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ESSAYS IN TRANSPARENCY AND LIABILITY IN THE HEALTHCARE SECTOR

By: Paolo Lorenzo Ferrara
Supervisor: Prof. Calogero Guccio

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Yours sincerely,
Paolo

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Summary

This thesis comprises three papers that represent three autonomous chapters. The linking "fil rouge" between the essays is the investigation of the issue of liability and transparency in the health care sector.

In the first chapter[1], we evaluate the role of transparency in measuring the performance of Local Health Authority (LHA) using the composite indicators prosed in literature and depict the relative geographical distribution in order to investigate whether transparency index matters on the performance for different expenditure functions at LHAs level. The health sector is considered to be one of the most exposed to the risk of corruption and therefore needs adequate levels of transparency. Healthcare is a particularly sensitive ground, where opportunistic behaviours germinate and can degenerate into corruption with several possible reasons behind:

- the magnitude of the expenditure
- the pervasiveness of information asymmetries
- the unpredictability of demand
- the high specialization of the products purchased
- the need for complex regulation systems

[1] "Evaluating the role of transparency in measuring the performance of Local Health Authority" This chapter mainly refer to a joint research conducted with prof. Carla Scaglioni and prof. Calogero Guccio

The forms and intensity differ according to the overall level of integrity and are becoming increasingly worrying even in the most advanced countries. Corruption in the health sector has both economic effects, diverting resources from assistance programs and social effects, undermining people's trust in the healthcare system. In the last years, several studies have considered this issue in order to assess the magnitude, the determinants and the effect of corruption in the healthcare sector. Italy recently has implemented legislation on transparency (so-called Code of Transparency - Leg. decree n. 33/2013), extended also to the health sector.

It provides several (about 270) detailed transparency obligations to be published in a standardized format (*Amministrazione trasparente*), regarding different aspects such as: the organization of public organizations with respect to politico-administrative bodies and top public managers and officers, external consulting and collaboration, public procurement, management of properties and assets, timing of payments, provision of public services.

In our analysis, we follow a "top-down" approach which develops indicators from the legal and formal aspect. In particular, we use the indicator "Composite Transparency Index" (CTI) developed by Galli et. al (2017) in a study on the transparency in the main Italian municipalities. The indicators CTI uses the values attributed by OIVs to the items included in ANAC resolution n. 77/2013, according to a scale going from 0 to 3. It is composed by two sub-indicators "CTI-Integrity" and "CTI-Performance" which investigate the two different aspects. In particular, the "CTI-Integrity" consider items on income and asset disclosure and conflict of interest (on both politicians and top and senior public officials, while the "CTI-Performance" considers items on the management of public property, the timeliness of public payments, the quality of public services. At the end, the total CTI is constitute by the average of the two indicators. The information was collected for all the 143 LHAs.

The degree of transparency of Italian Local Health Authorities (LHAs) using the composite indicators prosed by Galli et al. (2017) depicts the usual geographical dichotomy between North and South, with Tuscany and Emilia Romagna aligned with the former macro area, while Lazio, Umbria and Marche with the latter.

Then we explore the relationship between transparency and expenditure at LHA level. Our results show a negative correlation between transparency and total expenditure whereas we find a significant positive correlation for the administrative expenditure.

The second chapter[2] is devoted to exploring the role of medical malpractice liability and in physicians' behaviour using an experimental approach. The effect of the payment system on the behaviour of the physician has been a very hot topic, intensely studied by a lot of researches all over the world in the last decades, even in a laboratory study. Also, the effect of the medical liability on the behavioural changes has been deeply investigates. Nonetheless, to the best of our knowledge, there are no papers still that have studied the effect of medical liability on the physician in a laboratory environment.

Considering these aspects and building on the results of Brosig-Koch et al. (2017), we investigate whether the introduction of the possibility for a physician of being sued has any effect on the effort he/she devotes to cure his/her patients.

This effect has been observed through the two different payment schemes: fee-for-service and capitation. Finally, we check whether different samples of participants in our experiment show the same behaviour, running sessions with randomly chosen students, medical students and post-graduate MDs.

The experimental design is divided into four treatments differing in the payment system (fee-for-service and capitation) and in the presence of medical liability device. In each treatment, each participant plays the role of a physician who has to choose how many medical prescriptions (from zero to ten) to provide to his/her patients. Patients are divided according to the severity of disease (three levels) and gender (M/F).

The experiment was totally computer-based experiment and run with the z-Tree software. At the beginning of each treatment, subjects receive the instructions of

[2] "Medical malpractice liability and physicians' behavior: experimental evidence". This chapter mainly refer to a joint research conducted with prof. Massimo Finocchiaro Castro, prof. Domenico Lisi and prof. Calogero Guccio

that treatment only and the relative payoff table. Moreover, before starting the treatment they have to solve a couple of simple numerical exercises in order to be sure they have understood how FFS/Capitation payment scheme works and how to compute their profits.

Each treatment lasts for six periods, representing six patients differing in terms of severity of disease and in gender for the three levels of severity. The sequence of patients has been randomly drawn at the beginning of the research, it changes in every treatment but stays the same for all the subjects playing the experiment.

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.

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

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.

