Optimality of no-fault medical liability systems*

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Abstract

This paper considers a model of defensive medicine where doctors are imperfect agents of insured patients. A national insurer subsidises both curative and preventive medical care consumed by risk averse patients. We show that in such an environment, the optimal liability regime is similar to the no-fault systems of Sweden and New Zealand where the doctor faces zero liability. The reason is that the subsidy on preventive medicine is a better instrument to induce the optimal level of care than the malpractice regime.

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1 Introduction

Medical Malpractice regimes differ widely across countries. At one extreme, New Zealand and Sweden have a comprehensive no-fault regime. Under such no-fault systems, victims of accidents resulting from medical care are

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compensated by taxpayer-funded public insurance schemes. Crucially, these systems serve as the links between compensation for the patient and punishment of the doctor (Welier, 1993; Towse and Danzon, 1999; Danzon, 2000). Doctors face no financial consequences from treatment induced errors (although there are professional disciplinary bodies which punish gross negligence).

At the other extreme are "third-party liability" systems where doctors are held liable for treatment related injuries. The standard economic efficiency argument for third-party liability is that by requiring the injurer to compensate the victim, the accident risk is internalised and the efficient level of preventive care is provided (Shavell, 2006). In a standard model of accident liability therefore, a no-fault system would induce too little care by injurers [1].

However, this standard logic cannot be directly applied to treatment related injuries. In particular, the types of preventive actions that doctors undertake in response to liability risk (e.g. requesting diagnostic tests) are often paid for by health insurers (Kessler, Summerton and Graham 2006; Danzon, 1985). If patients (or their insurers) are unable to judge the appropriate level of care, then this subsidy coupled with malpractice pressure might provide incentives to choose too high a level of preventive care.

There is now a body of empirical evidence which shows that there is indeed too much preventive care in health (referred to as defensive medicine) (Kessler and McLellan, 1996, 2002; Dubay et al., 1999). These papers exploit the effect of changes in rules of malpractice liability to assess the extent to which health care is driven by malpractice pressure. Kessler and McClellan (1996) find that reforms which decreased malpractice risk had little effect on the health outcomes of Medicare patients but significantly reduce medical costs. They conclude that this is evidence of the existence of "defensive medicine" - that is care beyond the point at which there is any real health benefits to the patient. Kessler and McLellan (2002) find that the actual effect of such reforms depends on the degree of medicare penetration,

[1] For example, increased fatal road accidents were observed following the adoption of no-fault liability in automobile accident (Cummins, Phillips and Weiss (2001); Landes (1982) .

suggesting that supply-side cost sharing and tort reforms are substitutes. Fenn et al (2004) provide UK based evidence of the existence of defensive medicine. They document an increase in the utilisation of costly diagnostic imaging in response to increased malpractice liability at the hospital level. Currie and Macleod (2008) study the impact of changes to specific malpractice rules on birth related complications. They find that the effect of tort-reform to be more nuanced than suggested by previous studies – finding that decreased malpractice risk had harmful effects on patients. They conclude that "incentives created by the tort system are complex and interact in important ways with other incentives facing physicians. Without knowing more about the specific incentives faced by physicians, it is hazardous to predict that a specific tort reform will either reduce unnecessary procedure use or have beneficial impacts on health."

These studies suggest that the effect of malpractice pressure has to be analysed in the context of the other incentives in the system. The objective of this paper is to analyse the interaction between health insurance and the liability regime. We argue that in the presence of risk-averse patients who purchase insurance against health shocks, the optimal liability regime is *lower* than in the absence of health insurance – so much so that a no-fault liability might be optimal.

To our knowledge, theoretical models which consider the implications of health insurance for the optimal liability regime have not been analysed in the literature. Danzon (1985) considers how the structure of health insurance might distort doctor's choice of prevention as well as malpractice insurance. She points out that since tests are subsidised by insurers whereas doctor's time is not, this distortion in the relative price of preventive inputs causes a over-use of tests and under-utilisation of time in preventing accidents. However, her paper does not explicitly consider the health insurance and accident liability systems as a joint problem in optimal health system design. Currie and MacLeod (2008) have a theoretical section in their empirical model where procedure choice interacts with the nature of the third-party liability. They show that taking this "extensive margin" into account can have important implications for the predicted effect of malpractice reform.

In this paper we construct a theoretical model that explicitly takes into account the interaction between the health insurance contract and the liability regime. We show that in an environment where patient-copayments apply to preventive care, a no-fault liability regime is optimal. We also consider an environment where there is supply -side cost sharing. We show that our theoretical model matches Kessler and McLellan's (2002) finding that supply side pressure and malpractice pressure are substitutes.

2 Demand-side cost sharing

There are three types of agents in this model: the consumer, the doctor and the National Health Insurers (NHI). While we assume that health care is funded through taxes our model is equally applicable to a perfectly competitive private health insurance market where the consumer pays a fair-priced premium.

The patient's expected utility when sick is

$$U^p = V\left[W - H + h - \theta\left(h + d\right) - R\right] - p\left[d\right]\left(L + z\right),$$

where $V[.]$ is the individual's utility function with $V' > 0$ and $V'' < 0$, $W - H$ is the income after the health loss, h is the 1 unit of curative care that he needs, θ is the copayment ratio reflecting the degree of health insurance provided by the NHI, and R is the tax rate imposed by the NHI to fund health insurance. The probability of medical error, p, is a function of the amount of preventive medicine prescribed, d. We assume that $p' < 0$, $p'' < 0$, $p\left(\overline{d}\right) = \underline{p}$, and $p\left(0\right) = \overline{p}$. The price of d is 1, so d is also the expenditure on preventive care. Injury entails a loss $(L + z)$ where L is insurable and z is an additional loss which is uninsurable (e.g. the psychological trauma suffered by a treatment related injury).

We consider d which is designed to lower the risk of treatment related injury as "preventive medicine". An example of such expenditure would be the use of diagnostic tests.[2] The term d can also be interpreted as reflecting additional expenditure involved in choosing lower risk procedures.

[2] Kessler and McClellan (2002) analyse the effect of malpractice reform on the utilisation of diagnostic vs. therapeutic interventions on Medicare patients following a heart attack. They find that malpractice pressure had greater effect on diagnostic expenditure.

