# Does medical malpractice liability matter for calibration of mixed payment systems?

Massimo Finocchiaro Castro[a,c,d], Paolo Ferrara[b,c], Calogero Guccio[b,c,d,] and Domenico Lisi[b,c]

[a]*Department of Law and Economics, Mediterranean University of Reggio Calabria (Italy)*

[b]*Department of Economics and Business, University of Catania (Italy)*

[c]*Health Econometrics and Data Group, University of York (UK)*

[d]*Institute for Corruption Studies at the Illinois State University (USA)*

## Abstract

Both the use of mixed payment systems and the liability for medical malpractice are hot topics in the recent discussions about the way to decrease health expenditure without decreasing the quality and somehow the quantity of services provided by physicians. Nonetheless, while mixed payment systems remain at margins of the main countries' healthcare systems, medical liability has been even accused of increasing health expenditure and induce the practice of defensive medicine. Our paper tries to find some experimental evidence on the role of these two "main characters" in the "scene" of the healthcare providers, showing their positive effects on the optimal quantity of services offered to the patients.

**JEL Classification:** I12; K13; C91.

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

## 1. Introduction

This paper helps to understand how physicians' payment system affects their behaviour and how the effect of the presence of medical liability could be mitigated by a balanced mixed fee-for-service/capitation payment system.

We build on the seminal model of Ellis and McGuire (1986) which shows that mixed payment systems can be designed such that the optimal level of health care services is induced. The authors develop a theoretical model in which physicians choose the level of services to be provided to their patients and show that 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' behaviour 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).

Also, several empirical studies have estimated the effect of malpractice liability pressure on physicians' behaviour 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 the existing 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 order to better identify the causal effect, the use of a controlled environment such as a laboratory where to run experiments represents a promising tool. To the best of our knowledge, the only experimental study investigating the effect of introducing a mixed payment system as an alternative to non-blended FFS and CAP is Brosig-Koch et al. (2017). They show that, consistently with theoretical predictions (e.g., Ellis and McGuire, 1986), under mixed payment system both under-provision and over-provision are mitigated and, thus, patients' health benefit increased.

Looking at the potential effect of medical liability, Finocchiaro Castro et al. (2018) is the first work to analyse in an experimental setting how medical liability affects physicians' behaviour under different pure payment systems, FFS and CAP. They find that, 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. Then, they also show that the increase in the quantity of medical services induced by the risk of being sued for medical malpractice is welfare-improving in CAP as it counterbalances the CAP induced under-provision, while it decreases welfare in FFS as it exacerbates the FFS induced over-provision.

This paper is the first to study, in a controlled laboratory setting, the relation between a mixed payment system and the risk of being sued for medical malpractice as a factor affecting the provision of physicians' medical services. Specifically, in our paper the mixed payment system is "optimally" calibrated in order to induce subjects to choose the optimal quantity of medical services. Therefore, in this context, we are able to test the optimal calibration given to the mixed payment system with and without the presence of malpractice liability pressure, in order to check if medical liability influences the effectiveness of an optimal calibrated mixed payment system. Looking at the policy implication of our experimental exercise, this allows us to infer whether the implementation of a mixed payment system should take into account the malpractice liability pressure at play in the specific context.

In our experiment, medical and non-medical students play in the role of a physician deciding the quantities of services to give to heterogeneous patient, in different scenarios. The aim of the research is to infer the causal effect of malpractice liability on physicians' behaviour. Moreover, we control the interaction between malpractice liability and "optimally calibrated" mixed payment system.

Our behavioural 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.

The rest of the paper is organized as follows. Section 2 reports a quite precise literature review. In Section 3, we describe experimental design and the "inside the lab" procedures. Section 4 presents our behavioural predictions. In Section 5, we discuss the results of the experiments and in Section 6 we give some concluding remarks.

## 2. Literature background

Our study contributes and integrates the literature already existing showing how medical liability influence physicians' behaviour both in non-blended and in mixed payment systems and reporting that a balanced FFS-CAP payment system could avoid inadequate medical treatment, decrease useless medical expenditure and increase the patients' benefit.

In the literature, various studies have shown that medical responsibility influences the behaviour of doctors regardless of payment systems, pure or mixed, used. In this sense, Danzon (2000) highlights the relationship between the pressure exerted by doctors' responsibility and the selection of treatments. The existing literature has focused

mainly on the branch of obstetrics, one in which doctors face a rather high pressure of responsibility. In this field, studies have generally found that to reduce the risk of litigation, doctors more frequently choose cesarean sections instead of natural parts (applying the so-called defensive medicine), with consequent higher costs for the health system.

Dubay et al. (1999) conducted a survey on reforms of the Public Liability Act to highlight how an increase in the pressure of responsibility on doctors determines a growth of the practice of defensive medicine in obstetrics, especially for mothers who have a low socioeconomic status. Esposto (2012) also arrives at similar conclusions; he finds that in the United States, where the reforms for illicit had reduced the probability of cases of medical negligence, the incidence of caesareans was lower than that of the other states. Finally, Amaral-Garcia et al. (2015) found that in Italian hospitals the introduction of an insurance system that covers the risks of possible litigation is associated with a decrease in the use of caesarean sections.

Another branch in which doctors are subject to significant responsibility is that of heart disease. In this field, Kessler and McClellan (2002) find that the increase in responsibility pressure due to negligence has a more significant impact on diagnostic rather than therapeutic decisions. All this is confirmed by Fenn et al. (2007) who find that hospitals in the UK facing higher liability costs are using imaging procedures more frequently. Also, Baicker et al. (2007), analysing a large patient population, identifies diagnostic imaging procedures believed to be driven by fear of negligence, with no effect on aggregate mortality rates. Avrahm and Schanzenbach (2015) found that the introduction of non-economic damage limits reduce the treatment intensity of patients with heart attack without affecting mortality rates. Finally, Studdert et al. (2005)

investigated physicians directly on the role that systems of responsibility have in their service choices to be offered and noted that 93% of the interviewed doctors practised defensive medicine.

