HEDG

HEALTH, ECONOMETRICS AND DATA GROUP

WP 18/11

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May 2018

http://www.york.ac.uk/economics/postgrad/herc/hedg/wps/

Medical Malpractice Liability and Physicians' Behavior: Experimental Evidence

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Abstract

Medical liability systems have been accused of increasing health expenditure insofar as they induce the practice of defensive medicine. Despite the large evidence on the role of medical malpractice liability, the identification of its causal effect on physicians' treatment decisions is a difficult task. In this paper we study for the first time in a controlled laboratory setting the effect of introducing the risk of being sued for medical malpractice on the provision of physicians' medical services. In our experimental sessions both medical and non-medical students choose how many medical services to provide for heterogeneous patients. We implement exogenous variations in the presence of medical malpractice liability and expected probability of being sued, and thus we exploit the within-subject variation in the provision of medical services to infer the causal effect of malpractice liability. Furthermore, we analyze the impact of malpractice liability under different physicians' payment methods, which allows us to discuss the interplay between medical liability and payment systems. Our behavioral data show that introducing malpractice liability pressure does lead physicians to choose a higher amount of medical services, regardless of the physicians' payment system. However, we also find that the payment system in which malpractice liability is implemented makes the difference under the societal perspective, with relevant implications for health policy.

JEL Classification: I12; K13; C91.

Keywords: medical liability; defensive medicine; payment systems; physicians' behavior; laboratory experiment.

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1. Introduction

In the last decades, there has been a widespread concern about the growth of health expenditure in many OECD countries. While health expenditure as a share of GDP has remained stable and in line with the GDP growth in the years after the economic crisis, previously health spending outpaced economic growth in several healthcare systems (e.g., OECD, 2015). In this debate, medical liability systems are usually deemed a factor that can contribute to a high expenditure insofar as they induce the practice of defensive medicine, namely a physicians' intentional overuse of (not cost effective) healthcare services to reduce their liability risk (e.g., Mello et al., 2010). As argued by Kessler (2011), although the administrative cost of medical liability system represents a small share of total health spending, the additional costs induced by the practice of defensive medicine are likely to be far greater. For the US, Mello et al. (2010) estimate that medical liability system costs represent the 2.4% of total health spending.

Several empirical studies have estimated the effect of malpractice liability pressure on physicians' behavior and patient health outcomes, reporting evidence of defensive medicine (Kessler and McClellan, 1996; Dubay et al., 1999; Baicker et al., 2007; Fenn et al., 2007; Avrahm and Schanzenbach, 2015). Despite this large evidence on the role of medical liability, the identification of its causal effect on physicians' treatment decisions is a difficult task, due to the possible presence of unobserved factors that generate the variation in treatment decisions and outcomes of care (e.g., patients' risk profile), and are potentially correlated with measures of liability pressure (Kessler, 2011).

In this paper, we study for the first time in a controlled laboratory setting, to the best of our knowledge, the effect of introducing the risk of being sued for medical malpractice on the provision of physicians' medical services. In our experimental sessions, subjects (i.e. students) choose in the role of physicians how many medical services to provide for heterogeneous patients and, most importantly, under different scenarios. We include both medical and non-medical students, as previous experimental evidence reports that subjects with a medical background are more patient oriented than others (Hennig-Schmidt and Wiesen, 2014; Brosig-Koch et al., 2016). The quantity of medical services determines the physician's profit, the patient's health benefit and, when medical liability is at play, the *ex-ante* probability of being sued for medical malpractice. The decision-making in the experiment is incentivized by financial rewards, as all subjects at the end of each session get a monetary payment commensurate with their own payoff, which depends however on the *ex-post* event of being sued or not. On the other hand, real patients' health outside the lab is affected, as the monetary equivalent of the patients' health benefit resulting from subjects' behavior is transferred to a charity (*Famiglie SMA*) caring for children affected by spinal muscle atrophy (Hennig-Schmidt et al., 2011; Brosig-Koch et al., 2017).

We implement exogenous variations in the presence of medical malpractice liability and expected probability of being sued, while keeping all other variables (e.g., patients' severity) constant. Therefore, we exploit the within-subject variation in the provision of medical services to infer the causal effect of malpractice liability on physicians' behavior. Furthermore, motivated by a simple theoretical framework, we analyze the impact of malpractice liability under different physicians' payment methods, namely fee-for-service (FFS) and capitation (CAP), which allows us to discuss the interplay between medical malpractice liability and payment systems.

Our behavioral data show that introducing *ceteris paribus* variation in malpractice liability pressure does lead physicians to choose a higher amount of medical services for their patients, regardless of the patients' severity and the physicians' payment system. Under the societal perspective, however, we find that the payment system in which medical malpractice liability is implemented makes the difference. Specifically, as FFS embeds an incentive to provide too many services, introducing and/or intensifying medical liability pressure has the effect of exacerbating over-provision and, thus, reduces social welfare. Conversely, as physicians in CAP are incentivized to provide too few services, the increase in the amount of medical services induced by the fear of litigation helps to counterbalance the financial incentive to under-treat patients and, thus, improves social welfare. In this perspective, it is not surprising that the debate on medical liability systems is especially heated in the US where physicians are mainly paid by FFS.

This study complements the previous empirical research on the effect of liability pressure on physicians' behavior by providing experimental evidence, which is indeed important in this context given the difficulty to infer the causal effect of malpractice liability from empirical works. Moreover, our analysis clearly highlights that the effect of medical malpractice liability is best analyzed by considering the physicians' payment system and the associated financial incentives at play. In particular, our results suggest that, while in healthcare systems where physicians are paid by FFS tort reforms mitigating liability might reduce health expenditure without affecting patients' health outcomes, in healthcare systems where physicians are paid by CAP mitigating liability might make things worse.

The rest of the paper is organized as follows. Section 2 reviews the related literature. In Section 3, we derive behavioral predictions from a simple theoretical framework of physicians' behavior. Section 4 describes our experimental design and procedure. In Section 5, we discuss the result of our experiments. Section 6 concludes the study.

2. Literature review

Our study contributes and integrates three strands of literature. The first concerns the effect of medical liability pressure on physicians' behavior and, as a result, patients' health outcomes. The second relates to the financial incentives given by the different payment systems and the impact on physicians' behavior. Finally, our study integrates the growing literature that employs the experimental approach to study health-related behaviors. We briefly discuss these strands of literature in turn.

2.1 Medical liability and physicians' behavior

There is a widespread economic literature studying the effect of liability pressure on physicians' behavior. The basic premise is that physicians may practice defensive medicine, that is provide low-benefit (or not cost effective) diagnostic tests, procedures and treatments as liability shield against malpractice litigation. Danzon (2000) provides an extensive discussion on the economics of medical liability.

Several empirical contributions have studied the relationship between medical liability pressure and treatments selection. Extant literature focuses largely on obstetrics where physicians face significant liability pressure, finding mixed evidence on defensive medicine. In this respect, the conventional wisdom is that physicians choose cesarean sections (instead of natural deliveries) more frequently to reduce the risk of litigation, and this leads to higher costs for the healthcare system.