For example, doctors might choose to deliver a baby by Cesarean section in "marginal" pregnancies simply to lower the probability of birth related malpractice suites (Dubay, Kaestnerb and Waidmann, 1999). In this case, d is the extra costs incurred in a Cesarean section as opposed to a natural delivery for achieving the same delivery outcomes (h). The doctor chooses d and patients accept the doctor's choice.

The doctor's utility is

$$U^d = Y - E - p\,[d]\, L + \beta \widetilde{U}^p,$$

where E is a fixed effort cost of providing 1 unit of h and, assuming that the patient is fully insured against L,

$$\widetilde{U}^p = V\,[W - H + h - \theta\,(h + d)] - p\,[d]\, z.$$

We assume that $0 < \beta < 1$. The term β in the doctor's utility function reflects the degree of agency. The assumption that $\beta > 0$ is designed to capture the fact that doctors are not purely motivated by profits but are "imperfect agents" who will expand effort to benefit their patient (McGuire, 2000).[3] It also implies that the doctor is sensitive to the patient's out-of-pocket payment for d but not to R the tax rate paid.[4] The doctor's wage Y is paid by the NHI for treating the patient. We assume that the doctor has to be provided a reservation utility $\overline{U}^d$ for his service.

The NHI's preferences are the patient's *ex ante* utility given by

$$\Psi = (1 - \pi)\, V\,[W - R] + \pi U^p,$$

where π is the probability that the consumer falls ill.

[3] See for example Ellis and McGuire (1986, 1990); Vaithianathan (2003); Dranove and Spier (2003) for similar models of doctor-patient agency.

[4] There is evidence that doctors respond to patient's out-of-pocket costs. Rossiter and Wilensky,(1984) found that physician-initiated visits were responsive to the degree of cost-sharing and insurance status of the patient. Pham et al (2007) report that 78% of physicians they survey report routinely considering out-of-pocket payments when selecting diagnostic tests.

3 Third-party vs. No-Fault System

In this sub-section, as a benchmark, we consider two extremes of the liability regimes: the no-fault regime ($\emptyset$) similar to New Zealand and the third-party liability regime (III) (we will turn to a continuum of regimes in the next section). Under a no-fault insurance system, the consumer is paid L by the NHI if there is a medical error. Under a third-party liability regime he is paid L by the doctor.

The timing of the game is identical under each liability regime and is as follows:

1. NHI chooses copayment θ to maximise consumer's *ex ante* utility. The tax rate, R, is set to satisfy the NHI budget constraint, and the wage rate for the doctor Y is contracted to give him his reservation utility $\overline{U}^d$.

2. Nature moves and patient falls ill with probability π.

3. The doctor delivers 1 unit of h with effort E and chooses d.

4. An accident occurs with probability $p[d]$ and the NHI (doctor) pays the patient L in the $\emptyset$ (III) regime.

5. The doctor receives his wage for treating the patient.

We look for subgame perfect Nash equilibrium and solve this game using backward induction. The doctor's utility under the two regimes are

$$\begin{aligned} U_{III}^d &= Y - E - p[d] L + \beta \widetilde{U}^p \\ U_{\emptyset}^d &= Y - E + \beta \widetilde{U}^p, \end{aligned}$$

where the sub-scripts denote the regime. The choice of d by the doctor depends on θ and the liability regime and is denoted by $d_{III}[\theta]$ and $d_{\emptyset}[\theta]$:

$$d_{III}[\theta] = \arg\max_d -p[d] L + \beta \widetilde{U}^p, \tag{1}$$

and

$$d_{\emptyset}[\theta] = \arg\max_d \beta \widetilde{U}^p \tag{2}$$

Lemma 1 *(i)* $d'_{\{III,\emptyset\}} < 0$; *(ii)* $d_{\{III,\emptyset\}}[0] = \overline{d}$ *(iii) for a given* $\theta \in (0,1]$, $d_{\emptyset}[\theta] < d_{III}[\theta]$

Proof. For regime III, the optimal d satisfies the following condition:

$$-(1+\beta)\, p'[d]\, z = \beta V'[W - H + (1-\theta)\, h - \theta d]\, \theta, \tag{3}$$

with the marginal benefit on the LHS and marginal cost on the RHS. Similarly, for regime $\emptyset$, the optimal d satisfied the following condition:

$$-\beta p'[d]\, z = \beta V'[W - H + (1-\theta)\, h - \theta d]\, \theta. \tag{4}$$

As θ increases, for both regimes, the marginal benefit on the LHS remains the same while the marginal cost on the right hand side increases. Thus $d'_{\{III,\emptyset\}} < 0$. When $\theta = 0$, the marginal cost on the LHS is zero. With $p'(d) < 0$ and the marginal benefit always positive, the optimal d is the maximum possible, $\overline{d}$. Since $MB_{III} > MB_{\emptyset}$ and $MC_{III} = MC_{\emptyset}$, we have $d_{\emptyset}(\theta) < d_{III}(\theta)$. A corollary of this is that for any given d^*, the copayment ratio θ required to induce such d^* is lower in regime $\emptyset$. For any given d^*, as the MB is higher for regime III, we need a higher θ to satisfy the first order condition. ■

Lemma 1 means that the $d[\theta]$ functions look like what is shown in Figure 1. For any given θ, the doctor always prescribe more defensive medicine under regime III than under regime $\emptyset$. The corollary of this is that to induce any given level d, the θ required under regime $\emptyset$ is lower than under regime III. Note that the only reason $d < \overline{d}$ under either regimes is due to the fact that the patient has to pay for θ proportion of the costs of preventive care and the doctor cares about the patient's copayment. Therefore, as θ falls, the doctor will continue to prescribe more preventive care until the risk of an accident risk is minimised. When copayment is zero, then under both regimes, doctors will prescribe the maximum level of preventive medicine and the probability of iatrogenic effects will be $\underline{p}$.