More complete revisions of the literature on the effects of negligence systems are provided by Kessler (2011) and Bertoli and Grembi (2018). The last one, in particular, presents a detailed review of the existing literature on the relationship between liability and medical treatment selection. They highlight the main empirical evidence in the existing literature and their main critical points, offering guidelines for future research.

Some have argued that defensive medicine is the main driver of excessive health care spending in the United States. Frakes and Gruber (2018) have conducted a survey on the behaviour of doctors working in a system that exempts them from the risks of negligence. The structure examined is that of the Military Health System (MHS), a $ 50 billion program that provides insurance for all active military servants and their employees. The latter can decide whether to seek assistance in military treatment facilities (MTF) or to contact outside the MTFs, obtaining the reimbursement of the costs incurred, through a contract with a service plan managed by a private sector. The object of study is interesting as active-duty patients seeking care from military facilities cannot report the damage that comes from negligent care. The authors, drawing data from the Military Health System Data Repository (MDR), which is the main database of medical records managed by the military health system, found that immunity from responsibility reduces hospital spending by 5% without measurable negative effects on the patient's results. As a result, targeted reforms, such as those of the Military Health System (MHS), could have real effects on the costs of the health system without major effects on the quality of services offered to patients.

Other scholars have grasped the relationship between the level of services offered and the payment systems used to remunerate health services. Among these, Ellis and McGuire (1986) have developed a theoretical model in which physicians choose the level of services to be provided to their patients and have shown that, when they act as imperfect agents, the choice of medical care is strongly influenced by the systems of payment that could potentially lead to non-optimal services. In fact, the results of their work show that if doctors favour the profits of the hospital with respect to the benefits for the patient, a potential payment system, in which the payment depends on the group related to the diagnosis (DRG) in which the patient falls, can lead to a number of services provided lower than optimal. On the other hand, with a cost-based payment system, the services provided by doctors tend to be too high. They have developed a model that evaluates various types of mixed payment systems. The experimental investigation of these payment systems, in which physicians are partially paid in perspective and partly on costs, has led to the conclusion that they can mitigate excessive performance and increase the patient's health benefits.

Following the influential study by Ellis and McGuire (1986), the effect of changes in the health care payment system on the behaviour of physicians has been studied under different perspectives, in a variety of circumstances concerning asymmetric information and altruism of doctors (for example, Ellis and McGuire, 1990, Chalkley and Malcomson, 1998, Choné and Ma, 2011, Makris and Siciliani, 2013).

More generally, there is extensive literature showing that healthcare providers are responding to financial incentives (eg Gruber et al., 1999; Croxson et al., 2001; Cavalieri et al., 2014).

Gaynor and Gertler (1995), studying the practices of medical groups in the United States, found that compensation agreements with higher levels of revenue sharing, such as capita, significantly reduce the efforts of physicians. Sørensen and Grytten (2003) found that Norwegian primary care physicians with an FFS contract generate a high number of consultations and other medical services compared to doctors with a CAP contract.

Likewise, Devlin and Sarma (2008) found that Canadian family physicians, remunerated with a service fee, conduct more patient visits than those who are subject to other types of payment schemes.

Mixed payment systems have become a major alternative to the two extreme forms of fee-for-service and capitation. While the theory shows that mixed payment systems are superior to those that provide only for a form of remuneration, the causal effects on the behaviour of doctors when the two systems are mixed, are not well understood empirically.

Only in recent years the problem has been studied applying the experimental approach, through a growing literature dedicated to the study of how different payment structures influence the provision of medical services. In their pioneering work, Hennig-Schmidt et al. (2011) investigated the effects of FFS and CAP under controlled laboratory conditions, finding that the levels of medical services provided by FFS are significantly higher than those of the CAP, even though the health benefits of patients result also influenced.

In a recent work Brosig-Koch et al. (2017) performed a controlled laboratory experiment, in the spirit of the doctor's decision making by Hennig-Schmidt et al. (2011), to study the effect of introducing a mixed payment system as an alternative to

non-blended FFS and CAP. The experiment was conducted on medical students and non-physicians playing in the role of doctors, who were asked to decide the amount of medical services to offer to various hypothetical patients, according to the payment method proposed and with the same variables as, for example, the characteristics of the patient. In this way, it was possible to analyse the causal effect of a change in the payment system on individual behaviour. It is obvious that choosing the amount of services offered determines the doctor's profit and the patient's health benefit. At one extreme, researchers have implemented a pure fee-for-service (FFS) system, the most common form of payment, according to which doctors receive a fee for each service offered. In this case, the behavioural data revealed an "overprovision" (supply superior to the optimal quantity) of significant medical services. On the other hand, the pure capitation system (CAP) was considered, paying physicians a lump sum for each registered patient. In this case, it was evident a significant “under provision” (supply less than the optimal quantity) of medical services. However, under provision and overprovision would be less pronounced if accompanied by a higher degree of medical altruism. In the research, the introduction of mixed payment systems, which include components of FFS and CAP, was applied by systematically changing the salary of FFS or CAP doctors to mixed systems, which differed in the various weights given to the two components. The experimental data obtained by the authors confirmed the theoretical predictions. Mixed payment systems reduce the overprovision of the FFS system and the under provision of the CAP system, improving health benefits for patients. These results were found both in physicians and non-physicians, although medical students tended to be more patient-oriented than non-physicians.

Lagarde and Blauw (2017) have designed a new "real effort" experiment to study multitasking behaviour (quantity and quality) in the provision of medical services.

They have found that the highest amount of services is provided in the FSS payment system while the CAP system leads to the minimum amount of services offered. On the other hand, as regards the quality of services, it grows as the remuneration offered to doctors grows.

Some scholars have conducted experimental investigations on the effect of the introduction of pay-per-performance schemes (P4P). In his experiment, Green (2014) found that relying on extrinsic incentives through P4P to motivate doctors has a displacement effect on their intrinsic motivations and, therefore, is detrimental to the quality of care and expensive for the healthcare industry.