In the third Chapter[3] of the thesis, we further explore the role of malpractice liability using the experimental setting. In this Chapter, building on the seminal model of Ellis and McGuire (1986) and the experimental results of Brosig-Koch et al. (2017), we investigate whether the introduction of a mixed payment system and the possibility for a physician of being sued has any effect on the quantity of medical services provided to cure the patients. To do this, at first we compare the two main payment schemes fee-for-service and capitation with a perfectly balanced “fee-cap” mixed payment system. Then, we check if the presence of medical liability influences the optimal calibration of the mixed payment system.

The experimental design is made up by two parts, with two different samples composed by different subjects. The first sample plays the experiment following

[3] “Medical malpractice liability and mixed payment systems: experimental evidence on physicians’ behaviour”. Also this chapter mainly refer to a joint research with prof. Massimo Finocchiaro Castro, Domenico Lisi and prof. Calogero Guccio

the scheme Fee-for-service/Mixed and the second one with the scheme Capitation/Mixed. Each part is composed by four treatments differing in the payment system (fee/mixed, cap/mixed), as mentioned before, and in the presence of medical liability. In each treatment, each participant plays the role of a physician who has to choose only how many medical prescriptions (from zero to ten) to provide to his/her patients, which are divided according to the severity of disease (three levels-low, medium, high) and gender (M/F).

Each treatment lasts for six periods, in order to represent the six patients differing for severity of disease and gender. The sequence in which patients appears to subjects playing has been randomly drawn at the beginning of the research, it changes in every treatment but remains the same for all the experiment.

Even if there are no patients inside the lab, in order to make the effort decision more realistic subjects are made aware that the benefits awarded to patients through medical prescriptions are converted into euros and donated to a charity providing health care to children affected by spinal muscle atrophy (SMA). The experimental data give results in line with our behavioural hypothesis.

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Chapter 1

Is Transparency a Free Lunch? Evidence from the Italian Local Health Authorities[4]

[4] In conducting this research, I am largely in debt with Calogero Guccio (University of Catania) and Carla Scaglioni (University of Reggio Calabria).

Abstract

Transparency and integrity of public bodies play a relevant role in their accountability and to prevent misbehaviours. In the last decades, a significant amount of empirical research has proposed several measures to capture transparency and to understand their determinants. In the paper, we evaluate empirically the role of transparency in the performance of Local Health Authority (LHA) in the year 2013. Using composite indicators recently proposed in literature and depicting the relative geographical distribution we investigate whether transparency index matters on the performance for different expenditure functions at LHAs level. Our results show a negative correlation between transparency and total expenditure whereas we find a significant positive correlation for the administrative expenditure.

JEL Classification: C92, H30, H41.

Keywords: Transparency; Accountability; Local Health Authorities.

1. Introduction

Worldwide, the health sector is one of the areas that is extremely susceptible to corruption (European Commission, 2013; 2017). Several factors contribute to make health a particularly sensitive ground, where opportunistic behaviours germinate often degenerating into corruption (Vian 2008; Vian et al., 2010). The magnitude of the expenditure, the omnipresence of information asymmetries, the extent of the relationship with the private sector, the unpredictability and inelasticity of demand, the high specialization of the products purchased, the need for complex regulation systems are just some of these factors. Fraudulent and corruptive behaviours are all characterized by different forms of abuse of power positions for private purposes[5]. The mode and intensity of their diffusion differ according to the overall level of integrity present in the various countries and to the state of development of countries' health care systems. Furthermore, they are becoming increasingly worrying even in the most advanced countries. The European Network against Fraud and Corruption in the Health Sector (EHFCN) estimates that in Europe around 6% of the health budget is absorbed by corruption (Sauter et al., 2017). The theme also deserves attention because corruption in the health sector has not only economic effects (in particular public finances), but also on the health of populations[6] and undermines people's trust in the healthcare system[7]. For this reason, affirmation of legality and

[5] The European Commission (2017) identified six typologies of corruption in the healthcare sector: bribery in medical service delivery; procurement corruption; improper marketing relations; misuse of (high)level positions; undue reimbursement claims; fraud and embezzlement of medicines and medical devices".

[6] It reduces access to services, especially among the most vulnerable; significantly shrinks overall health indicators and is associated with higher infant mortality

[7] For an extensive review of the consequences of corruption in health care sector see Cavalieri et al. (2017).

integrity must be a priority commitment to public policy makers, especially at a time when institutions are perceived as far away from citizens' everyday concerns. Unfortunately, all these malpractices are not easy to be detected, therefore healthcare sector needs adequate levels of transparency. The term "transparency" usually is considered a synonym of openness, democracy, reliability, efficiency and proximity do citizens (Dyrberg, 1997, 81), whereas "opacity" is directly associated with secrecy on information and corruption, that is hidden by nature. Thus, transparency is both one of the principal measures in the fight against corruption[8] (Arrowsmith et al., 2000; Kaufmann and Bellver, 2005) and a key precondition for services improvement and productivity.

To this end, we apply a new composite indicator of transparency (CTI) and its two sub-indicators, CTI *Integrity* and CTI *Performance*, proposed by Galli et al., (2017) to assess the level of transparency of Italian Local Health Authorities in the year 2013. These indicators have the advantage to quantitatively describe the degree of transparency of public administrations as well as the two different aspects of the public activity's transparency. Then, we investigate whether transparency matters on the performance for different expenditure functions at LHAs level. As valuable as the impact of transparency could be, it is worth to note that it might not be a "free lunch".