Dubay et al. (1999) use state liability law reforms as a source of variation in liability pressure to study the effect on the use of c-sections, concluding that physicians practice defensive medicine in obstetrics, especially for mothers of lower socioeconomic status. Esposto (2012) also finds a lower c-section rate in states in the US where tort reforms lowered the probability of medical malpractice suit. Conversely, Currie and MacLeod (2008) find that caps on non-economic damages increase the use of c-sections, although they reduce liability pressure. In a similar vein, Amaral-Garcia et al. (2015) find that an increase in medical malpractice pressure, given by an experience rated insurance system in Italian hospitals, is associated with a decrease in the use of c-sections. A reconciling stance is provided by Shurtz (2014). He studies the effect of a tort reform that lowered the providers' liability risk in Texas considering also the type of financial incentives at play and, consistent with the theoretical framework, he finds that the effect of malpractice law is the sum of offsetting responses associated with other financial incentives.

Heart disease is also a branch where physicians face significant liability pressure and, thus, may practice defensive medicine. Kessler and McClellan (1996) study the impact of tort reforms that limit liability on medical costs and outcomes for a population of elderly Medicare patients with serious cardiac illness, finding evidence of defensive medical practices. Using similar data on Medicare heart patients, Kessler and McClellan (2002) report that increases in malpractice pressure have more significant impact on diagnostic rather than therapeutic decisions. Avrahm and Schanzenbach (2015) find that caps on non-economic damage reduce treatment intensity of heart attack patients without affecting mortality rates.

Looking at a broader population of patients, Baicker et al. (2007) report that higher malpractice premiums are associated with higher Medicare expenditures especially for imaging services that are deemed to be driven by fear of malpractice, with no effect in aggregate mortality rates. Similarly, Fenn et al. (2007) find that UK hospitals facing higher expected liability costs use diagnostic imaging procedures more frequently. Finally, Studdert et al. (2005) survey directly physicians about the role of liability systems, reporting that 93% of responding physicians practiced defensive medicine. More comprehensive reviews of the literature on the effects of malpractice systems are provided by Kessler (2011) and Bertoli and Grembi (2018).

2.2 Payment systems and physicians' behavior

In their seminal study, Ellis and McGuire (1986) develop a theoretical model in which physicians choose the level of services to be provided to their patients and show that, when they act as imperfect agents, physicians' choice of care is strongly affected by payment systems, potentially leading to non-optimal service provision. Following this influential study, several papers have analyzed the effects of different payment systems on physicians' behavior under a variety of circumstances regarding asymmetric information and physicians' altruism (e.g., Ellis and McGuire, 1990; Chalkley and Malcomson, 1998; Choné and Ma, 2011; Makris and Siciliani, 2013). Among these, Allard et al. (2011) study the treating-referring trade-off for general practitioners under three common payment schemes, namely fee-for-service, capitation and fundholding. Overall, the main result from this theoretical literature is that under capitation physicians are expected to undertreat and refer their patients, while under fee-for-service they are expected to overtreat their patients.

Empirical findings, by and large, confirm this prediction. Gaynor and Gertler (1995) study medical group practices in the US and find that compensation arrangements with greater degrees of revenue sharing, such as capitation, significantly reduce physicians' effort. Sørensen and Grytten (2003) report that Norwegian primary care physicians with a fee-for-service contract produce a higher number of consultations and other medical services than physicians with a fixed salary. Similarly, Devlin and Sarma (2008) find that Canadian family physicians under fee-for-service conduct more patient visits relative to other types of payment schemes. More generally, there is a large literature showing that healthcare providers do respond to financial incentives (e.g., Gruber et al., 1999; Croxson et al., 2001; Cavalieri et al., 2014).

2.3 Experimental health economics

Surprisingly, health economic issues have been studied through the lens of experimental economics only in the recent years. In particular, a growing experimental literature has been devoted to investigating how different payment structures affect medical service provision.[1] In their pioneering work, Hennig-Schmidt et al. (2011) study the effects of FFS and CAP under controlled laboratory conditions and find that the levels of medical services provided under FFS are significantly higher than under CAP, though patients' health benefits prove to be important as well. In a similar experimental setting, Hennig-Schmidt and Wiesen (2014) and Brosig-Koch et al. (2016) show that medical students are more patient oriented than non-medical students in the provision of medical services. Lagarde and Blaauw (2017) design a new framed real-effort experiment to study the multitasking (i.e. quantity and quality) behavior in the provision of medical services, finding that the highest (lowest) quantity of services is provided under FFS (CAP), while the highest quality is achieved under salary. Finally, Brosig-Koch et al. (2017) investigate the effect of introducing a mixed payment system as an alternative to non-blended FFS and CAP and show that, consistent with the economic theory (e.g., Ellis and McGuire, 1986), under mixed payment system both under-provision and over-provision are reduced and, thus, patients' health benefit increased.

Some related papers investigate the effect of introducing pay-for-performance (P4P) schemes in a similar experimental setting. In a real effort experiment, Green (2014) finds that relying on extrinsic incentives through P4P to motivate physicians has a crowding out effect on their intrinsic motivations and, thus, is detrimental to the quality of care and costly for the healthcare industry. Cox et al. (2016) focus on the adoption of P4P to cost effectively reduce hospital readmission rates as recently

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[1] Although we focus on experimental studies looking at providers' payment systems, in the recent years a number of laboratory experiments have been carried out to analyze other health-related issues, such as health care finance model (Buckley et al., 2012) and the impact of professional norms (Kesternich et al., 2015).

introduced in the US, finding that the use of P4P schemes leads to cost effective reductions in readmission rates.

While we draw from the above-mentioned literature in the experimental design, none of these studies considers the medical liability. Therefore, to the best of our knowledge, our study is the first to analyze in an experimental setting the role of medical liability in affecting physicians' behavior under different payment systems.

3. Theoretical framework and behavioral predictions

In this section we lay out a simple theoretical model of physicians' behavior under the risk of being sued for medical malpractice liability, drawing from the seminal Ellis and McGuire (1986) model. Although our model does not aim to capture all aspects of physicians' behavior, it provides a theoretical framework to discuss the role of medical malpractice liability in affecting the physicians' choice of medical services and, thus, to interpret the subsequent experimental evidence. In particular, we first present a general framework where medical malpractice liability affects physicians' behavior regardless of their payment system. Then, we introduce explicitly physicians' payment systems to study how the incentive due to the risk of medical malpractice interacts with the different payment systems.

3.1 General framework

Let consider a physician interested in both the profit and the benefits to patients. For each patient, the physician chooses the quantity of medical services q to be provided. The physician's profit is given by $\pi(q) = R(q) - C(q)$, where revenue, $R(q)$, depends on the physicians' payment system, while total cost, $C(q)$, depends on the cost of providing medical services. Specifically, we assume that $R'(q) \geq 0$ and $R''(q) = 0$, which are consistent with the standard physicians' payment systems (i.e. CAP and FFS); furthermore, the cost of providing medical services is assumed to be increasing and convex, $C'(q) > 0$ and $C''(q) > 0$. On the other hand, the patient's benefit after treatment is given by $B(q) + \varepsilon$, which depends also on a zero mean random component, ε, due to the unavoidable uncertainty associated with the provision of medical care, and assumed to be independent from the amount of medical services, that is $E[\varepsilon|q] = E[\varepsilon] = 0$. Therefore, the patient's expected benefit from medical services is given by $B(q)$, assumed to be increasing and concave, $B'(q) > 0$ and $B''(q) < 0$. Specifically, we imagine (and we will design in the experiment) that the patient's benefit function follows an inverted u-shape, implying that the expected benefit reaches a maximum at some quantity, q^B, after which starts to fall (Ellis and McGuire, 1986; Brosig-Koch et al., 2017).