Since the doctor is paid a compensating wage differential and has constant utility of $\overline{U}^d$, the wage paid to the doctor in each regime will be

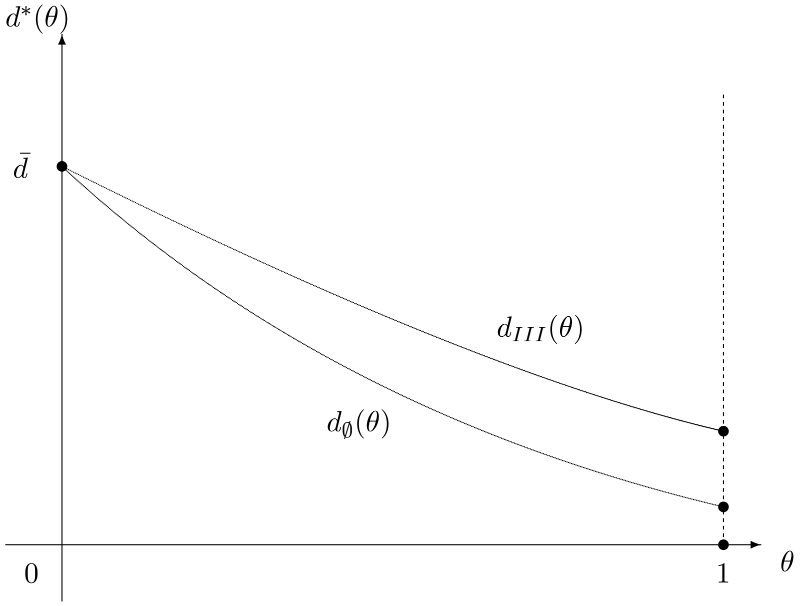

Figure 1: Best Response $d(\theta)$

different. In particular, in regime III, the doctor has to be compensated for facing a higher liability risk.

$$
\begin{aligned}
Y_{III} &= \overline{U}^d + E + p\left[d_{III}\left[\theta\right]\right]L + \beta\widetilde{U}^p_{III} \\
Y_{\emptyset} &= \overline{U}^d + E + \beta\widetilde{U}^p_{\emptyset}.
\end{aligned}
$$

The NHI has a zero-budget constraint and funds its costs from a lump-sum tax R. The tax R depends on the liability regime:

$$R_{III} = \pi\left(\left(1-\theta\right)\left(h + d_{III}\left[\theta\right]\right) + Y_{III}\right),$$

and

$$R_{\emptyset} = \pi\left(\left(1-\theta\right)\left(h+d\right) + p\left[d_{\emptyset}\left(\theta\right)\right]L + Y_{\emptyset}\right).$$

The NHI's utility under each regime is

$$\Psi_{III} = \left(1-\pi\right)V\left[W - R_{III}\right] + \pi U^p_{III},$$

and

$$\Psi_{\emptyset} = \left(1-\pi\right)V\left[W - R_{\emptyset}\right] + \pi U^p_{\emptyset}.$$

where

$$\begin{aligned} U^p_{III} &= V\left[W-H+(1-\theta)h-\theta d-R_{III}\right] \\ &-p\left[d_{III}(\theta)\right]z. \end{aligned}$$

and

$$\begin{aligned} U^p_{\emptyset} &= V\left[W-H+(1-\theta)h-\theta d-R_{\emptyset}\right] \\ &-p\left[d_{\emptyset}(\theta)\right]z. \end{aligned}$$

Since the doctor's utility is fixed at $\overline{U}^d$ and the NHI has zero profit, maximising Ψ is equivalent to maximising social welfare in our model.

Theorem 1 *Social welfare is higher under regime $\emptyset$ than regime III .*

Proof. First of all note that Lemma 1 implies that if $\widetilde{d}$ is the best response of the doctor to a copay $\widetilde{\theta}_{III}$ under III , then there exists some $\widetilde{\theta}_{\emptyset} < \widetilde{\theta}_{III}$, such that $\widetilde{d}$ is the best response under regime $\emptyset$. Let $\widetilde{\theta}_{III}$ be the optimal copay under regime III. Let Y_i be the wage of the doctor under regime i and copay $\widetilde{\theta}_i$.

$$Y_{III} = \overline{U} + E + p\left[\widetilde{d}\right]L - \beta\left(V\left[W-H+\left(1-\widetilde{\theta}_{III}\right)h-\widetilde{\theta}_{III}\widetilde{d}\right]-p\left[\widetilde{d}\right]z\right)$$

$$Y_{\emptyset} = \overline{U} + E - \beta\left(V\left[W-H+\left(1-\widetilde{\theta}_{\emptyset}\right)h-\widetilde{\theta}_{\emptyset}\widetilde{d}\right]-p\left[\widetilde{d}\right]z\right)$$

Since $\widetilde{\theta}_{\emptyset} < \widetilde{\theta}_{III}$ we have that $\varepsilon > 0$, where

$$\varepsilon = \beta\left(V\left[W-H+\left(1-\widetilde{\theta}_{\emptyset}\right)h-\widetilde{\theta}_{\emptyset}\widetilde{d}\right]-V\left[W-H+\left(1-\widetilde{\theta}_{III}\right)h-\widetilde{\theta}_{III}\widetilde{d}\right]\right).$$

Therefore, the income of the doctor under regime III has to *more* than compensate him for the increased liability he faces since he now treats patients who face higher copays and are therefore worse off:

$$Y_{III} - Y_{\emptyset} = p\left(\widetilde{d}\right)L + \varepsilon.$$

The tax rate under regime III and copay $\widetilde{\theta}_{III}$ is

$$\widetilde{R}_{III} = \pi\left(1-\widetilde{\theta}_{III}\right)\left(h+\widetilde{d}\right) + \pi Y_{III}$$