For this purpose, we built on results obtained by Di Novi et al., (2018) to estimate the determinants of the cost incurred by LHA in the year 2012 in four different

[8] Empirical analysis supports that more information leads to a reduction in corruption (Rose-Ackerman, 2004, 316–322). Nonetheless, these outcomes are not sufficient to conclude that transparency always means lower corruption (Cordis & Warren, 2014; Grimmelikhuijsen, 2010; Peisakhin & Pinto, 2010, 262).

expenditure functions (i.e. total expenditure, administrative expenditure, the cost for purchasing goods, and the cost for buying non-healthcare-related services).

Our analysis confirms that transparency matters. However, fulfilling transparency obligation is costly and thus it is important to evaluate its effect on public administration performance. In this respect, the stability of rules and obligations and their consolidation not only would promote the effectiveness of transparency but also reduce the costs of its design and implementation.

The analysis develops as follows. Section 2 report a short literature review on the field. Section 3 presents the empirical strategy, illustrating the methodology employed to build the new indicator of transparency and the econometric model we employ to estimate the determinants of the cost incurred by LHA. The characteristics of the sample performance, the distribution of the transparency compliance across the different Italian LHAs and results of the estimation are provided in Section 4. Finally, Section 5 offers some concluding remarks.

2. Related literature

2.1 Corruption in the healthcare sector

A growing body of literature analyse efficiency and productivity in health care sector, but international empirical evidence on the role played by corruption in the healthcare sector is less investigated (Transparency International, 2017; Cavalieri et al., 2017). Only recently, some important evidence comes from some in-depth studies on the characteristics, causes, remedies and effects of illicit in various healthcare dimensions, which show how the opacity of budgets and control systems and administrative confusion facilitate the emergence of interests illicit and collusion in the healthcare system. Cavalieri et al. (2017) show that, in Italy, the performance of the job contracts for healthcare infrastructures is significantly affected by 'environmental' corruption. Baldi and Vannoni (2017) stress the importance of healthcare governance. They focus on the relationship between the grade of centralization (or decentralization) in public procurement of Italian Local Health Authorities (LHAs) and the auction prices of selected drugs for hospital usage during the period 2009-2012. The analysis let emerge that centralized and mixed procurers are statistically associated with lower prices respect to decentralized ones and more importantly that higher corruption and lower institutional quality strengthen the effects of centralization in terms of lower prices.

2.2 Measuring the performance of public health departments

Our paper is also related to the literature on the performance of Local Health Authorities and their determinants. Santerre, (1985) investigates the relationship between the institutional structure of public health departments and their performance. Bates and Santerre (2012) compare the spending levels of the local and regional demands for public health services, then examine if resources for public health services are more efficiently allocated to independent or to regional public health departments. According to their results, regionalization seems to increase spending on public health services, especially when serving a large population. Similar outcomes are provided by Mukherjee et al. (2010). Their analysis reveals that the more Local Health Departments (LHDs) are centralized and at the urban level, the less efficient they are at producing local public health services. This findings also suggest that efficiency is higher for LHDs that produce a wider variety of services internally and rely more on internal funding. Gordon et al. (1997) identify the determinants of LHDs expenditures, emphasizing how local health department spending varies significantly across the jurisdictions even in case of similar size. The authors stress the need for effective strategies to analyse the efficiency of public health spending. A potential cost savings may be derived from the consolidation of local health authorities. This hypothesis is investigated by Bates and Santerre (2008) for LHDs in the USA. They show how better off municipalities are less likely to consolidate health departments. The consolidation process is impeded by population and income differences among municipalities. A similar approach, with a different outcome, to the determinants of Local Health Authorities (LHAs) expenditure and consolidation was recently proposed by Di Novi et. al (2018). The authors estimate the potential advantages from consolidation with specific reference to the Italian setting. Their main result is the presence of economies of scale with regard to a particular subset of the production costs of LHAs, i.e. administrative costs together with the purchasing costs of goods (such as drugs and medical devices) as well as non-healthcare-related services.

Noticeably, despite the numerous ongoing initiatives (see among others Mikkelsen-Lopez et al., 2011), to the best of our knowledge, no literature exists assessing the relationship between the degree of transparency and the performance achieved by the health authorities (or departments), running the governance of local healthcare systems.

Based on these, in the next Section, we first build a measure of transparency showing of how this approach could be applied to illuminate areas of governance weaknesses which are possibly addressable by specific interventions and policies.

3. Measuring Transparency in the health sector: the approach of Composite Indicator of Transparency (CTI)

In our analysis, we look at the degree of transparency in regard to the local governance of the healthcare sector focusing on the LHAs' activities and departing from the copious stream of literature on the transparency of costs, prices, quality, and effectiveness of medical services and products (among others Fung et al., 2008).