Therefore, without risk of being sued for medical malpractice, the physician's expected utility is equal to:

$$E[U(q)] = R(q) - C(q) + \alpha B(q) \tag{1}$$

where $\alpha \in [0, 1]$ measures the weight of the patients' benefit in the physician's utility function and, thus, it is usually interpreted as the degree of altruism. Under (1), the optimal quantity of medical services, q^*, is given by[2]:

$$R'(q^*) + \alpha B'(q^*) = C'(q^*) \tag{2}$$

However, in a context where physicians run the risk of being sued for medical malpractice liability, they may also consider the expected disutility of being sued and, as a consequence, ponder how their behavior affects this risk. In this respect, the most reasonable assumption to make is that the *ex-ante* probability of being sued for medical malpractice, $p(q)$, decreases with the amount of medical services provided, $p'(q) < 0$. The simple intuition of this assumption, which is also fully coherent with the idea of defensive medicine (Studdert et al., 2005; Baicker et al., 2007; Mello et al., 2010; Kessler, 2011), is that when physicians provide many medical services, this should increase the perception, and so support the argument in lawsuits, that a low health benefit suffered by the patient is not due to malpractice, but to the unavoidable uncertainty associated with the provision of medical care.

Therefore, with the risk of being sued for medical malpractice, the physician's expected utility becomes:

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[2] The second order condition for being q^* in (2) the optimal quantity of medical services (i.e. $[R''(q) + \alpha B''(q) - C''(q)]|_{q=q^*} < 0$) is guaranteed by the assumptions on the functional forms.

$$E[U(q)] = R(q) - C(q) + \alpha B(q) - p(q)H \quad (3)$$

where $H > 0$ is the medical malpractice disutility, such as the money and time involved in defending a lawsuit and the psychological costs of medical malpractice.[3] Then, the optimal quantity of medical services with the risk of being sued for medical malpractice, $q^{\#}$, is given by:

$$R'(q^{\#}) + \alpha B'(q^{\#}) - p'(q^{\#})H = C'(q^{\#}) \quad (4)$$

By comparing (2) and (4), we can make the following hypothesis to be tested in the experiment regarding the physician behavior[4]:

Behavioral Hypothesis 1. *Regardless of the payment system, the quantity of medical services provided by physicians is higher when the risk of being sued for medical malpractice is at play.*

3.2 Explicit physicians' payment systems

By and large, the two standard physicians' payment systems, which will also be the ones considered in the following experiment, are CAP and FFS. Under CAP system, physicians receive a lump sum payment, L, for each enrolled patient, irrespective of the quantity of medical services provided; thus, the revenue function in CAP is $R_{CAP} = L$. On the opposite, under FFS system, physicians receive a prospectively fixed fee, p, for each medical service provided to patients; thus, the revenue function in FFS is $R_{FFS} = pq$.

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[3] As suggested by Kessler (2011, p. 3), "… although doctors are largely insured against the financial costs of malpractice suits, the uninsured nonfinancial costs—such as lost time, stress, and damage to reputation —may be far more important".

[4] To see this, notice that under q^* we have that $R'(q^*) + \alpha B'(q^*) - C'(q^*)$ is equal to zero by the first order condition (2), while under $q^{\#}$ the first order condition (4) requires that $R'(q^{\#}) + \alpha B'(q^{\#}) - C'(q^{\#})$ is equal to $p'(q^{\#})H$, that is a strictly negative number. Since the second order condition guarantees that $[R''(q) + \alpha B''(q) - C''(q)]|_{q=q^*} < 0$, namely that a marginal increase in q reduces $R'(q) + \alpha B'(q) - C'(q)$, this unambiguously implies that $q^{\#} > q^*$. Moreover, it is straightforward to show (by the implicit function theorem) that $\frac{\partial q^{\#}}{\partial H} > 0$.

Before discussing how the risk of medical malpractice interacts with the different payment systems, let define the efficient quantity of medical services. Under the societal perspective, the efficient quantity of medical services is assumed to maximize the sum of the physician's profit and the patient's benefit net of the transfer to physicians (Chalkley and Malcomson, 1998; Ma and Mak, 2015).[5] Therefore, the efficient quantity of medical services, q^E, is given by:

$$B'(q^E) = C'(q^E) \tag{5}$$

Considering q^E as a benchmark, it is well-known (McGuire, 2000, 2011) that, without risk of being sued for medical malpractice, CAP embeds an incentive to under-provide medical services (i.e. $q^*_{CAP} < q^E$), as long as $\alpha < 1$:

$$\alpha B'(q^*_{CAP}) = C'(q^*_{CAP}) \tag{6}$$

On the other hand, as long as p is greater than (or equal to) the marginal cost, FFS can lead to over-provide medical services (i.e. $q^*_{FFS} > q^E$):

$$p + \alpha B'(q^*_{FFS}) = C'(q^*_{FFS}) \tag{7}$$

The role of malpractice liability, therefore, may be different between the two payment systems. Specifically, the incentive to increase the quantity of medical services to reduce malpractice concerns should be more stringent and welfare improving in CAP, where financial incentives lead to provide too little care; in FFS, instead, the payment system in itself embeds the incentive to provide much care, thus an additional increase in medical services could push further away from the efficient level of medical services.

Formally, the different role of malpractice concerns between CAP and FFS can be appreciated by looking at the optimal quantity of medical services, with the risk of being sued for medical malpractice, in the two payment systems:

$$\alpha B'\left(q^{\#}_{CAP}\right) - p'\left(q^{\#}_{CAP}\right)H = C'\left(q^{\#}_{CAP}\right) \tag{8}$$

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[5] For the sake of simplicity, we are deliberately overlooking the issue of the deadweight loss from raising taxes to pay healthcare providers, which is sometimes included in the social welfare function (Chalkley and Malcomson, 1998; Brekke et al., 2015).

$$p + \alpha B'(q^{\#}_{FFS}) - p'(q^{\#}_{FFS})H = C'(q^{\#}_{FFS}) \quad (9)$$

In both systems, not surprisingly, the optimal quantity of medical services is higher than without malpractice concerns.[6] However, given that in FFS physicians are already led to over-provide care (i.e. $q^{*}_{FFS} > q^{E}$), the marginal cost of a further increase in the quantity of medical services is especially high in FFS, due to the increasing marginal cost of providing medical services (i.e. $C''(q) > 0$) and, potentially, the marginal decrease in the patient's expected benefit (i.e. $B(q)$ follows an inverted u-shape). On the contrary, physicians in CAP tend to under-provide care (i.e. $q^{*}_{CAP} < q^{E}$), implying that the marginal cost of an increase in the quantity of medical services is lower than in FFS.

Therefore, we can make the following hypothesis to be tested in the experiment regarding the different effect of medical malpractice concerns between the two physicians' payment systems:

Behavioral Hypothesis 2a. *The increase in the quantity of medical services induced by the risk of being sued for medical malpractice is higher in CAP than in FFS.*

Behavioral Hypothesis 2b. *While the increase in CAP brings closer to the efficient level of medical services, the increase in FFS pushes further away from the efficient level of medical services.*

4. Experimental design

4.1 Basic setup

Our experimental design aims at testing the effects of medical liability pressure on the physicians' provision of medical services under different payment systems. In our experiment, each participant plays in the role of a physician who decides on the

[6] The formal proof follows exactly the same argument in footnote 4 for the general case.

quantity of medical services for their patients. All subjects play with two different payment systems, namely FFS and CAP, which determine the revenue. In the first two treatments, they face only the cost deriving from the amount of services provided. Then, they play again facing also the risk of being sued for medical malpractice. Thus, the 2x2 structure of the experiment leads to four treatments as shown in Table 1.