The tax rate under $\emptyset$ and copay $\widetilde{\theta}_\emptyset$ is $\widetilde{R}_\emptyset = \pi\left(1-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right)+\pi p\left[\widetilde{d}\right]L+\pi Y_\emptyset$. Note that

$$\begin{aligned}
\widetilde{R}_\emptyset - \widetilde{R}_{III} &= \left[\pi\left(1-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right)+\pi p\left(\widetilde{d}\right)L+\pi Y_\emptyset\right] \\
&\quad -\left[\pi\left(1-\widetilde{\theta}_{III}\right)\left(h+\widetilde{d}\right)+\pi Y_{III}\right] \\
&= \pi\left(\left(\widetilde{\theta}_{III}-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right)\right)+\pi p\left(\widetilde{d}\right)L+\pi\left(Y_\emptyset - Y_{III}\right) \\
&= \pi\left(\widetilde{\theta}_{III}-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right)+\pi p\left(\widetilde{d}\right)L+\pi\left(-p\left(\widetilde{d}\right)L-\pi\varepsilon\right) \\
&= \pi\left(\widetilde{\theta}_{III}-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right)+\pi p\left(\widetilde{d}\right)L-\pi p\left(\widetilde{d}\right)L-\pi\varepsilon \\
&= \pi\left(\widetilde{\theta}_{III}-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right)-\pi\varepsilon \\
&= \pi Z-\pi\varepsilon
\end{aligned}$$

where

$$\begin{aligned}
Z &= \left(\widetilde{\theta}_{III}-\widetilde{\theta}_\emptyset\right)\left(h+\widetilde{d}\right) \\
\Rightarrow Z+\widetilde{\theta}_\emptyset\left(h+\widetilde{d}\right) &= \widetilde{\theta}_{III}\left(h+\widetilde{d}\right).
\end{aligned}$$

The consumer's ex-post utility if sick under regime $\emptyset$ is

$$\begin{aligned}
U_\emptyset^p &= V\left[W-H+h-\widetilde{\theta}_\emptyset\left(h+\widetilde{d}\right)-\widetilde{R}_\emptyset\right]-p\left[\widetilde{d}\right]z \\
&= V\left[W-H+h-\widetilde{\theta}_\emptyset\left(h+\widetilde{d}\right)-\left(\widetilde{R}_{III}+\pi Z-\pi\varepsilon\right)\right]-p\left(\widetilde{d}\right)z \\
&= V\left[W^*-\pi Z+\pi\varepsilon\right]-p\left[\widetilde{d}\right]z
\end{aligned}$$

where $W^* = W-H+h-\widetilde{\theta}_\emptyset\left(h+\widetilde{d}\right)-\widetilde{R}_{III}$.

Therefore, their ex-ante utility can be written as

$$\begin{aligned}
\widetilde{\Psi}_\emptyset &= (1-\pi)V\left[W-\widetilde{R}_\phi\right]+\pi V\left[W^*-\pi Z+\pi\varepsilon\right]-\pi p\left[\widetilde{d}\right]z \\
&= (1-\pi)V\left[W-\widetilde{R}_{III}-\pi Z+\pi\varepsilon\right]+\pi V\left[W^*-\pi Z+\pi\varepsilon\right]-\pi p\left[\widetilde{d}\right]z
\end{aligned}$$

Similarly for regime III

$$\begin{aligned}
U_{III}^p &= V\left[W-H+\left(1-\widetilde{\theta}_{III}\right)h-\widetilde{\theta}_{III}\widetilde{d}-\widetilde{R}_{III}\right]-p\left[\widetilde{d}\right]z \\
&= V\left[W-H+h-\widetilde{\theta}_{III}(h+d)-\widetilde{R}_{III}\right]-p\left[\widetilde{d}\right]z \\
&= V\left[W-H+h-\widetilde{\theta}_\emptyset\left(h+\widetilde{d}\right)-Z-\widetilde{R}_{III}\right]-p\left[\widetilde{d}\right]z \\
&= V\left[W^*-Z\right]-p\left[\widetilde{d}\right]z.
\end{aligned}$$

and ex-ante utility is

$$\widetilde{\Psi}_{III} = (1-\pi)\, V\left[W - \widetilde{R}_{III}\right] + \pi V\left[W^* - Z\right] - \pi p\left[\widetilde{d}\right] z$$

Then from the fact that consumers are risk averse, and the principle that they will purchase fair priced insurance for the loss Z with probability π, and that $W^* < W - R_{III}$ we have that

$$\begin{aligned} & (1-\pi)\, V\left(W - R_{III} - \pi Z\right) + \pi V\left(W^* - \pi Z\right) \\ > \; & (1-\pi)\, V\left(W - R_{III}\right) + \pi V\left(W^* - Z\right), \end{aligned}$$

and since $V[\cdot]$ is increasing we have

$$\begin{aligned} & (1-\pi)\, V\left(W - \pi Z + \pi\varepsilon\right) + \pi V\left(W^* - \pi Z + \pi\varepsilon\right) \\ > \; & (1-\pi)\, V\left(W - R_{III} - \pi Z\right) + \pi V\left(W^* - \pi Z\right) \end{aligned}$$

This implies that $\widetilde{\Psi}_{\emptyset} > \widetilde{\Psi}_{III}$. Moreover, given that $\widetilde{\theta}_{III}$ was optimal for regime III, this completes the proof. ■

Theorem 2 *The equilibrium copay ratio is lower under regime $\emptyset$ than regime III.*

Proof. Let $\left(\theta^*_{\emptyset}, d^*_{\emptyset}\left[\theta^*_{\emptyset}\right]\right)$ and $\left(\theta^*_{III}, d^*_{III}\left[\theta^*_{III}\right]\right)$ be the subgame perfect equilibrium for regimes $\emptyset$ and III respectively. Suppose that $\theta^*_{\emptyset} \geq \theta^*_{III}$. From Lemma 1, we have $d^*_{\emptyset}\left[\theta^*_{\emptyset}\right] < d^*_{III}\left[\theta^*_{III}\right]$. From Theorem 1, $\Psi^*_{\emptyset} > \Psi^*_{III}$. Given that α only affects Ψ indirectly through the doctor's choice of d, $\Psi = \Psi\left(\theta, d\left[\theta\right]\right)$.Therefore, it must be the case that we can find a $\widetilde{\theta} > \theta^*_{III}$ with $\widetilde{d}\left[\widetilde{\theta}\right] < d^*_{III}\left[\theta^*_{III}\right]$ such that $\Psi_{III}\left(\widetilde{\theta}, \widetilde{d}\left[\widetilde{\theta}\right]\right) > \Psi^*_{III}\left(\theta^*_{III}, d^*_{III}\left[\theta^*_{III}\right]\right)$. This violates the condition that $\left(\theta^*_{III}, d^*_{III}\left[\theta^*_{III}\right]\right)$ is a subgame perfect equilibrium. Thus, in equilibrium, we must have $\theta^*_{\emptyset} < \theta^*_{III}$. ■

The above theorem is quite intuitive. Given that regime III always gives the doctor more incentive to prescribe defensive medicine than regime $\emptyset$, if the preference is such that it is optimal to set θ_{III} in regime III, any $\widehat{\theta}$ greater than θ_{III} would not be optimal in regime $\emptyset$. First, if it is optimal to raise θ to reduce the consumption of defensive medicine in region $\emptyset$, θ_{III} would never be optimal in regime III since doctor has even stronger incentive to increase d in regime III. On top of that, raising θ in regime $\emptyset$ gives the patient less insurance and would decrease welfare. This would violate our result $\Psi^*_{\emptyset} > \Psi^*_{III}$.