As above mentioned, transparency refers to several attributes that make a specific administration more transparent. Practitioners and academics agree on considering *Integrity* and *Performance/Efficiency* as key features to assess the degree of transparency reached by a public organization. Galli et al., (2017) propose to measure them through two distinct indicators – respectively the CTI *Integrity* (CTI*In*) and the CTI *Performance* (CTI*MaEf*). To this end, they operationalize the two dimensions selecting some of the obligations contained within the Italian "Code of Transparency - Leg. decree n. 33/2013". Thus, CTI *Integrity* includes items such as income and asset disclosure and conflicts of interest (on both politicians and top and senior public officials); whereas CTI *Performanc*e consists of information about the management of public property, the timeliness of public services provision, the quality of public services. Finally, to offer a single measure of public transparency, they aggregate the previous indicators, according to a simple average, into the so-called *Composite Transparency Indicator* (CTI).

This "top-down approach" provides a limited set of meaningful and robust indicators that, in our opinion, are suitable also to appraise and measure the degree of transparency of the authorities running the governance of local healthcare systems and to drive policy choices. This belief is supported also by the fact that the Italian Legislator has extended the same obligation to the LHAs.

Therefore, we straightway follow the same methodology as in Galli et al. (2017), first building a dataset containing information about several aspects of LHAs' activity and then derive the three indicators i.e the CTI, the CTI*In* and the CTI*MaEf*. Each sub-indicator must be computed as an average of the set of the previously weighted and then normalized elementary indicators. The standardization method applied to elementary weighted indicators has to be that of so-called *re-scaling*. The data can be retrieved from official LHAs' web pages or reports, making the methodology straightforwardly replicable in other contests.

To this extent, our analysis is, also, related to the little literature analyzing the effect of health care decentralization on several health outcomes (e.g., Jepsson and Okuonzi, 2000; Tang and Bloom, 2000; Bossert et al., 2003; Arreondo et al., 2005; Kolehmainen-Aitken, 2005; Saltman et al., 2007) along with the one focusing on the relationship between decentralization and health policies' efficiency (e.g., Bordignon and Turati, 2009; Piacenza and Turati, 2014; Francese et al., 2014).

4. The role of transparency as a determinant of health expenditure

As valuable as the impact of transparency could be, it is worth to note that it might not be a "free lunch". To investigate whether transparency matters on the performance for different expenditure functions at LHAs level, we propose to include the degree of transparency among the determinants of the cost incurred by LHAs. Following the results obtained by Di Novi et al., (2018), we propose to estimate four different expenditure functions (i.e. total expenditure, administrative expenditure, the cost for purchasing goods, and the cost for buying non-healthcare-related services).

Accordingly, the general specification of the determinants of different expenditure functions is expressed as follows:

$$lnC_i = \alpha + \beta_1 lnPOP_i + \beta_2 lnPOP_i^2 + \sum_{j=1,k} \delta_j X_j + \varepsilon_i \quad [1]$$

where C_i refers to the per capita expenditure in different functions incurred by the *i-th* LHA, POP refers to the population in the *i-th* LHA, to control for potential scale effects in the costs we include in [1] the POP square, finally and X is a set of other covariates at LHA level that are reported in Table 1.

Table 1 – Employed variables

Variable	***Description***
C_i	per capita expenditure in different functions incurred by the i-th LHA
POP	population in the *i-th* LHA
POP^2	controls for potential scale effects in the costs
CTI_i^h	transparency index both at LHAs and regional level
X	set of other covariates at LHAs level

5. Setting the stage

5.1 The sample: the Italian Local Health Authorities

The National Health System (*Servizio Sanitario Nazionale*, SSN) in Italy shows some interesting institutional characteristics. Since 1978, Italy relies on an SSN, which grants universal access to a uniform level of care all over the country. Over time, Italy has undergone a set of reforms inspired by the principles of regionalization, competition and managerialism. As a result, responsibilities for the financing and delivery of healthcare are now in charge of Regional governments, which administer, finance and organize healthcare according to the populations' needs, though within the national regulatory framework. This organization pass through different structures. At first, we have Local Health Authorities (*Aziende Sanitarie Locali*), a network of geographic and population-defined bodies, which are independent public entities with their own budgets and management. They provide services for the patients and also directly run small public hospitals. Secondly, we have major public hospitals, which are granted the status of trusts with full managerial autonomy (*Aziende Ospedaliere*), and thirdly, we have accredited private providers.

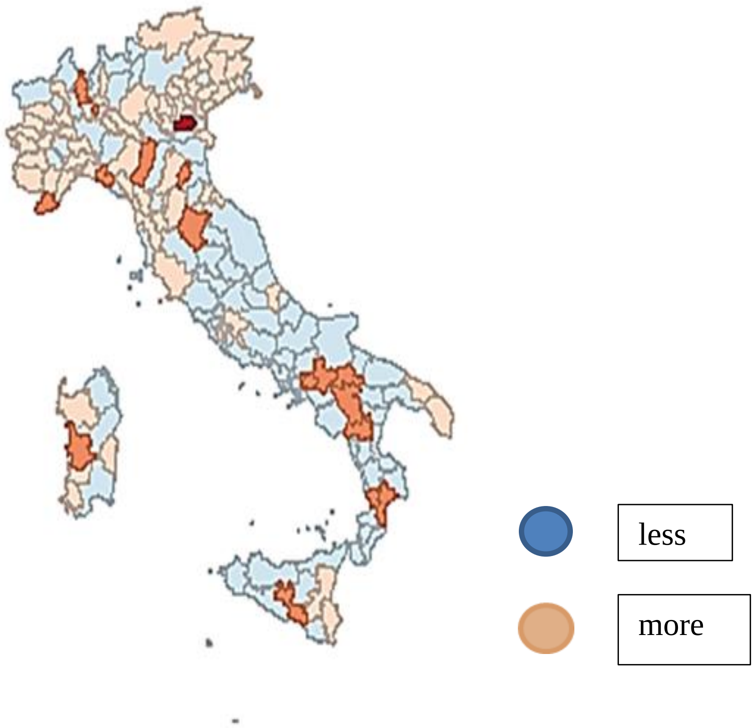
We collected data from all the LHSs in order to compute our transparency index. In particular, the information were first-hand data collected for 143 LHAs. All the information used to compute the index were taken from the OIV (*Organismo Interno di Valutazione*) grid 77/2013, which is available in every website of the Public Administration in the "Transparent Administration" section[9].