Table 1 about here

In all treatments, physicians decide on the quantity of medical services $q \in [0, 10]$ for six hypothetical patients, varying in the severity of illness $s \in \{x, y, z\}$ and in gender. Specifically, patients 1, 2, 3 are male whit low (x), medium (y) and high (z) severity, while patients 4, 5, 6 are female whit low (x), medium (y) and high (z) severity, respectively. The sequence of patients for which physicians choose the amount of services has been computed from a uniform distribution that remained the same within each treatment, but differed among treatments.[7] Moreover, patients are assumed to be passive and fully insured, accepting each level of medical services.

The amount of medical services q determines the physician's profit, $\pi(q)$, and the patient's expected health benefit, $B(q)$. The revenue, however, depends on the payment system at play. Formally, the physician's profit is given by:

$$\pi(q) = \begin{cases} pq - cq^2 & under\ FFS \\ L - cq^2 & under\ CAP \end{cases} \tag{10}$$

where p is the fee per service provided to a patient in a FFS, c is the parameter governing the marginal cost of providing medical services, and L is the lump-sum payment per patient in a CAP. Specifically, in our experiment $p = 2$, $c = 0.1$ and

[7] Details about the chosen probability distribution and the four sequences generated are available from the authors upon request.

$L = 10$. Figure 1 illustrates the pattern of physicians' profit as a function of medical services in the two payment systems. Notice that, however, as explained below in the case physicians get sued for medical malpractice, they lose entirely their profit.

Figure 1 about here

On the other hand, the different severity of illness $s \in \{x, y, z\}$ implies a different patient's health benefit function, $B^s(q)$. Though all patients share the same maximum health benefit, that is $B^s(q^*) = 10 \; \forall \; s$, the patient-optimal quantity of medical services, q^*, varies consistently with severities. In particular, $q^* = 3$ for low (x), $q^* = 5$ for medium (y), and $q^* = 7$ for high (z) severity. Formally, the patient's expected health benefit employed in the experiment is given by:

$$B^s(q) = \begin{cases} B_0^s + q & if\; q \leq q^* \\ B_1^s - q & if\; q \geq q^* \end{cases} \tag{11}$$

with $B_0^x = 7$, $B_0^y = 5$, $B_0^z = 3$, and $B_1^s = B_0^s + 2q^* \; \forall \; s$. Figure 2 shows the patterns of patients' expected health benefit as a function of medical services for the three levels of severity implemented in the experiment.

Figure 2 about here

It is important to note that, knowing the patient's health benefit function and the cost function, we can also analyze under-provision and over-provision of medical services relative to the efficient level under the societal perspective (Brosig-Koch et al., 2017). Specifically, it can be easily seen that in our experimental setup the efficient quantities of medical services, implicitly defined by $B'(q^E) = C'(q^E)$, are $q^E = 3$ for low (x), and $q^E = 5$ for medium (y) and high (z) severities.

Finally, the quantity of medical services q influences the *ex-ante* probability of being sued for medical malpractice, $p^s(q)$, which is also severity specific. In particular, though for all patients a higher amount of medical services reduces the probability of being sued, that is $p^{s\prime}(q) < 0 \; \forall \; s$, for each quantity the probability of being sued is higher for more severe patients, that is $p^x(q) < p^y(q) < p^z(q) \; \forall \; q$. Formally, the *ex-ante* probability of being sued for medical malpractice employed in the experiment is given by:

$$p^s(q) = \lambda^s \left(1 - \frac{q}{10}\right) \tag{12}$$

with $\lambda^x = 0.3$, $\lambda^y = 0.4$, and $\lambda^z = 0.5$. The *ex-ante* probability function (12) is illustrated in Figure 3 for the three levels of severity.

Figure 3 about here

While the *ex-ante* probability of being sued (12) is deterministic and, thus, physicians in the experiment know how they can influence it through their behavior, the *ex-post* event "being sued"/"not being sued" is still a random variable, X, and it is known only after their choices on the quantity of medical services. Specifically, in the experiment the event $[1, 0]$, where 1 is "being sued" and 0 is "not being sued", is drawn (by the software Z-Tree) after each physician's choice from a Bernoulli distribution with parameter $p = Pr(X = 1)$ equal to (12), and then it is displayed in the screen of each participant (i.e. "You have been sued"/"You have not been sued") so as to make them aware of the *ex-post* event "being sued"/"not being sued". In the case physicians are sued, then they suffer the disutility of getting a malpractice lawsuit that in the experiment, as mentioned above, it is paid in the form of the lost of their own profit and, thus, their monetary payment.

The complete set of parameter values employed in the experiment are shown in Table 2. Overall, all parameters of the experiment, as well as the values of physicians' profit and patients' health benefit are common knowledge. The only unknown information concerns the random event "being sued"/"not being sued", even if participants know they can influence the probability of being sued through their behavior.

Table 2 about here

4.2 Experimental protocol

Before starting the experiment, we provided an assessment of individual's attitude towards risk. In fact, subjects' choices under liability condition may be affected by their risk attitudes. For this reason, as first task of the experiment, we asked participants to complete a brief questionnaire to evaluate the level of risk attitude as suggested by Holt and Laury (2002). The questionnaire has been based on ten choices between paired lotteries A and B. Given the payoffs structure and the probabilities assigned to the different payoffs, it has been possible to evaluate individual's risk attitude by the number of times each player chooses lottery A before switching to B. Doing so, we have been able to verify if the distribution of risk loving/neutral/averse subjects was common to other experiments. Nevertheless, we acknowledge that the Holt and Laury (2002) procedure may lead to inconsistent risk preferences when subjects switch back from lottery B (risky choice) to lottery A (safe choice) more than once. At the same time, authors report that the number of players switching back and forth between lotteries has been low and that, in most of the cases, a clear-cutting point between clusters of A and B choices existed, making it possible to assess the attitude towards risk of the majority of subjects. The results of the questionnaire we have implemented showed that the level of risk aversion of participants to the experiment was high, similar to the results obtained by Holt and Laury (2002). Almost two-thirds of subjects chose more than the four safe choices predicted by risk neutrality and only 15% of subjects showed inconsistent risk preferences. Therefore, most of the subjects can be classified as risk averse according with economic wisdom.

After risk assessment, subjects received the instructions regarding the first treatment (T1) and the corresponding table describing the profits accruing to each physician, the cost, and the benefits accruing to the patient, according to each possible levels of medical services under the FFS payment system. Before starting the treatment, they had to solve some numerical exercise in order to be sure that participants had fully understood the way profits and benefits were computed. Once we have checked and eventually corrected all the answers, the treatment started. Each participant has to decide on the level of medical services to provide to the first patient knowing his/her severity of illness and gender. Once each physician has faced all the six patients, the experiment moves to the second treatment (T2) that has been run in the same way as T1, but under the CAP payment system.