Cox et al. (2016) focused on the adoption of P4P to effectively reduce hospital readmission rates while others, in recent years, have conducted numerous laboratory experiments to analyse other health problems. Among the latter we can mention Buckley et al. (2012), who designed a financial model of health care, and Kesternich et al. (2015), who studied the impact of professional standards on the level of health care.

Understanding how doctors respond to changes in the payment method is important for policymakers and researchers, even if determining the causal effect of a change in the payment system is a difficult task. A further problem presented to researchers and which has only recently been studied experimentally is the relationship between the payment system and the responsibility of physicians.

To the best of our knowledge, the only one work which study the role of medical liability in an experimental laboratory context is the paper of Finocchiaro Castro et al. (2018) which analyse the role of medical responsibility in influencing the behaviour of doctors in the context of different pure payment systems (FFS and CAP). They show

that, regardless of the payment system, the amount of services provided by doctors is greater when the risk of being reported for medical malpractice is at play.

The aim of our work is to contribute to this flow of literature by testing the effect of medical responsibility on the behaviour of doctors in an optimally calibrated mixed payment system, highlighting, in particular, its interaction with the medical liability pressure.

## 3. Experimental design

In our experimental sessions, subjects (i.e. students) choose, playing the role of physicians, how many medical services to provide for heterogeneous patients and, most importantly, under different scenarios. We include in our sample of 97 subjects 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). All the subjects are asked to choose the quantity of medical services for each patient determining in this way 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 process is incentivized by financial rewards considering that all subjects at the end of each session get a monetary payment commensurate with their own payoff, which include also the ex-post event of being sued or not. Moreover, real patients' health outside the lab are affected by subjects' decisions, 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 the 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' behaviour. Furthermore, motivated by a simple theoretical framework, we analyse the impact of a mixed payment system and of malpractice liability compared to non-blended payment methods, namely fee-for-service (FFS) and capitation (CAP), which allows us to discuss the interplay between medical malpractice liability and payment systems.

The experimental design we propose aims at testing the effects of medical liability pressure on the physicians' provision of medical services under both non-blended (FFS and CAP) and blended payment systems in order to understand how physicians' payment system affect their behaviour and how the presence of medical liability could be mitigated by a optimally calibrated and perfectly balanced mixed fee-for-service/capitation payment system. As in the previous literature in the field, each participant plays in the role of a physician who decides only on the quantity of medical services to provide to their patients, going from a scale of 0 to 10. The experiment is divided into four treatments according to the different payment systems and the presence/absence of medical liability scheme, as reported in Table 1. In order not to make the experiment too complicated for participants, we have divided our subject pool into two subsamples. The first subsample (51 subjects) played the sequence Fee-

for-service/Mixed, whereas the second one (46 subjects) played the sequence Capitation/Mixed.

Both the payment systems and the effect of the risk of being sued for medical malpractice liability will determine the revenue obtained by the subjects at the end of the experiment. So, the amount of medical services q determines the physician's profit, $\pi(q)$, but it determines also the patient's expected health benefit, B(q).

In all treatments, each physician decides the quantity of medical services $q \in [0,10]$ for 6 hypothetical patients, heterogeneous in terms of both the severity of illness $s \in \{x,y,z\}$ and gender (M/F). Specifically, patients 1, 2, 3 are male with low (x), medium (y) and high (z) severity, while patients 4, 5, 6 are female with low (x), medium (y) and high (z) severity, respectively. The sequence of patients for which physicians choose the amount of services has been randomly drawn for each treatment from a uniform distribution, it differed among the treatments but remained the same for all the experiment. Patients are assumed to be passive and fully insured, accepting each level of medical services.

Formally, the physician's profit is given by:

$$(q) = \begin{cases} pq - cq^2 \quad underFFS \\ L - cq^2 \quad underCAP \\ \mu M + (1-\mu)\, pq - \quad cq^2 \;\; under\; Mixed \end{cases} \qquad (1)$$

where p is the fee per service provided to a patient in FFS, c is the parameter governing the marginal cost of providing medical services, L is the lump-sum payment per patient

in CAP and M is the lump-sum payment per patient in mixed. Specifically, in our experiment p=2, c=0.1; μ=0.5, L=10 M=15.

Considering our setting, in the treatments where subjects do not run the risk of being sued for medical malpractice they face only the cost deriving from the amount of services provided. When they play in presence of medical malpractice risk, they face also the cost of being sued. Then, the structure of the experiment involves two 2x2 matrix as shown in Table 1 and Table 2. In the case physicians get sued for medical malpractice, they lose entirely their profit.

| | TREATMENTS | | | |
|---|---|---|---|---|
| | T1 | T2 | T3 | T4 |
| Payment Scheme | FFS | MIXED | FFS | MIXED |
| Medical Liability | No | No | Yes | Yes |

**Table 1 – Fee-for-service/Mixed scheme (Part 1)**

| | TREATMENTS | | | |
|---|---|---|---|---|
| | T1 | T2 | T3 | T4 |
| Payment Scheme | CAP | MIXED | CAP | MIXED |
| Medical Liability | No | No | Yes | Yes |

**Table 2 – Capitation/Mixed scheme (Part 2)**

Looking now at the patient's health benefit B(q), the different severity of illness s ∈ {x,y,z} implies a different patient's health benefit function. 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:

$$B^s(q) = \begin{cases} B_0^s + q & if\, q \leq q^* \\ B_1^s - q & if\, q \geq q^* \end{cases} \qquad (2)$$

with $B_0^x = 7$, $B_0^y = 5$, $B_0^z = 3$, and $B_1^s = B_0^s + 2q^* \forall s$.

Considering 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 $(x)$, $q^E = 5$ for medium $(y)$ and $q^E = 7$ high $(z)$ severities.

For what regards the ex-ante probability of being sued it is influenced by the quantity of medical services q provided and by the severity of the disease. In particular, as a higher amount of medical services q reduces the probability of being sued, it is increased by the rise of the level of the severity.