[9] However, during the collecting activity we found wide heterogeneity in displaying the data among the different LHAs and a widespread incompleteness of information.

5.2 The degree of transparency across the Italian Local Health Authorities

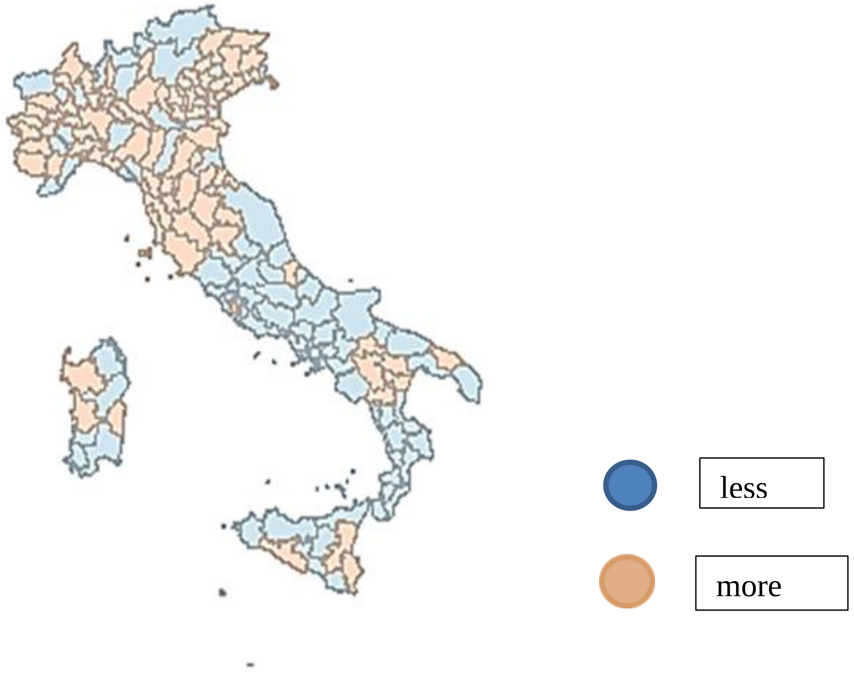
The degree of transparency of Italian Local Health Authorities (LHAs) using the composite indicators prosed by Galli et al. (2017) are reported in Figures 1, 2 and 3. More specifically, Figures 1, 2 and 3 report, respectively, the geographical distribution of CTI Integrity, CTI Performance and CTI.

Figure 1 – CTI Integrity



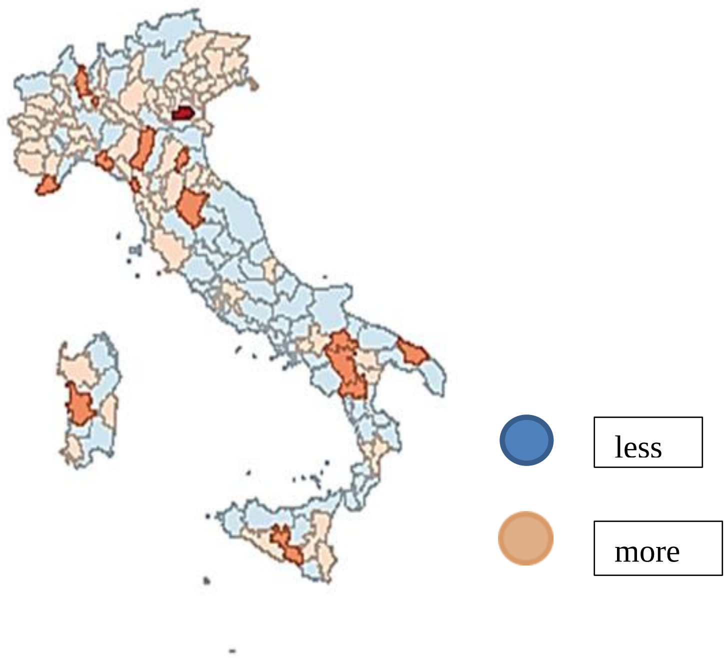
Source: our elaboration on the data of the CTI index

Figure 2 – CTI Performance



Source: our elaboration on the data of the CTI index

Figure 3 – CTI index



Source: our elaboration on the data of the CTI index

Depicts the usual geographical dichotomy between North and South, with Tuscany and Emilia Romagna aligned with the former macro area, while Lazio, Umbria and Marche with the latter. Basilicata represents an exception, but Potenza is not, as among the ten most transparent LHAs there are Oristano, Brindisi and Caltanissetta. CTI and CTIMaEf are almost aligned. Basilicata and FVG reach the highest level, while in terms of Integrity the best performer, besides Basilicata, is Liguria. Marche and Molise are located in lowest positions in the ranking. Nonetheless, we can notice that our results are in line with those presented by AGE.NA.S, despite the different approach followed in measuring LHAs' transparency.