4 First-best preventive medicine

To see how the health insurance contract and the liability regime interact, we compare the doctor's choice of d under four extreme scenarios according to liability regime and health insurance contract.

Let us define the first-best level of d as the *ex post efficient* level, i.e., the level that would be chosen by a fully informed and uninsured consumer who faces the full risk of the loss. Therefore, d^1 (the first best level) is where the marginal benefit from d is equal to the marginal cost:

$$-p'[d](L+z) = V'[W-H-d].$$

We now compare the d chosen by the doctor under four scenarios with d^1. The doctor chooses d to maximise U_i^d, $i = \{\emptyset, III\}$.

1. **Patient Uninsured, Doctor Fully Liable:** $\theta = 1$, and $\alpha = 1$. In this case the doctor's choice of d satisfies

   $$-p'[d](L+\beta z) = \beta V'[W-H-d]$$

   For $\beta = 1$, $d = d^1$. For $\beta < 1$, the choice of d

   $$\frac{-p'[d](L+\beta z)}{\beta} = V'[W-H-d]$$

   and since

   $$-p'[d](L+z) > \frac{-p'[d](L+\beta z)}{\beta}$$

   $d > d^1$.

   There is too much preventive medicine, since the doctor over-weights his own liability compared to the cost faced by the patient.

2. **Patient Uninsured, No-Fault Liability:** $\theta = 1$ and $\alpha = 0$. In this case, the doctor's choice of d satisfies

   $$-p'[d](\beta z) = \beta V'[W-H-d],$$

   and we have $d < d^1$.

   There is too little preventive medicine, since the doctor ignores the accident loss L.

	$\boldsymbol{\alpha = 0}$	$\boldsymbol{\alpha = 1}$
$\boldsymbol{\theta = 0}$	$d = \overline{d} > d^1$	$d = \overline{d} > d^1$
$\boldsymbol{\theta = 1}$	$d < d^1$	$d > d^1$

Table 1: Summary of optimal d versus the doctor's choice.

3. **Patient Fully Insured, Doctor Fully Liable:** $\theta = 0$ and $\alpha = 1$. In this case the doctor's choice of d satisfies

$$-p'(d)(L + \beta z) = 0.$$

As analysed also in Lemma 1, for $\theta = 0$, we have $d = \bar{d} > d^1$.

There is too much preventive medicine, since the doctor over-weights his own liability and patients face no costs.

4. **Patient Fully Insured , No-Fault Liability:** $\theta = 0$ and $\alpha = 0$. In this case the doctor's choice of d satisfies

$$-p'[d](\beta z) = 0.$$

We again have $d = \bar{d} > d^1$.

There is too much preventive medicine, since the patients face no costs.

The results are summarised in Table 1.

Consistent with the standard economic theory of tort law, the theory we outline here predicts that with less liability, physicians will exert less care (see Landes and Posner [1987]; Shavell [1987]; and Danzon [2000] for exhaustive reviews). However, this exercise has confirmed that if we considered the optimal liability regime *for an uninsured patient* $(\theta = 1)$, we might conclude that $\alpha = 0$ is not optimal. In the case of uninsured patients, our model shows that $\alpha = 0$ provides too little incentive for preventive medicine while $\alpha = 1$ provides too much. However, once we take the $\theta = 0$ case, we see that whatever the liability regime, there will be too much d.

5 Partial Liability

In the previous sub-section we presented a stark contrast between a complete third-party insurance where doctors were fully exposed to the risk of liability and a completely no-fault system. We now consider a system where the liability can be shared between the doctor and the NHI and ask whether regime ϕ is still optimal. Under partial liability, the NHI imposes a proportionate third-party liability, where the doctor is liable for αL if there is some medical error. The rest of the loss $(1-\alpha) L$ is paid for by the NHI.

The timing of the game is identical to that above, but this time at stage 1, the NHI chooses α and θ . Under this scenario, $\alpha = 0$ corresponds to the no-fault regime while $\alpha = 1$ corresponds to the third party regime. For the doctor's optimisation problem, d^* is determined by

$$\beta V' [W - H + (1-\theta) h - \theta d] \theta = -p' [d] (\alpha L + \beta z) .$$

As α increases, the marginal benefit increases and the optimal d increases. As θ increases, the marginal cost increases and the optimal d decreases.

Theorem 3 *No-fault system* $(\alpha = 0)$ *is optimal when there is demand side-cost sharing and inelastic* h *.*

Since the Proof of Theorem 3 follows along very similar lines to the proof of Theorem 1, we provide the proof in the Appendix.

6 Elasticity in Demand for h

So far we have assumed that demand for h was inelastic to highlight the interaction between α, θ, and d. In this section, we analyse what happens if h is elastic with respect to θ. With a variable h chosen by the doctor, there is now an additional source of over-consumption, and a lower θ encourages the over-consumption of h as well as d. Thus we have the traditional moral hazard problem (Pauly, 1968) .

The timing and pay-offs are the same as the previous section, except that $H = H[h]$ with $H' < 0$, $H'' < 0$, and $H(h) = 0$ for $h \geq \overline{h}$. Let $h[\theta]$ be the doctor's demand for h. Then

$$h[\theta] = \max_h Y - E - p[d]\alpha L + \beta\widetilde{U}^p.$$

Therefore,

$$h[\theta] = -H'^{-1}[\theta].$$

Given $H' < 0$, $H'' < 0$, the demand for h is downward sloping, $h'[\theta] < 0$.