Then, subjects started the third treatment (T3) under FFS and medical liability condition, as shown in the instructions and table handed out to them.[8] In particular, we checked through the solution of numerical examples that it was clear to all participants that the probability of being sued for medical malpractice was inversely related to the quantity of medical services, and that it was also increasing in the severity of the patient under cure, so as shown in Figure 3. On the other hand, we also checked that all participants were aware that the random event “being sued” implied the lost of their own profit and, as a result, their monetary payment at the end of the experiment.

Finally, the last treatment (T4) has been conducted under CAP and medical liability condition. Upon the completion of the fourth treatment, the experiment ended. Overall, each physician has taken 24 medical decisions (six patients in four treatments) differing in terms of payment system and medical liability condition.

A total of one hundred and six students with different backgrounds (economics, law, political science, and medicine) joined our experiment. In particular, twenty-five per cent of the sample has been formed by medical doctors or students of medicine. We conducted fourteen sessions that lasted, on average, for about one hour. In order to test for sequence effects, in half of the sessions the order of the treatments is reversed. The Mann-Whitney U test cannot reject the hypothesis of no sequence effects (p=0.75). Moreover, following the relevant experimental literature, we used an in-context wording clearly referring to health payment

[8] The instructions of T3 together with the related tables handed out to participants can be found in the Appendix.

systems, physicians, medical prescription and medical liability for the experimental instructions to increase the external validity of the experiment.

At the end of the experiment, we randomly chose one decision in each treatment of the experiment to be relevant for a subject's actual payoff and the corresponding patient's benefit. This procedure rules out income effects. Before paying subjects in private according to the randomly determined decisions, they have been asked to fill in a questionnaire on social demographics, such as age, gender, and household income. Whereas all participants played in the role of physicians on service provision for hypothetical patients, real patients' health outside the lab has been affected by their choices. In fact, participants read on the instructions that the monetary equivalent of the patients' health benefit resulting from their decisions will be transferred to *Famiglie SMA* (http://www.famigliesma.org/campagna-raccolta-fondi-sms-solidale/), a charity caring for children affected by spinal muscle atrophy (SMA). For this purpose, we applied a procedure similar to Brosig-Koch et al. (2016), Hennig-Schmidt et al. (2011), and Eckel and Grossman (1996). In particular, one of the participants was randomly chosen to be a monitor. After the experiment, the monitor verified that one of the experimenters entered the *Famiglie SMA* website and transferred the aggregate benefits trough credit card payment.

The experimental currency earned in the randomly chosen decision period of the game were converted into Euros at the exchange rate of 1 experimental crown (EC) = EUR 0.45 at the end of the experiment. Average reward for participation, net of the attendance fee, was EUR 15.00. In total, EUR 396.00 was transferred to the *Famiglie SMA.*

5. Results

In this section we analyze behavioral data resulting from our experiment by employing non-parametric testing. The aim of the following analysis is to test whether introducing medical liability pressure affects significantly the provision of medical services, in accordance to our behavioral predictions.

Table 3 shows the average levels of medical services according to payment systems, the introduction of medical malpractice liability, and the patients' severity of illness. The overall level of prescription is 5.42, which is basically the median value of physician’s choice set. Also, it can be seen that under CAP (T2) the level of prescriptions is just above the one maximizing the benefit of the low severity patients, whereas under the FFS (T1) the average value is just above the one maximizing the benefit of the medium severity patients. Differently, when the medical liability condition is at play, the average level of prescriptions under the CAP (T4) gets slightly higher than the one maximizing the benefit of medium severity patients. Finally, in the FFS case (T3), the average level of medical prescriptions chosen by physicians equals the one maximizing the benefit of high severity patients. If we consider the average prescriptions by the degree of severity of illness the results are slightly different. Whereas in both low and medium severity cases the average prescriptions is above the equilibrium values ($q_L = 4.68$ and $q_M = 5.42$, respectively), the level achieved in the case of high severity of illness remains below the equilibrium value ($q_H = 6.16$).

Table 3 about here

Looking at the payment systems adopted in the different treatments, as explained in the previous sections, we can compare the prescription levels reached under CAP and FFS systems both in the presence or not of medical liability condition. As suggested by the theoretical results, the prescription levels achieved under the FFS are significantly higher than those reached under CAP (T1 vs. T2, Wilcoxon test p = 0.001). Also when comparing the two payment systems under liability condition the Wilcoxon test provides the same result (i.e. T3 vs. T4, p = 0.001). In fact, medical prescription levels under both FFS and medical liability condition are almost always higher than those achieved under CAP and medical liability condition. The pattern of average levels of medical prescription across the periods (or patient types) is illustrated in Figure 4. The line is divided into four sections one for each treatment in order to make it easy to compare the different trends.

Figure 4 about here

To test our first behavioral hypothesis, we compare the choices made by physicians in treatments T3 vs. T1 and T4 vs. T2. In other words, we check whether the prescription levels reached under medical liability condition are always higher than those achieved without medical liability condition, regardless of the adopted payment system. In both cases, the Wilcoxon test confirms our first hypothesis ($p_{T3vsT1} = p_{T4vsT2} = 0.001$). Figure 4 shows the change in the trend of average levels of medical prescriptions when medical liability condition is implemented. It appears clear that from period 12 onwards there is a steep increase in the prescriptions due to the role of liability in shaping physicians choices. Hence, we can state that the introduction of medical liability, regardless of the payment system in use, causes a significant increase in the level of medical prescriptions chosen by physicians.

A second relevant result pertains the change in physicians' behavior when the medical liability condition is implemented under different payment systems. As shown in Section 3.2, given the different incentives embedded into the payment systems, we expect a higher increase in the provision of medical care under the CAP than under the FFS when the physician runs the risk of being sued. Surprisingly, the increase reported above in the average levels of medical prescription when moving from T4 to T2 is not statistically different from the one achieved when moving from T3 to T2. The signtest run on the difference D_CAP (T4-T2) and D_FFS (T3-T1) has shown a p_value = 0.95. In other words, the introduction of medical liability condition has led, on average, to an equivalent increase of prescriptions under both payment systems. Looking at the difference between medical and non-medical students, however, we find that the increase in the levels of medical services provided by medical students due to the introduction of medical liability is significantly higher ($p = 0.07$) under the CAP than under the FFS, consistently with our behavioral hypothesis 2a.

More generally, like in Brosig-Koch et al. (2016) we investigate whether the different samples taking part into our experiment (medical students vs. non-medical students) react differently to the incentives coming from different payment systems and from the introduction of medical liability. In particular, we find that under FFS with medical liability, the level of medical services provided by medical students are significantly higher than those of the other participants ($p = 0.001$). This result might be due to fact that subjects with a medical background are potentially more sensitive than non-medical subjects about the risk of being sued for medical malpractice.

Then, we compare the different levels of medical services provided by physicians according to the different severity of illness they faced. The average values per treatment are shown in Table 3. Pooling the data by treatment, the Wilcoxon test shows that the only statistically significant difference can be found under treatment T3 ($p_{\text{high vs. low}} = 0.001$, $p_{\text{high vs. medium}} = 0.001$). In details, we find mild evidence that physicians significantly increase the level of medical services consistently with their patients' needs.