6. The cost of being transparent for the Italian Local Health Authorities

In this section, we empirically test the role of transparency for our sample of Italian LHAs. They seem particularly well-suited to test our predictions that transparency might not be a "free lunch" for the administrations. In fact, not only Italy exhibits one of the most interesting initiatives in detailing the transparency obligation for the public administrations among the OECD countries but, because of the high decentralization, great variation exists across regions both in the regulation and in the delivery of services (e.g., Francese et al., 2014; Cavalieri et al., 2014). As far as the Italian National Health System (NHS) is concerned, most works have focused on the relationship between decentralization and the efficiency of health policies (e.g., Bordignon and Turati, 2009; Piacenza and Turati, 2014; Francese et al., 2014). This literature supports the idea that fiscal decentralization makes local governments more accountable and efficient.

Thus, in this Section, we carry out an empirical assessment of Italian LHAs using the data on cost collected by Di Novi et al., (2018) using information provided by Italian Ministry of Health (New Health Information System - NSIS). In particular, we considered the determinants of expenditure thanks to data provided by Di Novi et al., (2018) which include several information about expenditure and main characteristics of Italian LHAs for the year 2012. The following Table 2 provides some descriptive statistics of the variables.

Table 2 - Descriptive statistics of the sample

Variable	Meaning	Obs	Mean	Std. Dev.	Min	Max
Total_costs	Total production costs (euro per capita)	143.000	1659.277	224.898	1089.718	2192.018
Administrative_cost	Costs for administrative services and personnel (euro per capita)	143.000	43.151	16.867	13.190	129.340
Cost_goods	Cost of buying health and non-health goods (euro per capita)	143.000	182.359	94.425	24.496	683.755
Cost_non_health_service	Cost of buying non-health services (euro per capita)	143.000	93.098	47.179	5.873	211.322
Pop	Resident population in the LHA on 1 January 2012	143.000	415344.100	295115.700	57349.020	1540688.000
Density	Demographic density (pop/surface area)	143.000	516.410	1180.619	30.606	7679.612
Dependency	Dependency ratio of the population (pop over 65 and pop under 14 upon pop between 15–64)	143.000	0.541	0.041	0.449	0.651
Doctors	Number of General Practitioners (for 1000 residents)	143.000	0.769	0.078	0.557	1.048
Paediatricians	Number of paediatricians (for 1000 residents)	143.000	0.124	0.021	0.081	0.171
Purch_health_service	Reimbursements for health services (as percentage of Total production costs)	143.000	0.170	0.073	0.046	0.370
Lump_sum_fund	Per-capita lump-sum funding received from Regional Governments	143.000	1620.009	192.482	1085.767	2151.178
d_sep	Dummy for LHA in regions with a separated organisational model	142.000	0.106	0.308	0.000	1.000
d_semi_sep	Dummy for LHA in regions with a semi-separated organisational model	143.000	0.238	0.427	0.000	1.000
d_int	Dummy for LHA in regions with an integrated organisational model	143.000	0.259	0.439	0.000	1.000
d_semi_int	Dummy for LHA in regions with a semi-integrated organisational model	143.000	0.399	0.491	0.000	1.000
d_central_h	Dummy for LHA in regions with Centralised Purchasing System only for Health services	143.000	0.280	0.450	0.000	1.000
Addiction_service	Number of Addiction Treatment Services (for 1000 residents)	143.000	1.177	0.661	0.285	4.101
Emergency_service	Emergency medical service (hours/pop)	143.000	0.366	0.271	0.000	1.435
Purch_adm_service	Cost of buying administrative services (as percentage of Total production costs)	143.000	0.002	0.003	0.000	0.024
d_recovery	Dummy for LHA in regions under the Recovery Plan	143.000	0.399	0.491	0.000	1.000
Foreigners	Percentage share of foreign residents	143.000	0.068	0.034	0.009	0.139
Municipalities	Number of municipalities in the LHA (2012)	143.000	0.172	0.139	0.001	0.594
Income	Tax base of personal income tax (IRPEF), 2011 (euro per capita)	143.000	12105.490	3007.114	6166.729	21393.290
d_central	Dummy for LHA in regions with Centralised Purchasing System	143.000	0.490	0.502	0.000	1.000
Hospital_beds	Number of beds programmed in hospitals/pop	143.000	0.086	0.278	0.000	1.000
d_reservation	Unified reservation centre—Type 2 (dummy)	143.000	0.280	0.450	0.000	1.000
d_maternal	Maternal and child department (dummy)	143.000	0.811	0.393	0.000	1.000
d_transport	Transport service to dialysis centre (dummy)	143.000	0.629	0.485	0.000	1.000
d_reanimation	Mobile Resuscitation Units (dummy)	143.000	0.273	0.447	0.000	1.000
d_ambulances	Ambulances for emergency transport of newborn babies (dummy)	143.000	0.077	0.267	0.000	1.000
Facilities	Doctor's offices and laboratories (accredited private hospitals) 100,000/pop	143.000	15.178	8.877	3.357	53.812
Home_care	Integrated home care assistance 1000/pop	143.000	11.765	8.459	1.436	48.655