So formally, the ex-ante probability of being sued for medical malpractice employed in the experiment is given by:

$$Pr^s(q) = \lambda^s \left(1 - \frac{q}{10}\right) \qquad (3)$$

with $\lambda^x = 0.3$, $\lambda^y = 0.4$, and $\lambda^z = 0.5$.

On the other hand, even if subjects know exactly the ex-ante probability of being sued and how to influence it, the ex-post event "being sued"/"not being sued" is still a random variable and it is known only after their choices on the quantity of medical services. Specifically, 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 Pr(X=1) equal to (3) , and then it is displayed on the screen of each subject with the formulation "You have been sued"/"You have not been sued", in order to make them aware of the ex-post event of having been sued or not.

In the case of being sued, physicians suffer the disutility of being cited in court, which in the experiment means that they lose all their profit for that period.

*3.1 Inside the lab*

Our experiment takes in consideration the individual's attitude toward risk cause to the fact that under liability condition subjects may be affected by their risk attitudes For this reason before to start 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 where, 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. It is well known 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 but, similar to the results obtained by Holt and Laury (2002), most of the subjects of our experiment can be classified as risk-averse.

After the control for risk preferences, subjects received the instructions regarding just the first treatment (T1FFS) and the corresponding table describing all the information necessary to do the experiment: the profit's level for the physician, the cost, and the benefits for the patient. Moreover, the treatment started only after subjects solved some numerical exercise related to the payment system in order to show they had fully understood the way in which profits and benefits were computed. After the end of the first treatment, where each physician 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 mixed payment system.

Then, subjects started the third treatment (T3) under FFS with the presence of medical liability condition. Before to start treatment we used other numerical exercises to be sure 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 increasing with the severity of the patient under cure and that all participants were aware that the random event "being sued" implied the loss of their own profit in that single period.

Finally, the last treatment (T4) has been done under the mixed system with the presence of medical liability condition. After the completion of the fourth treatment, the experiment ended.

As mentioned before, while half of the sample followed this order, the other half started with the capitation payment system (T1CAP) then followed the mixed system (T2) and the again the CAP (T3) and the mixed (T4) with the presence of medical liability. The procedure followed was exactly the same as the one described before.

A total of 97 students with different backgrounds (economics, law, political science, and medicine) joined our experiment, 51 subjects played in Part 1 (FFS-Mixed) and 46 in Part 2 (CAP-Mixed). Thirteen sessions were done with a lasting average of 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 ($p=0.75$).

At the end of the experiment, subjects has been paid in relation to one period randomly chosen by a volunteer subject rolling a dice. The number drawn was relevant both for the subjects' payment and for the corresponding patient's benefit. Before paying subjects in private according to the randomly drawn period, they have been asked to

complete a questionnaire on social demographics, such as age, gender and the University faculty they belong to. Even if participants played for hypothetical patients, real patients' health outside the lab has been affected by their choices. In fact, participants was informed by 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). To this end, we applied a procedure similar to Brosig-Koch et al. (2016), Hennig-Schmidt et al. (2011), and Eckel and Grossman (1996) where one of the participants was randomly chosen to be a monitor and verified that one of the experimenters entered the Famiglie SMA website and transferred the aggregate benefits.

The exchange rate used for the experimental currency was 1 Experimental Crown (EC) = EUR 0.45. Average reward for participation, net of the attendance fee, was EUR 14,68 In total, EUR 350,00 was transferred to the Famiglie SMA.

The experiment is entirely computer-based and run with the z-Tree experimental software. All the experimental sessions have been done in the laboratory of the "Department of Economics and Business" of the University of Catania.

## 4. Predictions and hypotheses

We draw our model from the seminal Ellis and McGuire (1986) adding the probability of being sued for medical malpractice. In our model we consider the role of both a perfectly balanced FFS-CAP mixed payment system and the medical malpractice

liability in affecting the physicians' choice of medical services, interpreting the experimental evidence.

We make the two following behavioural hypotheses.

**Behavioural Hypothesis 1**. Mixed payment system leads physicians to choose an amount of medical services closer to the efficient level as compared to non-blended payment systems.

**Behavioural Hypothesis 2**. The optimal calibration of a mixed payment system, which induces the physician to choose an efficient level of medical services, is affected by medical malpractice liability.

*4.1 Physicians' payment systems*

The two standard physicians' pure payment systems are CAP and FFS, the ones considered in our experiment. Under CAP system, physicians receive a lump sum payment, $L$, for each enrolled patient, regardless 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 $f$ for every medical service provided to patients; thus, the revenue function in FFS is $R_{FFS} = pq$.

In response to these two systems, we consider a perfectly balanced 50%-50% mixed payment system, which has the following revenue function presented in (1).

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 (Chalkley and

Malcomson, 1998; Ma and Mak, 2015).[1] Therefore, the efficient quantity of medical services, $q^E$, is given by:

$$B'(q^E) = C'(q^E) \quad (4)$$

## 5. Empirical results

In this section, we analyze the data resulting from experimental sessions using non-parametric techniques. The aim of the following analysis is to test whether the introduction of the mixed payment system and, then, the medical liability pressure affects significantly the provision of medical services, according to our behavioural predictions.

To test our first behavioural hypothesis, we compare the choices made by physicians in treatments T1(FFS) vs. T2(MIX) and T1(CAP) vs. T2(MIX). In other words, we check if the prescription levels under mixed payment system against the non-blended FFS and CAP leads physicians to choose an amount of medical services closer to the efficient level. In both cases, the Wilcoxon test confirms our first hypothesis ($p_{T1FFSvsT2} = p_{T1CAPvsT2} = 0.001$).

A second relevant result pertains the change in physicians' behaviour when the medical liability condition is implemented under different payment systems. To do this we compare the choices made by physicians in treatments T3 (FFSL) against T4

[1] 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).

