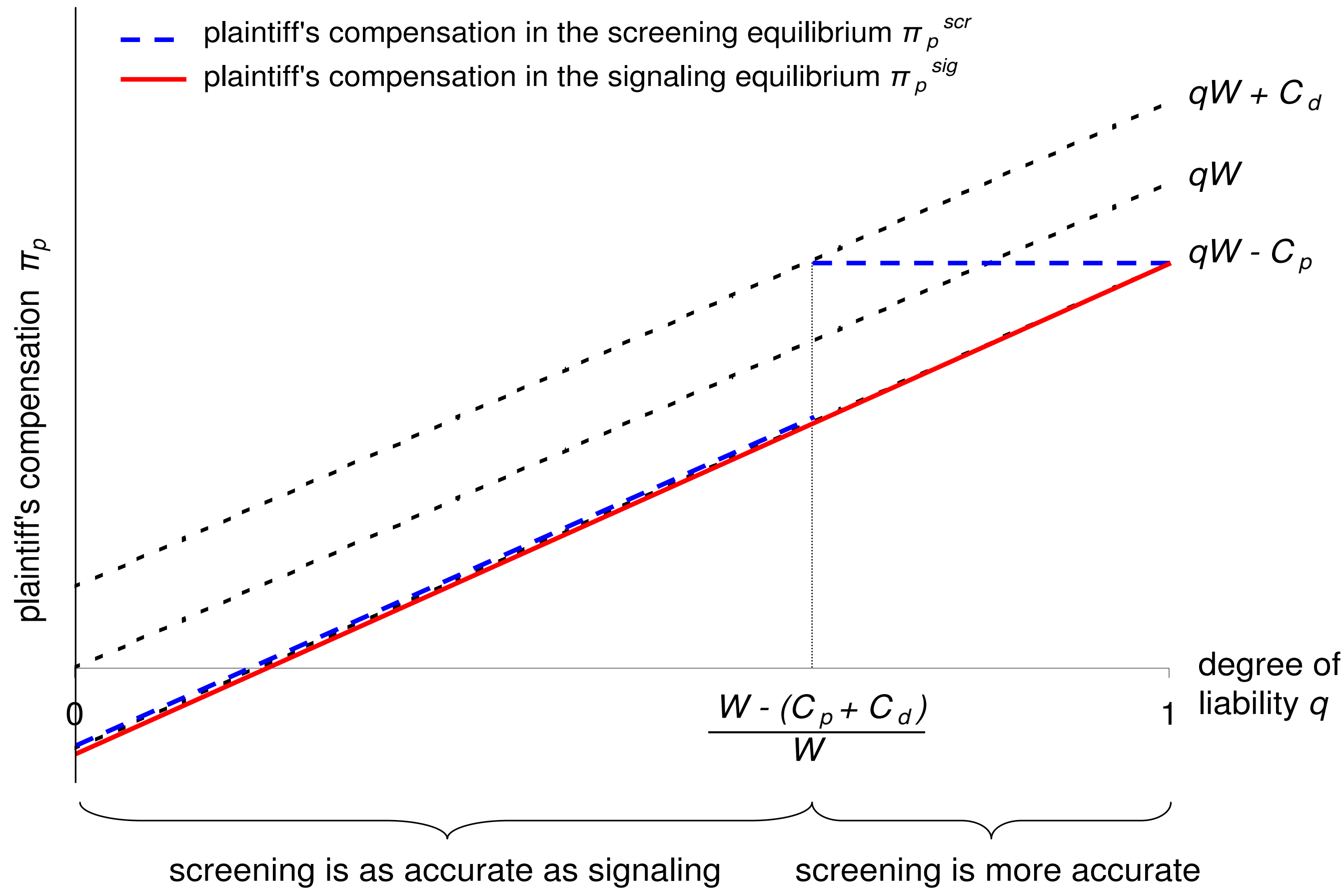

Figure 5: The Plaintiff's Compensation $\pi_p(q)$ as a Function of the Defendant's Degree of Liability q in the Signaling and Screening Games.