Finally, we investigate whether the different payment systems combined with the introduction of medical liability led to welfare-improving levels of medical prescriptions. Given that the different levels of severity of illness affecting the hypothetical patients imply three patient's welfare maximizing quantities, we compare the effects of medical liability keeping constant the level of severity. Looking at the prescription levels under the CAP, they are significantly well below the welfare optimal ones regardless of the severity of illness at play ($p_{CAP1} = p_{CAP2} = p_{CAP3} = 0.001$). When medical liability gets introduced, the levels of prescription reached in the low and medium severity cases are significantly above the welfare maximizing ones ($p_{CAP\_ML\_1} = 0.001$; $p_{CAP\_ML\_2} = 0.004$). Differently, when physicians face hypothetical patients with highest level of severity of illness they, nonetheless, significantly under-provide medical care under CAP ($p_{CAP3} = 0.001$).

If we look at what happens when the FFS is implemented, the picture is somehow different. Without medical liability condition, the levels of medical prescriptions are significantly higher than the optimal ones when the severity of illness is low or medium ($p_{FFS1} = p_{FFS2} = 0.001$), providing evidence of over-provision. However, when the severity increases the level of medical prescriptions is not statistically different from the welfare maximizing choice ($p_{FFS3} = 0.8$). Finally, adopting the medical liability mechanism, in this case, causes that the average levels of medical care provided by physicians are higher than the welfare optimal ones, regardless of the severity of illness ($p_{FFS\_ML\_1} = p_{FFS\_ML\_2} = p_{FFS\_ML\_3} = 0.001$).

Therefore, we find overall evidence of our behavioral hypothesis 2b. While under the CAP without medical liability under-provision is the norm, when medical liability is at play the increase in medical prescriptions induced by the fear of litigation brings closer to the welfare maximizing levels. On the other hand, under the FFS without medical liability, it appears that over-provision of medical care takes place (with only the exception of high severity patients), thus the increase in medical services induced by medical liability has the effect of exacerbating over-provision and, thus, pushes further away from the efficient level of medical services.

6. Conclusions

This paper studied in a controlled laboratory setting the effect of medical malpractice liability on physicians' provision of medical services, looking also at the interplay between malpractice pressure and physicians' payment systems. In our experiment, we implemented *ceteris paribus* variations in the presence of medical malpractice liability, in order to exploit the within-subject variation among treatments to infer the causal effect of malpractice liability on physicians' behavior. Given the difficulty to infer the causal effect of malpractice pressure from empirical works, it is indeed important to complement the empirical research with the experimental evidence.

The within-subject variation among treatments shows that, when malpractice liability pressure is at play, physicians increase the provision of medical services for their patients, regardless of the patients' severity and the physicians' payment system. This result holds for both medical and non-medical students, though subjects with a medical background appear to be more sensitive to malpractice liability pressure, someway consistently with the previous experimental evidence reporting behavioral differences between medical and non-medical students (Hennig-Schmidt and Wiesen, 2014; Brosig-Koch et al., 2016). We also find that, regardless of medical liability pressure, physicians' decisions on the amount of medical services are also influenced by the patients' severity, with more severe patients receiving more services consistently with their higher needs (Brosig-Koch et al., 2017).

On the other hand, our analysis highlights that considering the interplay between malpractice pressure and physicians' payment systems is important to draw conclusions under the societal perspective. Specifically, we find that, as FFS in itself embeds the incentive to provide much care, medical liability pressure has the effect of exacerbating over-provision and, thus, pushes further away from the efficient level of medical services; on the contrary, as physicians in CAP are incentivized to under-treat patients, the increase in medical services induced by the fear of litigation brings closer to the efficient level of medical services.

Since the within-subject variation in our experiment is due to the *ceteris paribus* introduction of the risk of being sued for medical malpractice, we interpret the increase in medical services as the causal effect of malpractice pressure on physicians' behavior. Therefore, our experimental evidence complements and integrates the previous empirical evidence on the extensive use of defensive medical practices (e.g., Kessler and McClellan, 1996; Studdert et al., 2005; Baicker et al., 2007; Fenn et al., 2007; Mello et al., 2010; Avraham and Schanzenbach, 2015).

The findings of this paper are also relevant from the policy perspective. First, our results strengthen the common perception that medical liability system affects physicians' behavior and induces defensive medical practices, by providing evidence in an experimental setting where it is easier to identify the causal effect on subjects' behavior through real *ceteris paribus* variation. While our experimental approach might raise concerns about the external generalizability of our results and, as such, it is complement to other empirical methods (Harrison and List, 2004; Levitt and List, 2009), the experimental evidence is especially important in any empirical research question where identifying causal effect is a difficult task (Hennig-Schmidt et al., 2011; Brosig-Koch et al., 2016). On the other hand, our paper highlights the important role of the interplay between medical liability system and other financial incentives provided by physicians' payment systems to draw policy conclusions. Specifically, our results suggest that, while in healthcare systems where physicians are paid by FFS tort reforms mitigating liability might reduce health expenditure without affecting patients' health outcomes, in healthcare systems where physicians are paid by CAP mitigating liability might make things worse.