With elastic demand for h, the optimality of $\alpha = 0$ is no longer so straightforward. An exception is if the insurer can set differential co-payment rates for h (we label as θ_h) and d (we label as θ_d) . In this case, it is easy to see that the results from Theorem 3 continues to apply. The NHI sets the rates $\{\theta_d, \theta_h\}$ which maximises its social welfare function. Consider the optimal (θ_d^*, θ_h^*) when $\alpha > 0$. Let $h^* = h[\theta^*]$. Then to see that Theorem1 directly applies, we need only replace h with h^* in that proof and everything goes through as before.

We now turn to the more difficult issue of a single θ with an elastic demand for h. The next Theorem shows that in this case, as long as the elasticity of demand for h is not too high, a no-fault system continues to be optimal.

Theorem 4 *No-fault system* $(\alpha = 0)$ *is optimal in the presence of demand side-cost sharing , elastic* h*, and a common copayment* (θ) *as long as* $h[\cdot]$ *is not too elastic.*

Proof. The proof follows similar lines to Theorem 1. In particular, consider the optimal copayment θ^* under a regime where $\alpha > 0$ (refer to this as regime III) which implements d^* and h^*. Now, consider no-fault regime $\emptyset$ $(\alpha = 0)$. There exists a copayment $\widehat{\theta} < \theta^*$ such that d^* continues to be consumed. At this lower copayment, the h implemented, $\widehat{h}$ will be higher than h^*. Let $\Delta = \widehat{h} - h^*$. We have

$$\Psi[\alpha > 0] = (1-\pi)V\left[W - \widetilde{R}\right] + \pi V\left[W - H[h^*] - \widetilde{\theta}\left(h^* + \widetilde{d}\right) - \widetilde{R}\right] - \pi p[d^*]z$$

and

$$\begin{aligned}\Psi[\alpha = 0] &= (1-\pi)V\left[W - \widehat{R}\right] \\ &\quad + \pi V\left[W - H[h^* + \Delta] - \widehat{\theta}\left(h^* + \Delta + \widehat{d}\right) - \widehat{R}\right] - \pi p[d^*]z,\end{aligned}$$

where

$$\widetilde{R} = \pi \left(\left(1 - \widetilde{\theta}\right) (h^* + d^*) + p\,[d^*]\,(1-\alpha)\,L + \widetilde{Y} \right)$$

and

$$\widehat{R} = \pi \left(\left(1 - \widehat{\theta}\right) (h^* + \Delta + d^*) + p\,[d^*]\,L + \widehat{Y} \right).$$

The compensation wage required for the doctors are

$$\widetilde{Y} = \overline{U} + E + p\,[d^*]\,(\alpha L + \beta z) - \beta V\,[W - H + h^* - \theta^*\,(h^* + d^*)]$$

and

$$\widehat{Y} = \overline{U} + E + p\,[d^*]\,\beta z - \beta V \left[W - H + h^* + \Delta - \widehat{\theta}\,(h^* + \Delta + d^*) \right].$$

Since both $H\,[.]$ and $V\,[.]$ are continuous in Δ, $\Psi\,[\alpha = 0]$ is continuous in Δ. On the other hand, $\Psi\,[\alpha > 0]$ is independent of Δ. Theorem 1 shows that for $\Delta = 0$, $\alpha = 0$ is strictly preferred. Therefore, there exists some Δ small enough, that Theorem 1 continues to hold. ■

7 Supply side cost sharing

So far we have only considered the interaction between the liability regime and demand side-cost sharing. We now turn to the optimal liability when there is zero patients coinsurance, but the doctor pays some c for each test or x-ray that he orders. We use inelastic h to illustrate the results. The patient's utility when sick is therefore

$$U^p = V\,[W - H + h - R] - p\,[d]\,z.$$

The doctor's utility is

$$U^d = Y - E - p\,[d]\,\alpha L - cd + \beta \widetilde{U}^p,$$

where

$$\widetilde{U}^p = V\,[W - H + h] - p\,[d]\,z.$$

Therefore, doctor prescribes d to equalise the marginal benefit with the supply-side cost c

$$\begin{aligned} c &= -p'[d](\alpha L+\beta z) \quad (5)\\ -p'^{-1}\left[\frac{c}{\alpha L+\beta z}\right] &= d \quad (6)\end{aligned}$$

Equation 5 illustrates the point that supply side cost sharing and the liability regime are substitutes since it is the ratio of c to $(\alpha L+\beta z)$ that matters. This result echoes the findings of Kessler and McLellan (2002) which showed that areas with higher penetration of managed care (i.e. areas with higher c) were less responsive to tort reform (i.e. a lowering of α).

We assume that when imposing supply-side cost sharing, the doctor's income Y will have to rise to compensate him for the payment of c therefore

$$Y=\overline{U}+E+p(\alpha L+\beta z)-\beta V[W-H+h]+cd. \quad (7)$$

The contribution paid by the doctor is collected by the NHI and therefore lowers the tax rate:

$$R=\pi(h+d)+p(1-\alpha)L+Y-cd. \quad (8)$$

We now turn to the optimal c. In the case of demand side cost sharing, we showed that there was a welfare gain in having $\alpha=0$ since it allowed a lower copayment - which was beneficial to the consumer who is risk averse. However, in our model the doctor is risk-neutral. Therefore, we would expect there to be no added advantage from allowing $\alpha=0$. The following result shows this to be the case.

Theorem 5 *The liability regime* (α) *and the supply-side cost* (c) *are perfect* substitutes.