(MIXL) and T3 (CAPL) against T4 (MIXL) in order to check if medical malpractice liability influences medical prescriptions. In both cases, the Wilcoxon test confirms our first hypothesis ($p_{T3FFSLvsT4MIXL} = p_{T3CAPLvsT4MIXL} = 0.001$). Medical liability also influences the behaviour of the subjects when they play with a mixed payment system. In fact, both in Part 1 and Part 2 of the experiment, T2 (MIX) < T4 (MIXL) with p=0.0001.

To sum up, 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, as reported in the previous literature (Finocchiaro et al. 2018).

Moreover, we implemented the Mann-Whitnhey test for unmatched sample data in order to see if any difference would exist in the physicians' behaviour between Part 1 (FSS-Mixed) and Part 2 (CAP-Mixed) of the experiment, considering in this way the two different samples. The test compared the quantity provided in $T2_{(Part\ 1)}$ vs $T2_{(Part\ 2)}$ and $T4_{(Part\ 1)}$ vs $T4_{(Part\ 2)}$ finding no significant differences.

To conclude our analysis, and just for sake of completeness, we compared the prescription levels reached under FFS and CAP systems both in the presence or not of medical liability condition. As suggested by previous results in the literature (Brosig-Koch et al. 2017, Finocchiaro Castro et al. 2018) the prescription levels achieved under the CAP are significantly less than those reached under FFS (T1FFS > T1CAP, Wilcoxon test p = 0.001). Also when comparing the two payment systems with liability condition at play, the Wilcoxon test provides the same result (i.e. T3FFSL > T3CAPL, p = 0.001).

In the following figures it is graphically shown the results of our analysis.