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FIGURES

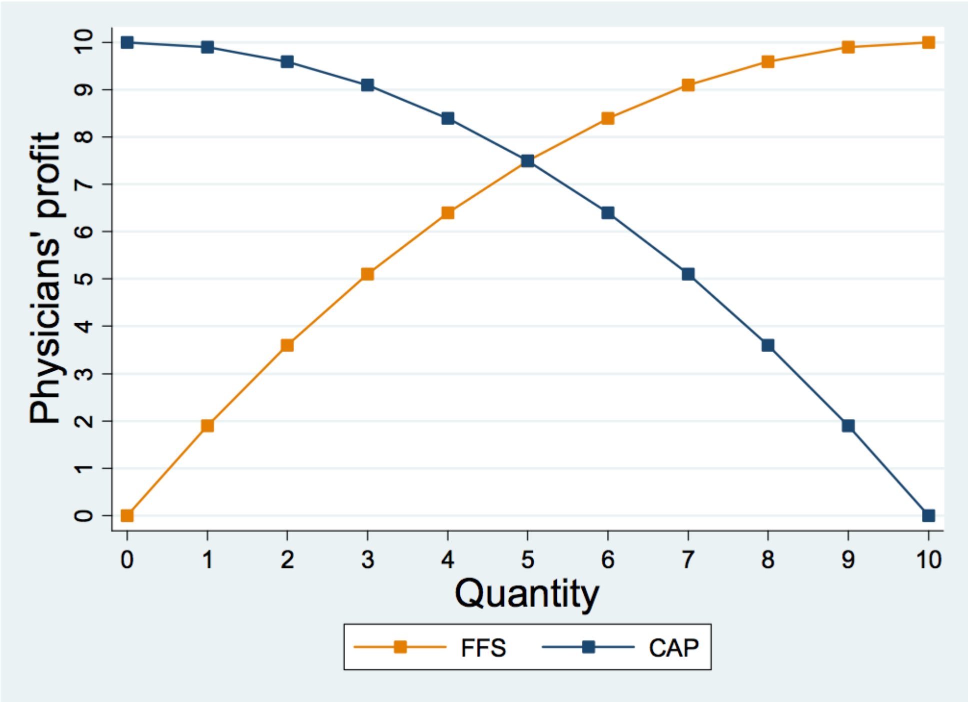

Figure 1. Physicians' profit by payment system

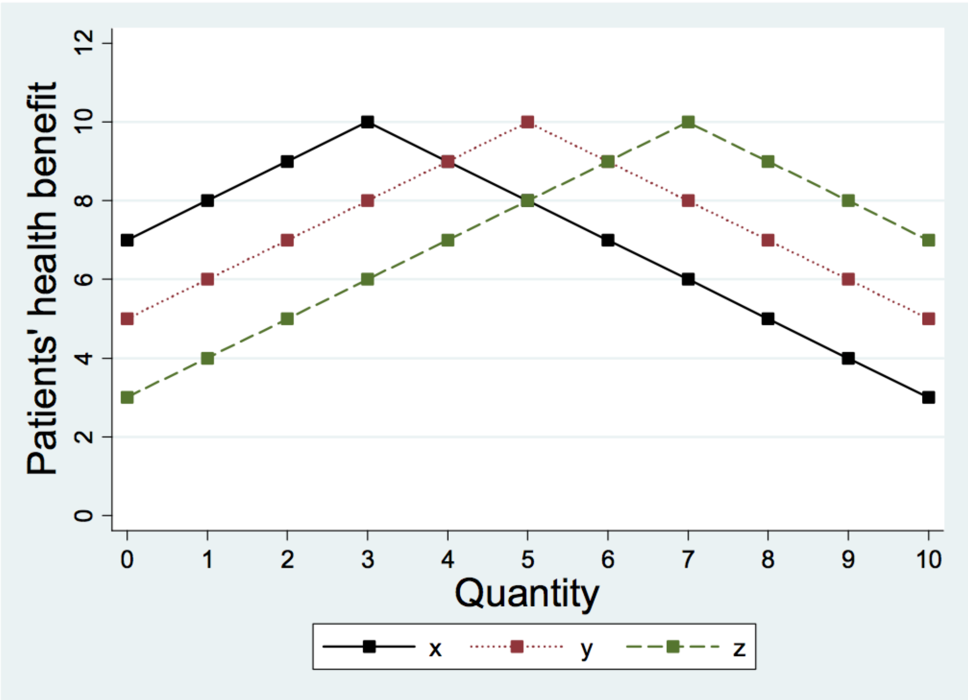

Figure 2. Patients' health benefit by severity of illness

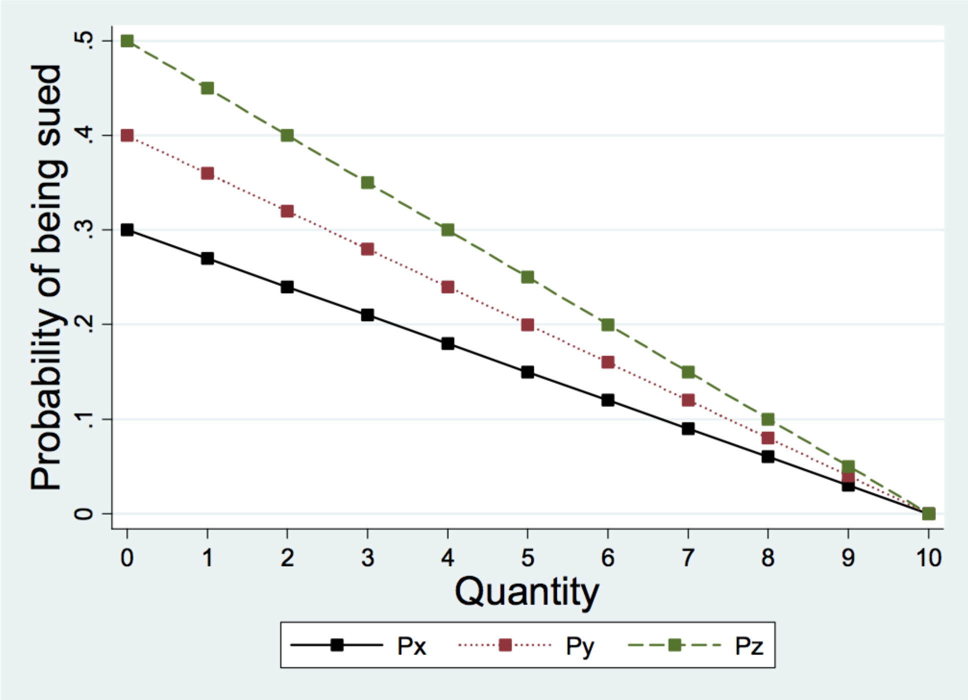

Figure 3. Probability of being sued by severity of illness

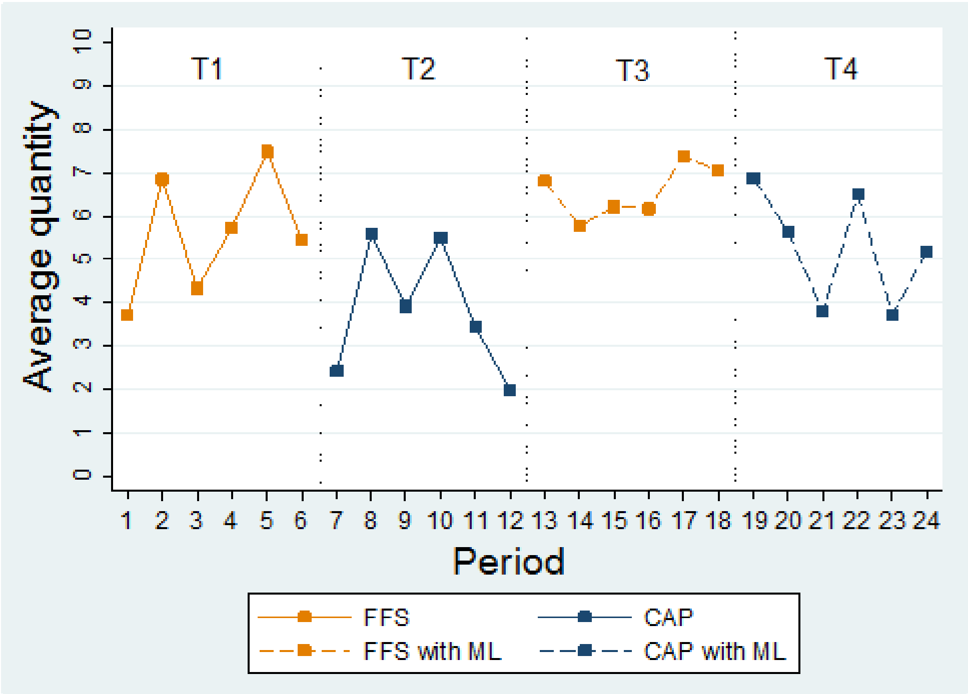

Figure 4. Average quantity of medical services across treatments

TABLES

Table 1. Experimental design

	Treatment			
	T1	T2	T3	T4
Payment Scheme	FFS	CAP	FFS	CAP
Medical Liability	No	No	Yes	Yes

FFS: fee-for-service; CAP: capitation.