Proof. Consider implementing a particular d^* through some $\alpha\in[0,1]$ and a c where $c=d^*(\alpha^*L+\beta z)$. Welfare is

$$\Psi=(1-\pi)V[W-R^*]+\pi V[W-R^*]-\pi p^* z$$

Combining 8 and 7 with Ψ yields

$$\begin{aligned}\Psi &= V\left[W-\left(\pi(h+d^*)+p(d^*)(1-\alpha)L+\overline{U}+E+p(d^*)(\alpha L+\beta z)-\beta V(W)\right)\right]\\ &\quad -\pi p(d^*)z\end{aligned}$$

$$= V\left[W - \left(\pi\left(h + d^*\right) + p\left(d^*\right)L + \overline{U} + E + p\left(d^*\right)\beta z - \beta V\left(W\right)\right)\right] \quad (9)$$
$$-\pi p\left(d^*\right)z$$

which only depends on d^* and not on α or c. The NHI therefore chooses d to maximise 9 and any (α, c) that implements d yields identical levels of welfare. Therefore the NHI chooses the optimal $d^* \in \left[0, \overline{d}\right]$ which maximises Ψ, and (α, c) where $c = d^*\left(\alpha L + \beta z\right)$. ∎

8 Concluding Comments

The purpose of this paper is to point out that a no-fault regime might be optimal in systems where the NHI has additional demand or supply side mechanisms to affect preventive care. In the case where the NHI relies purely on a demand-side mechanism, no-fault systems offer better insurance to consumers and are therefore welfare improving. On the other hand, systems with third party liability are forced to impose higher coinsurance rates in order to prevent excessive prescribing of preventive medicine by doctors who face liability.

Our model abstracts from the fact that doctors' choice to treat is also effected by the tort environment (Currie and MacLeod 2008). That is, while no-fault liability might discourage the use of preventive care, it might encourage doctors to preform more dangerous procedures such a as C-sections which in a more liable environment they might have eschewed. The effect of no-fault liability on procedure choice is an interesting area of future research.

The main practical objection to more countries adopting no-fault systems is that they would be expected to bring forth an increase in compensation costs (Kessler, Summerton and Graham, 2006). This concern might be to do with the additional dead-weight costs involved in collecting taxes to pay for the compensation, and issue which we ignore in this paper.

9 Appendix

Proof of Theorem. 3. Under the partial liability system, the patient is still fully insured against the L:

$$U^p = V\left[W - H + (1-\theta) h - \theta d - R\right] - p\left[d\right] z,$$

and

$$\widetilde{U}^p = V\left[W - H + (1-\theta) h - \theta d\right] - p\left[d\right] z$$

The doctor's utility is

$$U^d = Y - E - p(d)\,\alpha L + \beta \widetilde{U}^p.$$

For the doctor's optimisation problem, d^* is determined by

$$\beta V'\left[W - H + (1-\theta) h - \theta d\right]\theta = -p'\left[d\right](\alpha L + \beta z).$$

As α increases, the marginal benefit increases and the optimal d increases. As θ increases, the marginal cost increases and the optimal d decreases.

For any $\left(\widetilde{\alpha} > 0, \widetilde{\theta}\right)$ such that the doctor's best response is $\widetilde{d}$, let $\widehat{\theta}$ be the θ which induces $\widetilde{d}$ as the doctor's best response when $\alpha = 0$. From the above inspection of the marginal cost and benefit, we have $\widehat{\theta} < \widetilde{\theta}$. The ex ante consumer welfare is therefore

$$\Psi\left[\widetilde{\alpha}, \widetilde{\theta}, \widetilde{d}\right] = (1-\pi) V\left[W - R\right] + \pi V\left[W - H + h - \widetilde{\theta}\left(h + \widetilde{d}\right) - R\right] - \pi p\left[\widetilde{d}\right] z.$$

and

$$\Psi\left[0, \widehat{\theta}, \widetilde{d}\right] = (1-\pi) V\left[W - R\right] + \pi V\left[W - H + h - \widehat{\theta}\left(h + \widetilde{d}\right) - R\right] - \pi p\left[\widetilde{d}\right] z.$$

Furthermore,

$$R\left[\widetilde{\alpha}, \widetilde{\theta}, \widetilde{d}\right] = \pi\left(\left(1 - \widetilde{\theta}\right)\left(h + \widetilde{d}\right) + p\left[\widetilde{d}\right](1 - \widetilde{\alpha}) L + Y\right)$$

and

$$R\left[0, \widehat{\theta}, \widetilde{d}\right] = \pi\left(\left(1 - \widehat{\theta}\right)\left(h + \widetilde{d}\right) + p\left[\widetilde{d}\right] L + Y\right).$$

For the doctor's compensation wage,

$$Y\left[\widetilde{\alpha}, \widetilde{\theta}, \widetilde{d}\right] = \overline{U} + E + p\left[\widetilde{d}\right](\widetilde{\alpha} L + \beta z) - \beta V\left[W - H + h - \widetilde{\theta}\left(h + \widetilde{d}\right)\right]$$

and

$$Y\left[0,\widehat{\theta},\widetilde{d}\right]=\overline{U}+E+p\left[\widetilde{d}\right]\beta z-\beta V\left[W-H+h-\widehat{\theta}\left(h+\widetilde{d}\right)\right].$$

We have

$$Y\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]-Y\left[0,\widehat{\theta},\widetilde{d}\right]=p\left[\widetilde{d}\right]\widetilde{\alpha}L+\varepsilon,$$

where $\varepsilon=\beta\left(V\left[W-H+\left(1-\widehat{\theta}\right)h-\widehat{\theta}\widetilde{d}\right]-V\left[W-H+\left(1-\widetilde{\theta}\right)h-\widetilde{\theta}\widetilde{d}\right]\right)>0$. For $\widetilde{\alpha}>0$, the doctor needs to be compensated more than the additional liability they bear, $p\left[\widetilde{d}\right]\widetilde{\alpha}L$, due to patient's disutility for facing a higher copay.

$$\begin{aligned}
& R\left[0,\widehat{\theta},\widetilde{d}\right]-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right] \\
= & \pi\left(\left(1-\widehat{\theta}\right)\left(h+\widetilde{d}\right)+p\left[\widetilde{d}\right]L+Y\left[0,\widehat{\theta},\widetilde{d}\right]\right) \\
& -\pi\left(\left(1-\widetilde{\theta}\right)\left(h+\widetilde{d}\right)+p\left[\widetilde{d}\right](1-\widetilde{\alpha})L+Y\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]\right) \\
= & \pi Z-\pi\varepsilon.
\end{aligned}$$

where $Z=\left(h+\widetilde{d}\right)\left(\widetilde{\theta}-\widehat{\theta}\right)$.