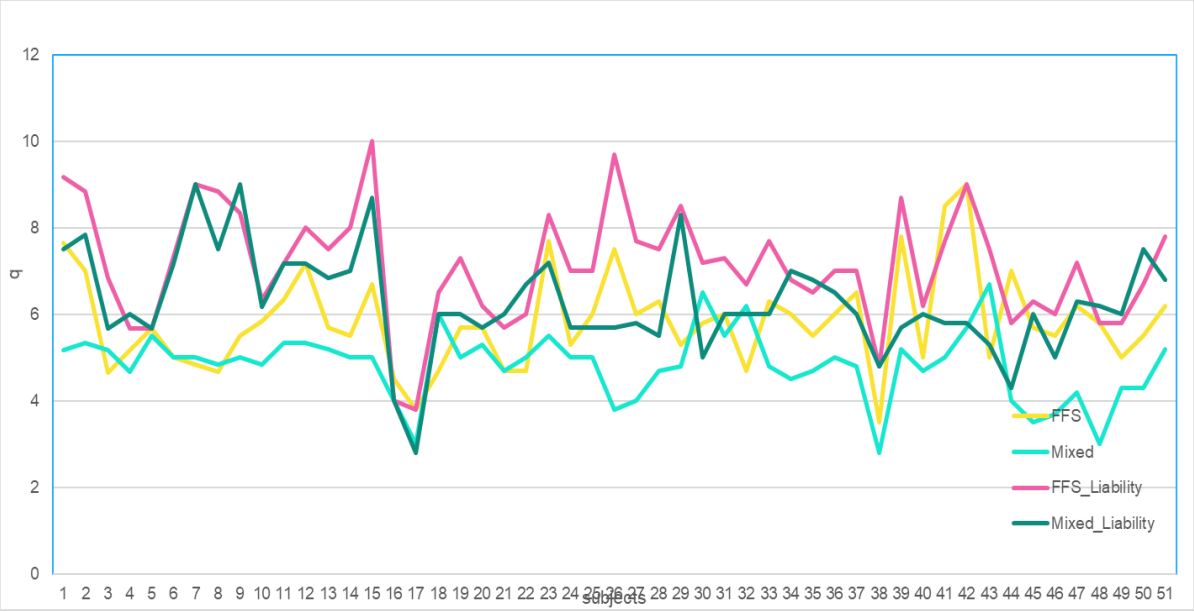


**Figure 1 – Part 1**

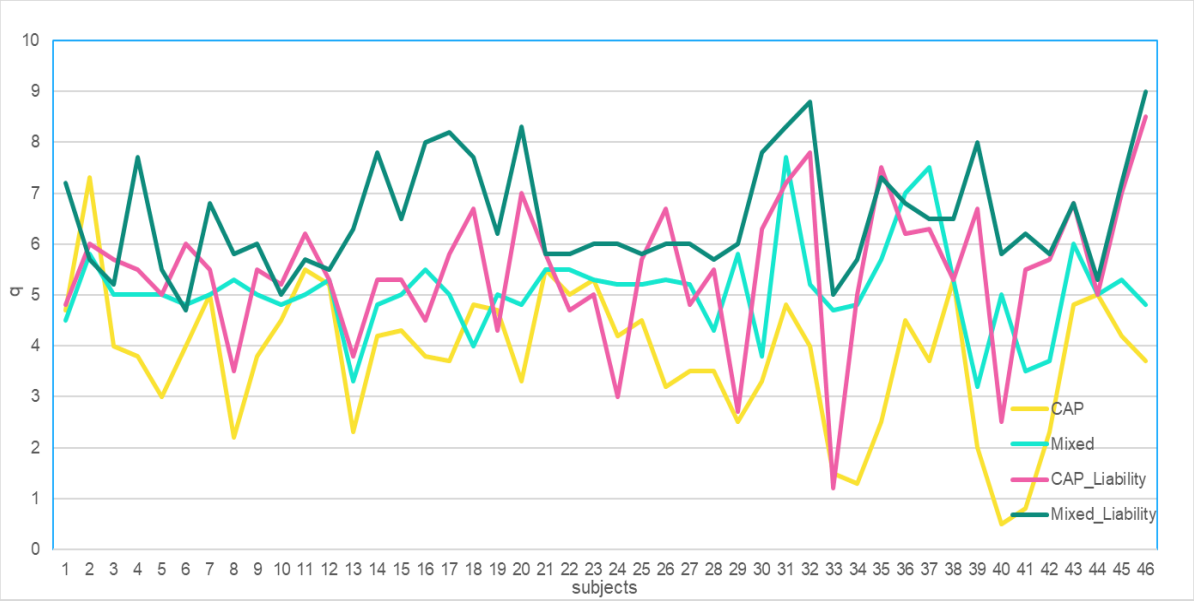


**Figure 2 – Part 2**

## 6. Concluding remarks

This paper reports the result of a lab controlled experimental setting which studied the effect of medical malpractice liability on physicians' provision of medical services considering also the effect of a mixed payment system. In our experiment, we considered "ceteris paribus" variations in the quantity of medical services offered in relation to the presence of medical malpractice liability in an optimally calibrated mixed payment system. To do so, we exploited the within-subject variation among treatments to infer the causal effect of medical liability in an optimally calibrated mixed payment system, considering the difficulty to conduct such analysis only with empirical evidence.

We report that when malpractice liability pressure is at play, physicians increase the provision of medical services for their patients, regardless of the physicians' payment system. However, the mixed payment system seems to mitigate the negative effects of the non-blended systems reducing the overprovision generated by FFS and the systematical under provision generated by CAP.

Under the societal perspective, although the optimal calibration of the mixed payment system induces physicians to choose an efficient level of medical services, its effect is influenced by the medical malpractice liability making it even more effective.

## References


Amaral-Garcia, S., Bertoli, P., & Grembi, V. (2015). Does experience rating improve obstetric practices? Evidence from Italy. Health Economics, 24(9), 1050-1064.

Avraham, R., & Schanzenbach, M. (2015). The impact of tort reform on intensity of treatment: Evidence from heart patients. Journal of Health Economics, 39, 273-288.

Baicker, K., Fisher, E. S., & Chandra, A. (2007). Malpractice liability costs and the practice of medicine in the Medicare program. Health Affairs, 26(3), 841-852.

Bertoli, P., & Grembi, V. (2018). Medical Malpractice: How Legal Liability Affects Medical Decisions. In: B. H. Baltagi and F. Moscone (ed.), Health Econometrics, Contributions to Economic Analysis (Chapter 10). Emerald Publishing, Forthcoming.

Brosig-Koch, J., Hennig-Schmidt, H., Kairies-Schwarz, N., & Wiesen, D. (2016). Using artefactual field and lab experiments to investigate how fee-for-service and capitation affect medical service provision. Journal of Economic Behavior & Organization, 131, 17-23.

Brosig‐Koch, J., Hennig‐Schmidt, H., Kairies‐Schwarz, N., & Wiesen, D. (2017). The effects of introducing mixed payment systems for physicians: Experimental evidence. Health Economics, 26(2), 243-262.

Buckley, N. J., Cuff, K., Hurley, J., McLeod, L., Mestelman, S., & Cameron, D. (2012). An experimental investigation of mixed systems of public and private health care finance. Journal of Economic Behavior & Organization, 84(3), 713-729.

Cavalieri, M., Guccio, C., Lisi, D., & Pignataro, G. (2014). Financial Incentives and Inappropriateness in Health Care: Evidence from Italian Cesarean Sections. FinanzArchiv: Public Finance Analysis, 70(3), 430-457.

Chalkley, M., & Malcomson, J. M. (1998). Contracting for health services when patient demand does not reflect quality. Journal of Health Economics, 17(1), 1-19.

Choné, P., & Ma, C. T. A. (2011). Optimal health care contract under physician agency. Annals of Economics and Statistics, 229-256.

Cox, J. C., Sadiraj, V., Schnier, K. E., & Sweeney, J. F. (2016). Incentivizing cost-effective reductions in hospital readmission rates. Journal of Economic Behavior & Organization, 131, 24-35.

Croxson, B., Propper, C., & Perkins, A. (2001). Do doctors respond to financial incentives? UK family doctors and the GP fundholder scheme. Journal of Public Economics, 79(2), 375-398.

Danzon, P. M. (2000). Liability for medical malpractice. In: A. J. Culyer and J. P. Newhouse (ed.), Handbook of Health Economics, (Chapter 26). New York: Elsevier.

Devlin, R. A., & Sarma, S. (2008). Do physician remuneration schemes matter? The case of Canadian family physicians. Journal of Health Economics, 27(5), 1168-1181.

Dubay, L., Kaestner, R., & Waidmann, T. (1999). The impact of malpractice fears on cesarean section rates. Journal of Health Economics, 18(4), 491-522.

Eckel, C. C., & Grossman, P. J. (1996). Altruism in anonymous dictator games. Games and Economic Behavior, 16(2), 181-191.

Ellis, R. P., & McGuire, T. G. (1986). Provider behavior under prospective reimbursement: Cost sharing and supply. Journal of Health Economics, 5(2), 129-151.

Ellis, R. P., & McGuire, T. G. (1990). Optimal payment systems for health services. Journal of Health Economics, 9(4), 375-396.

Esposto, A. G. (2012). Tort reform and caesarean deliveries. Applied Economics Letters, 19(12), 1171-1174.

Fenn, P., Gray, A., & Rickman, N. (2007). Liability, insurance and medical practice. Journal of Health Economics, 26(5), 1057-1070.

Finocchiaro Castro et al. (2018). Medical malpractice liability and physicians' behavior. Experimental evidence. WP University of York

Frakes M. and Gruber J. (2018). Defensive Medicine: Evidence from Military Immunity (2018). NBER Working Paper

Gaynor, M., & Gertler, P. (1995). Moral hazard and risk spreading in partnerships. The RAND Journal of Economics, 591-613.

Green, E. P. (2014). Payment systems in the healthcare industry: an experimental study of physician incentives. Journal of Economic Behavior & Organization, 106, 367-378.

Gruber, J., Kim, J., & Mayzlin, D. (1999). Physician fees and procedure intensity: the case of cesarean delivery. Journal of Health Economics, 18(4), 473-490.