Table 2. Parameter values employed in the experiment

		Quantity q										
Treatment	Variable	0	1	2	3	4	5	6	7	8	9	10
1 and 3	R^{FFS}	0	2	4	6	8	10	12	14	16	18	20
2 and 4	R^{CAP}	10	10	10	10	10	10	10	10	10	10	10
all	C	0	0.1	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10
1 and 3	π^{FFS}	0	1.9	3.6	5.1	6.4	7.5	8.4	9.1	9.6	9.9	10
2 and 4	π^{CAP}	10	9.9	9.6	9.1	8.4	7.5	6.4	5.1	3.6	1.9	0
3 and 4	$P\ of\ sued_x$	30%	27%	24%	21%	18%	15%	12%	9%	6%	3%	0%
	$P\ of\ sued_y$	40%	36%	32%	28%	24%	20%	16%	12%	8%	4%	0%
	$P\ of\ sued_z$	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
3 and 4	π *if sued*	0	0	0	0	0	0	0	0	0	0	0
all	B_x	7	8	9	10	9	8	7	6	5	4	3
	B_y	5	6	7	8	9	10	9	8	7	6	5
	B_z	3	4	5	6	7	8	9	10	9	8	7

R: revenue; *C*: total cost; π: profit; *P of sued*: probability of being sued; *B*: patients' health benefit.

Table 3. Average quantities by treatment and severity

	Quantity q				
	Without Medical Liability		With Medical Liability		
Severity	FFS	CAP	FFS	CAP	Average
x	4.32	2.61	6.75	5.04	4.68
y	5.77	3.83	6.78	5.28	5.41
z	6.76	4.96	7.5	5.44	6.16
Average	5.62	3.80	7.01	5.25	5.42

FFS: fee-for-service; CAP: capitation.

Appendix: Instructions (Treatment 3 of the experiment)

Welcome to our laboratory

You are going to join an experiment on individual decision-making. Instructions are straightforward and, if you pay close attention, you may gain a monetary amount that will be paid to you in cash at the end of the experiment. The amount of cash you may win depends only on your decisions and will not be affected by the decisions taken by other participants in the lab. Your monetary gains, measured in Experimental Crown (EC), will be converted into Euro at the following exchange rate 1 EC = 0.45 Euro. For instance, it means that if, at the end of the experiment, you achieve 40 EC, you will receive 18 Euro.

Experimental Design

The experiment lasts approximately 60 minutes and is divided into four stages. You are going to receive detailed instructions at the beginning of each stage. Please, remind that the decisions taken in one stage of the experiment bear not effect on the decisions that you will have to take in the following stages of the experiment.

Stage III

Please, read carefully the following instructions regarding stage III. If anything in the instructions is not clear please raise your hand and one of the experimenters will approach you. From this moment onward, you cannot communicate with any other participant. If you fail to do so, you will be asked to leave the laboratory.

Stage III lasts for six periods. In each period, you will play in the role of a physician and you will have to decide how many medical prescriptions to provide to patients.

In other words, you have to decide on the level of medical care (in terms of drugs, diagnostic exams, …) to provide to patients according to his/her severity of illness. Patients can be classified according to three levels of severity of illness (low, medium, high) and to gender (male, female). Thus, you will face six patients. When taking the decision on patient's medical care, you can choose among 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 prescriptions per patient.

In this stage of the experiment, after the decision on the level of medical prescriptions to provide, the patient could sue you for medical malpractice with probability *p*, which depends on the level of medical prescriptions already provided. The relationship between provided prescriptions and the probability of being sued is shown in the table that you can see on the pc screen before taking your decision on the level of medical prescriptions.

Earnings

In each period of stage III, you will be paid according to the FFS payment system. Your earnings increase together with the number of medical prescriptions that you provide to patients. Moreover, you bear a cost due to the level of effort devoted to visiting each patient that depends on how many medical prescriptions you provide to patients. If you get sued by a patient, you will incur a fixed monetary loss equal to the profits earned in the same period you are sued. Hence, your profit in each period is computed as the payment you receive from the FFS system minus the cost due to the provision of medical services minus, if sued, the monetary loss due to being sued by the patient.

Each level of medical prescription provided accrues a certain level of benefit to patient according to her/his severity of illness. Therefore, your choice on the quantity of medical prescriptions to provide determines both your profits and the patients' benefits.

In each period, you will see on the screen (see below) all the information regarding the patient you currently face: the severity of illness, your earning according to the payment system in use, the related costs, the probability of being sued for each possible level of medical prescriptions, the monetary loss due to being sued, your profits and the corresponding patient's benefits.

Patient with illness x

Quantity of medical treatment	Your fee-for-service payment (in EC)	Your costs (in EC)	Your profit (in EC)	Expected benefit of the Patient (in EC)	Probability of being sued for medical malpractice	Your profit in case of being sued for MM
0	0	0	0	7	30%	0
1	2	0.1	1.9	8	27%	0
2	4	0.4	3.6	9	24%	0
3	6	0.9	5.1	10	21%	0
4	8	1.6	6.4	9	18%	0
5	10	2.5	7.5	8	15%	0
6	12	3.6	8.4	7	12%	0
7	14	4.9	9.1	6	9%	0
8	16	6.4	9.6	5	6%	0
9	18	8.1	9.9	4	3%	0
10	20	10	10	3	0%	0

Patient with illness y

Quantity of medical treatment	Your fee-for-service payment (in EC)	Your costs (in EC)	Your profit (in EC)	Expected benefit of the Patient (in EC)	Probability of being sued for medical malpractice	Your profit in case of being sued for MM
0	0	0	0	5	40%	0
1	2	0.1	1.9	6	36%	0
2	4	0.4	3.6	7	32%	0
3	6	0.9	5.1	8	28%	0
4	8	1.6	6.4	9	24%	0
5	10	2.5	7.5	10	20%	0
6	12	3.6	8.4	9	16%	0
7	14	4.9	9.1	8	12%	0
8	16	6.4	9.6	7	8%	0
9	18	8.1	9.9	6	4%	0
10	20	10	10	5	0%	0

Patient with illness z

Quantity of medical treatment	Your fee-for-service payment (in EC)	Your costs (in EC)	Your profit (in EC)	Expected benefit of the Patient (in EC)	Probability of being sued for medical malpractice	Your profit in case of being sued for MM
0	0	0	0	3	50%	0
1	2	0.1	1.9	4	45%	0
2	4	0.4	3.6	5	40%	0
3	6	0.9	5.1	6	35%	0
4	8	1.6	6.4	7	30%	0
5	10	2.5	7.5	8	25%	0
6	12	3.6	8.4	9	20%	0
7	14	4.9	9.1	10	15%	0
8	16	6.4	9.6	9	10%	0
9	18	8.1	9.9	8	5%	0
10	20	10	10	7	0%	0

Payment

At the end of the experiment, one of the six periods of stage III will be randomly drawn. The profit achieved in that period will be paid to you in cash. While you in this stage have decided in the role of physician on service provision for hypothetical patients, real patients' health outside the lab is affected by your choices. The overall benefits accruing to patients will be converted into Euro and donated to the charity *Famiglie SMA* (http://www.famigliesma.org/campagna-raccolta-fondi-sms-solidale/). To verify that the monetary amount corresponding to the sum of the patients' benefits in a session is actually transferred, one of the subjects will be randomly chosen to be a monitor. After the experiment, the monitor will verify that one of the experimenters will actually transfer the monetary amount through credit card payment on the *Famiglie SMA* website. The money will support the charity caring for children affected by spinal muscle atrophy in Italy.

Questionnaire

Before starting the experiment, we kindly ask you to answer some simple questions aiming at checking your comprehension of the design of stage III and of the profit generation mechanism.

If you have any question regarding the questionnaire, please raise your hand and one of the experimenters will come to your seat. Stage III will start only when all the participants answer to all questions correctly.