Source: our elaboration on data provided by Di Novi et al., (2018)

To investigate whether transparency index matter for the considered expenditure functions (i.e. total expenditure, administrative expenditure, the cost for purchasing goods, and the cost for buying non-healthcare-related services) we first consider three possible levels of transparency and then we use a linear regression model.

Considering the general specification of the determinants of the different expenditure function presented in the previous section, differently from Di Novi et al., (2018) we estimate the equation [1] for all LHA including those located in Special Statute regions (SSR). To control for the difference with Ordinary Statute regions we include in each estimate a dummy variable (d_SSR). Furthermore, to take into account that in the year 2013 the four LHAs in Umbria are merged in two LHAs, we aggregate the data for those LHA obtaining two virtual LHA. Finally, we estimated the equation [1] using a slightly different approach of those proposed by Di Novi et al., (2018) that is based on stepwise backward elimination technique (at 5% level of significance). We believe that this approach although based on statistical significance potentially exclude variables that in principle could be important to explain the expenditure variability at LHA level. Thus, as a first exploratory assessment, we perform a stepwise backward elimination technique with a lower level of significance (i.e. 10% level of significance) and include in each estimate the control for SSR.

Tables 3, 4, 5 and 6 report the estimates obtained for our four expenditure functions using OLS with robust standard errors and stepwise backward elimination at 10% level of significance. In each table, the analysis is conducted considering separately the two sub-indicators (CTIIn – CTIMaEf) and the general one (CTI), in order to test both for the specific components of the sub-indicators and for the main index.

Table 3 – Total expenditure (per capita)

	(1)	(2)	(5)	(6)	(9)	(10)
VARIABLES	lTotal_costs	lTotal_costs	lTotal_costs	lTotal_costs	lTotal_costs	lTotal_costs
CTI	-0.0124*	-0.0172*				
	(0.0072)	(0.0089)				
CTIIn			-0.0093	-0.0088		
			(0.0061)	(0.0062)		
CTIMaEf					-0.0132*	-0.0185**
					(0.0072)	(0.0089)
lPop	-0.0375	0.1251	-0.0375	0.1829	-0.0419	0.1326
	(0.1386)	(0.1496)	(0.1408)	(0.1618)	(0.1370)	(0.1453)
lPop2	0.0011	-0.0049	0.0011	-0.0072	0.0012	-0.0053
	(0.0054)	(0.0058)	(0.0054)	(0.0062)	(0.0053)	(0.0056)
lLump_sum_fund	1.0262***	1.0569***	1.0261***	1.1025***	1.0284***	1.0637***
	(0.0233)	(0.0224)	(0.0233)	(0.0220)	(0.0230)	(0.0225)
d_int	-0.0220***		-0.0218***		-0.0224***	
	(0.0076)		(0.0076)		(0.0077)	
d_sep	-0.0306***		-0.0313***		-0.0299***	
	(0.0074)		(0.0076)		(0.0073)	
lForeigners						
d_recovery						
d_central_h						
d_central				0.0115*		
				(0.0062)		
lPurch_health_serv		-0.0240***				-0.0221**
		(0.0090)				(0.0088)
lIncome	0.0621***	0.0573***	0.0598***		0.0629***	0.0572***
	(0.0168)	(0.0199)	(0.0165)		(0.0167)	(0.0193)
d_reanimation						
lMunicipalities						
d_maternal						
lDoctors						
lPurch_adm_serv				0.0044*		
				(0.0025)		
d_reservation						
d_transport						
d_ROS	0.0018		0.0020		0.0021	
	(0.0074)		(0.0073)		(0.0074)	
Constant	-0.4358	-1.7557*	-0.4216	-1.8652*	-0.4242	-1.8414*
	(0.8870)	(1.0163)	(0.9000)	(1.0887)	(0.8764)	(0.9949)
Sample	All regions	Only ordinary regions	All regions	Only ordinary regions	All regions	Only ordinary regions
Observations	143	117	143	117	143	117
R-squared	0.9447	0.9442	0.9439	0.9405	0.9451	0.9451

Source: our elaboration on CPI index and data provided by Di Novi et al., (2018).