Hennig-Schmidt, H., Selten, R., & Wiesen, D. (2011). How payment systems affect physicians' provision behaviour—an experimental investigation. Journal of Health Economics, 30(4), 637-646.

Hennig-Schmidt, H., & Wiesen, D. (2014). Other-regarding behavior and motivation in health care provision: An experiment with medical and non-medical students. Social Science & Medicine, 108, 156-165.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. The American Economic Review, 92(5), 1644-1655.

Kessler, D. P. (2011). Evaluating the medical malpractice system and options for reform. Journal of Economic Perspectives, 25(2), 93-110.

Kessler, D. P., & McClellan, M. B. (2002). How liability law affects medical productivity. Journal of Health Economics, 21(6), 931-955.

Kessler, D., & McClellan, M. (1996). Do doctors practice defensive medicine?. The Quarterly Journal of Economics, 111(2), 353-390.

Kesternich, I., Schumacher, H., & Winter, J. (2015). Professional norms and physician behavior: homo oeconomicus or homo hippocraticus?. Journal of Public Economics, 131, 1-11.

Lagarde, M., & Blaauw, D. (2017). Physicians' responses to financial and social incentives: A medically framed real effort experiment. Social Science & Medicine, 179, 147-159.

Makris, M., & Siciliani, L. (2013). Optimal incentive schemes for altruistic providers. Journal of Public Economic Theory, 15(5), 675-699.

Sørensen, R. J., & Grytten, J. (2003). Service production and contract choice in primary physician services. Health Policy, 66(1), 73-93.

Studdert, D. M., Mello, M. M., Sage, W. M., DesRoches, C. M., Peugh, J., Zapert, K., & Brennan, T. A. (2005). Defensive medicine among high-risk specialist physicians in a volatile malpractice environment. Jama, 293(21), 2609-2617.

# Appendix A: Instructions

*(Treatment T4: Mixed under medical liability)*

## 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 IV

Please, read carefully the following instructions regarding stage IV. 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 IV 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 *Pr*, 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 IV, you will be paid according to the mixed payment system. You will be paid in part on the basis of the FFS system (your income increases as the total amount of health services you prescribe) and partly on the basis of a remuneration based on the capitation system (it does not depend on the number of health services provided). 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 mixed 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 capitation 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 | 7,5 | 0 | 7,5 | 7 | 30% | 0 |
| 1 | 1 | 7,5 | 0,1 | 8,4 | 8 | 27% | 0 |
| 2 | 2 | 7,5 | 0,4 | 9,1 | 9 | 24% | 0 |
| 3 | 3 | 7,5 | 0,9 | 9,6 | 10 | 21% | 0 |
| 4 | 4 | 7,5 | 1,6 | 9,9 | 9 | 18% | 0 |
| 5 | 5 | 7,5 | 2,5 | 10 | 8 | 15% | 0 |
| 6 | 6 | 7,5 | 3,6 | 9,9 | 7 | 12% | 0 |
| 7 | 7 | 7,5 | 4,9 | 9,6 | 6 | 9% | 0 |
| 8 | 8 | 7,5 | 6,4 | 9,1 | 5 | 6% | 0 |
| 9 | 9 | 7,5 | 8,1 | 8,4 | 4 | 3% | 0 |
| 10 | 10 | 7,5 | 10 | 7,5 | 3 | 0% | 0 |

***Patient with illness y***

| Quantity of medical treatment | Your fee-for-service payment (in EC) | Your capitation 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 | 7,5 | 0 | 7,5 | 5 | 40% | 0 |
| 1 | 1 | 7,5 | 0,1 | 8,4 | 6 | 36% | 0 |
| 2 | 2 | 7,5 | 0,4 | 9,1 | 7 | 32% | 0 |
| 3 | 3 | 7,5 | 0,9 | 9,6 | 8 | 28% | 0 |
| 4 | 4 | 7,5 | 1,6 | 9,9 | 9 | 24% | 0 |
| 5 | 5 | 7,5 | 2,5 | 10 | 10 | 20% | 0 |
| 6 | 6 | 7,5 | 3,6 | 9,9 | 9 | 16% | 0 |
| 7 | 7 | 7,5 | 4,9 | 9,6 | 8 | 12% | 0 |
| 8 | 8 | 7,5 | 6,4 | 9,1 | 7 | 8% | 0 |
| 9 | 9 | 7,5 | 8,1 | 8,4 | 6 | 4% | 0 |
| 10 | 10 | 7,5 | 10 | 7,5 | 5 | 0% | 0 |

***Patient with illness z***

| Quantity of medical treatment | Your fee-for-service payment (in EC) | Your capitation 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 | 7,5 | 0 | 7,5 | 3 | 50% | 0 |
| 1 | 1 | 7,5 | 0,1 | 8,4 | 4 | 45% | 0 |
| 2 | 2 | 7,5 | 0,4 | 9,1 | 5 | 40% | 0 |
| 3 | 3 | 7,5 | 0,9 | 9,6 | 6 | 35% | 0 |
| 4 | 4 | 7,5 | 1,6 | 9,9 | 7 | 30% | 0 |
| 5 | 5 | 7,5 | 2,5 | 10 | 8 | 25% | 0 |
| 6 | 6 | 7,5 | 3,6 | 9,9 | 9 | 20% | 0 |
| 7 | 7 | 7,5 | 4,9 | 9,6 | 10 | 15% | 0 |
| 8 | 8 | 7,5 | 6,4 | 9,1 | 9 | 10% | 0 |
| 9 | 9 | 7,5 | 8,1 | 8,4 | 8 | 5% | 0 |
| 10 | 10 | 7,5 | 10 | 7,5 | 7 | 0% | 0 |

## Payment

At the end of the experiment, one of the six periods of stage IV 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 muscular 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 IV 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 IV will start only when all the participants answer to all questions correctly.