$\Psi\left[0,\widehat{\theta},\widetilde{d}\right]>\Psi\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]$ if

$$\begin{aligned}
& (1-\pi)V\left[W-R\left[0,\widehat{\theta},\widetilde{d}\right]\right]+\pi V\left[W-H+\left(1-\widehat{\theta}\right)h-\widehat{\theta}\widetilde{d}-R\left[0,\widehat{\theta},\widetilde{d}\right]\right] \\
= & (1-\pi)V\left[W-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]+\pi\varepsilon-\pi Z\right] \\
& +\pi V\left[W-H+h-\widehat{\theta}\left(h+\widetilde{d}\right)-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]+\pi\varepsilon-\pi Z\right] \\
> & (1-\pi)V\left[W-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]\right]+\pi V\left[W-H+\left(1-\widetilde{\theta}\right)h-\widetilde{\theta}\widetilde{d}-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]\right] \\
= & (1-\pi)V\left[W-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]\right]+\pi V\left[W-H+h-\widehat{\theta}\left(h+\widetilde{d}\right)-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]-Z\right].
\end{aligned}$$

This holds since

$$\begin{aligned}
& (1-\pi)V\left[W-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]+\pi\varepsilon-\pi Z\right] \\
& +\pi V\left[W-H+h-\widehat{\theta}\left(h+\widetilde{d}\right)-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]+\pi\varepsilon-\pi Z\right] \\
> & (1-\pi)V\left[W-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]-\pi Z\right]+\pi V\left[W-H+h-\widehat{\theta}\left(h+\widetilde{d}\right)-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]-\pi Z\right] \\
> & (1-\pi)V\left[W-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]\right]+\pi V\left[W-H+h-\widehat{\theta}\left(h+\widetilde{d}\right)-R\left[\widetilde{\alpha},\widetilde{\theta},\widetilde{d}\right]-Z\right].
\end{aligned}$$

Since for every $\widetilde{\alpha}$, this holds for given $\widetilde{\theta}$ and $\widetilde{d}$, doctor's best response to $\left(\widetilde{\alpha},\widetilde{\theta}\right)$. Let $\widetilde{\theta}$ be the optimal θ^{*} given $\widetilde{\alpha}$ and the doctor's best response. This completes the proof. ■

References

[1] Cummins, J. D., R. D. Phillips, and M. A. Weiss (2001) "The Incentive Effects of No-Fault Automobile Insurance," *Journal of Law and Economics*, **44**(2): 427-64.

[2] Currie, J. and B. MacLeod (2008) "First Do No Harm? Tort Reform and Birth Outcomes," *Quarterly Journal of Economics*, **CXXIII**(2), May 2008: 795-830.

[3] Dubaya, L., R. Kaestnerb and T. Waidmann (1999) “The Impact of Malpractice Fears on Cesarean Section Rates, ” *Journal of Health Economics,***18**(4): 491 - 522.

[4] Danzon, P. (1985) "Liability and Liability Insurance for Medical Practice," *Journal of Health Economics*, **4**(4):309 - 31.

[5] Danzon, P. (2000) "Liability for Medical Malpractice" in *Handbook of Health Economics*, Culyer, A. J. and J. P. Newhouse eds, Elseiver: 1339 - 1404.

[6] Dranove, D. and K. Spier (2003) "A Theory of Utilization Review," *Contributions to Economic Analysis & Policy*, **2**(1), article 9.

[7] Ellis, R. P. and T. G. McGuire (1986) "Provider Behavior under Prospective Reimbursement: Cost Sharing and Supply." *Journal of Health Economics*, **5**(2): 129 - 51.

[8] Ellis, R. P. and T. G. McGuire (1990) "Optimal Payment Systems for Health Services," *Journal of Health Economics*, **9**(4): 375 - 96.

[9] Fenn, P., A. Gray, and N. Rickman (2004) “Enterprise Liability, Insurance and Defensive Medicine: UK Evidence,” memio, Nottingham University Business School.

[10] Kessler, D. and M. McClellan (1996) "Do Doctors Practice preventive Medicine?", *Quarterly Journal of Economics*, **111**(2): 353 - 90.

[11] Kessler, D. and M. McLellan (2002) “Malpractice Law and Health Care Reform: Optimal Liability Policy in an Era of Managed Care,” *Journal of Public Economics*, **84** (2): 175 - 97.

[12] Kessler, D., N. Summerton, and J. Graham (2006) "Effects of the Medical Liability System in Australia, the UK, and the USA." *Lancet*, Vol **368**, No. 9531: 240 - 46.

[13] Landes, E. M. (1982) "Insurance, Liability, and Accidents: A Theoretical and Empirical Investigation of the Effect of No-Fault Accidents," *Journal of Law and Economics*, **25** (1): 49-65

[14] McGuire, T. (2000) "Physician Agency" in *Handbook of Health Economics*, Culyer, A. J. and J. P. Newhouse eds, Elseiver: 461 - 536.

[15] Pauly, M (1968) "The Economics of Moral Hazard: Comment," *American Economic Review*, **58** (3): 531 - 37.

[16] Pham, H. H., G. C. Alexander, and A. S. O’Malley (2007) "Physician Consideration of Patients’ Out-of-Pocket Costs in Making Common Clinical Decisions," *Archives of Internal Medicine*, **167**: 663 - 68.

[17] Rossiter, L. F. and G. R. Wilensky (1984) "Identification of Physician-Induced Demand," *The Journal of Human Resources*, **19**(2): 231 - 44.

[18] Shavell, S. (2006) "Liability for Accidents." *Handbook of Law and Economics*, A. Polinsky and S. Shavell eds., Vol **1**.

[19] Towse, A. and P. Danzon (1999) "Medical Negligence and the NHS: An Economic Analysis." *Health Economics* **8**: 93 - 101.

[20] Vaithianathan, R. (2003) "Supply-side cost sharing when patients and doctors collude." *Journal of Health Economics*, **22** (5):763 - 80.

[21] Weiler, P. (1993) "The Case for No-Fault Medical Liability." *Maryland Law Review*, **52**: 908 - 50.