# Appendix B: " Inside z-Tree "

## Experimental session – 4 treatment of 6 periods each

In the following appendix, we report all the commands used in the software z-Tree during the four treatments of each experimental session. The experiment is divided in two parts, each made up by four treatments. Each treatment is made up by six periods representing the six types of patients involved in the research.

In part 1 of the experiment subjects are paid thanks to a pure payment system, namely Fee-for-Service, and a mixed payment system perfectly balanced between FFS and CAP.

In part 2 of the experiment subjects are paid thanks to a pure payment system, namely Capitation, and the previous perfectly balanced mixed payment system.

Both in part 1 and in part 2 we follow the same structure for the four treatments. In the treatment 1 and treatment, 2 subjects face no risk of being sued for medical malpractice, in the treatment 3 and treatment 4 they face the risk of being sued for medical malpractice, according to the following probability function, p(q)=lambda*(1-q/10).

The conversion rate is 1 EC (Experimental Crown) = 0.45 Euro.

Each subject can earn from a minimum of 10 Euro (including the participation fee) to a maximum of 18 Euro.

### Part 1

**Treatment 1 – pure payment system fee-for-service without risk of being sued for medical malpractice**

***Globals variable:***

a=2;  // fixed fee
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

***Subject variable:***

q= min 0 – max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  pieriod 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

Profit= q*a-cost*power(q,2);

**Treatment 2 – mixed payment system without risk of being sued for medical malpractice**
***Globals variable:***
a=2;  // fixed fee
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

***Subject variable:***
q= min 0 – max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  period 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

Profit= (0.5*a*q)+(15*0.5)-cost*power(q,2);

**Treatment 3 – pure payment system fee-for-service with risk of being sued for medical malpractice**
***Globals variable:***
a=2;  // fixed fee
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

p(q)=lambda*(1-q/10);  // probability of being sued for medical malpractice
lambda= 0,3;  // for disease 1 e 3
lambda= 0,4;  // for disease 2 e 4
lambda= 0,5  // for disease 3 e 6

***Subject variable:***
q= min 0 – max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  pieriod 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

sued=if(random()<lambda*(1-q/10),1,0);  // event of being sued for medical malpractice

Profit= if (((q*a)-cost*power(q,2))-sued*10 >0) {Profit=((q*a)-cost*power(q,2))-sued*10;} else {Profit=0;};

**Treatment 4 – mixed payment system with risk of being sued for medical malpractice**
***Globals variable:***
a=2;  // fixed fee
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

p(q)=lambda*(1-q/10);  // probability of being sued for medical malpractice
lambda= 0,3;  // for disease 1 e 3
lambda= 0,4;  // for disease 2 e 4
lambda= 0,5  // for disease 3 e 6

***Subject variable:***
q= min 0 - max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  period 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

sued=if(random()<lambda*(1-q/10),1,0);  // event of being sued for medical malpractice

Profit= if (((0.5*a*q)+(15*0.5)-cost*power(q,2))-sued*10 >0)
{Profit=((0.5*a*q)+(15*0.5)-cost*power(q,2))-sued*10;} else {Profit=0;};

**Part 2**

**Treatment 1 – pure payment system capitation without risk risk of being sued for medical malpractice**
***Globals variable:***
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

***Subject variable:***
q= min 0 – max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  pieriod 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

Profit=  if ((10-cost*power(q,2)) >0) {Profit=(10-cost*power(q,2));} else {Profit=0;};

**Treatment 2 – mixed payment system without risk of being sued for medical malpractice**
***Globals variable:***
a=2;  // fixed fee
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

***Subject variable:***
q= min 0 – max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  period 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

Profit=  Profit= (0.5*a*q)+(15*0.5)-cost*power(q,2);

**Treatment 3 – pure payment system capitation with risk of being sued for medical malpractice**
***Globals variable:***
cost=0,1;  // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

p(q)=lambda*(1-q/10);  // probability of being sued for medical malpractice
lambda= 0,3;  // for disease 1 e 3
lambda= 0,4;  // for disease 2 e 4
lambda= 0,5  // for disease 3 e 6

***Subject variable:***
q= min 0 – max 10  // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;}  pieriod 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;}  period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;}  period 4 e 6  // wellness of the patient

disease= 1,2,3,4,5,6  // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

sued=if(random()<lambda*(1-q/10),1,0);  // event of being sued for medical malpractice

Profit= if ((10-cost*power(q,2))-sued*10 >0) {Profit=(10-cost*power(q,2))-sued*10;} else {Profit=0;};

**Treatment 4 – mixed payment system with risk of being sued for medical malpractice**

***Globals variable:***

a=2; // fixed fee
cost=0,1; // cost for offering the services
conversion rate= 1/0,45 // 1 Experimental Crown= 0,45 Euro

// Termination rules:
numPeriods=6;
RepeatTreatment=if(Period<numPeriods,1,0);

p(q)=lambda*(1-q/10); // probability of being sued for medical malpractice
lambda= 0,3; // for disease 1 e 3
lambda= 0,4; // for disease 2 e 4
lambda= 0,5 // for disease 3 e 6

***Subject variable:***

q= min 0 - max 10 // quantity of medical treatment chosen by the subject

benesserepaziente=
if (q<=3) {benesserepaziente=7+q;} else {benesserepaziente=13-q;} period 1 e 4
if (q<=5) {benesserepaziente=5+q;} else {benesserepaziente=15-q;} period 3 e 5
if (q<=7) {benesserepaziente=3+q;} else {benesserepaziente=17-q;} period 4 e 6 // wellness of the patient

disease= 1,2,3,4,5,6 // 1, 2, 3 low, medium, high – men ; 4, 5, 6 low, medium, high – women

sued=if(random()<lambda*(1-q/10),1,0); // event of being sued for medical malpractice

Profit= if (((0.5*a*q)+(15*0.5)-cost*power(q,2))-sued*10 >0)
{Profit=((0.5*a*q)+(15*0.5)-cost*power(q,2))-sued*10;} else {Profit=0;};