Notes: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4 – Administrative expenditure (per capita)

	(1)	(2)	(5)	(6)	(9)	(10)
VARIABLES	lAdmin_cost	lAdmin_cost	lAdmin_cost	lAdmin_cost	lAdmin_cost	lAdmin_cost
CTI	0.0162	0.0631**				
	(0.0357)	(0.0306)				
CTIIn			0.0254	0.0427		
			(0.0326)	(0.0283)		
CTIMaEf					0.0032	0.0669**
					(0.0348)	(0.0309)
lPop	-0.9460	-2.4175***	-0.9712	-2.4629***	-0.9192	-2.4323***
	(0.6804)	(0.7741)	(0.6824)	(0.7661)	(0.6721)	(0.7728)
lPop2	0.0283	0.0854***	0.0293	0.0866***	0.0272	0.0861***
	(0.0270)	(0.0304)	(0.0271)	(0.0300)	(0.0267)	(0.0304)
lLump_sum_fund	1.0202***		1.0275***		1.0156***	
	(0.2323)		(0.2332)		(0.2301)	
d_reservation	0.0686*		0.0681*		0.0696*	
	(0.0386)		(0.0384)		(0.0386)	
lDependency	0.9421**	1.1070**	0.9385**	1.2912***	0.9554**	1.0714**
	(0.3796)	(0.4582)	(0.3805)	(0.4576)	(0.3802)	(0.4517)
lHospital_beds	-0.0410***		-0.0410***		-0.0412***	
	(0.0114)		(0.0114)		(0.0114)	
d_recovery	0.2305***		0.2316***		0.2277***	
	(0.0493)		(0.0494)		(0.0492)	
lIncome	-0.3655***	-0.2778*	-0.3678***	-0.3016**	-0.3639***	-0.2788**
	(0.1311)	(0.1433)	(0.1318)	(0.1486)	(0.1305)	(0.1392)
d_central	-0.1754***	0.1283**	-0.1734***	0.1134**	-0.1768***	0.1291**
	(0.0500)	(0.0511)	(0.0499)	(0.0502)	(0.0499)	(0.0515)
lPurch_health_serv	-0.2350***	-0.3616***	-0.2353***	-0.3400***	-0.2324***	-0.3686***
	(0.0623)	(0.0898)	(0.0617)	(0.0904)	(0.0628)	(0.0910)
d_central_h	-0.3310***	-0.1307**	-0.3290***	-0.1437**	-0.3319***	-0.1317**
	(0.0685)	(0.0621)	(0.0681)	(0.0642)	(0.0689)	(0.0629)
d_int	0.2229***	0.1792***	0.2219***	0.1922***	0.2229***	0.1788***
	(0.0673)	(0.0618)	(0.0671)	(0.0648)	(0.0678)	(0.0618)
lDoctors	-1.0240***	-0.3976**	-1.0149***	-0.4475**	-1.0313***	-0.3981**
	(0.2422)	(0.1731)	(0.2396)	(0.1732)	(0.2426)	(0.1767)
lDensity		0.0467**		0.0453**		0.0481***
		(0.0180)		(0.0191)		(0.0180)
lAddiction_services		0.0919***		0.1110***		0.0919***
		(0.0319)		(0.0318)		(0.0317)
d_sep		-0.4319***		-0.4250***		-0.4331***
		(0.0848)		(0.0877)		(0.0834)
lPaediatricians		-0.1673*				-0.1752*
		(0.0983)				(0.0985)
lMunicipalities						
lHome_care						
lEmergency_hours						
d_maternal						
d_ROS	0.1071*		0.1085*		0.1052*	
	(0.0630)		(0.0625)		(0.0633)	
Constant	6.5629	22.4312***	6.6814	23.5491***	6.4452	22.4469***
	(4.5866)	(4.9493)	(4.5989)	(4.8590)	(4.5330)	(4.9194)
Observations	143	117	143	117	143	117
R-squared	0.7992	0.8375	0.7998	0.8322	0.7988	0.8388

Source: our elaboration on CPI index and data provided by Di Novi et al., (2018).

Notes: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5 – The cost of purchasing goods (per capita)

	(1)	(2)	(5)	(6)	(9)	(10)
VARIABLES	lCost_goods	lCost_goods	lCost_goods	lCost_goods	lCost_goods	lCost_goods
CTI	-0.0624	-0.0511				
	(0.0501)	(0.0545)				
CTIIn			-0.0463	-0.0360		
			(0.0443)	(0.0476)		
CTIMaEf					-0.0674	-0.0579
					(0.0489)	(0.0547)
lPop	1.1551	-0.2999	1.1453	-0.3503	1.1401	-0.2618
	(0.8366)	(1.1204)	(0.8481)	(1.1089)	(0.8300)	(1.1329)
lPop2	-0.0480	0.0070	-0.0473	0.0091	-0.0476	0.0054
	(0.0330)	(0.0436)	(0.0334)	(0.0431)	(0.0327)	(0.0441)
lLump_sum_fund	1.2707***	1.1081***	1.2548***	1.0860***	1.2904***	1.1344***
	(0.2466)	(0.2723)	(0.2423)	(0.2615)	(0.2519)	(0.2843)
d_reanimation						
lAddiction_services						
lFacilities						
lEmergency_hours	-0.0534***	-0.0557***	-0.0536***	-0.0563***	-0.0522***	-0.0544***
	(0.0110)	(0.0123)	(0.0110)	(0.0123)	(0.0111)	(0.0122)
d_maternal						
d_transport						
lPurch_health_serv	-0.7173***	-0.7249***	-0.7254***	-0.7326***	-0.7108***	-0.7183***
	(0.0980)	(0.1085)	(0.0971)	(0.1067)	(0.0984)	(0.1098)
lHome_care						
d_int	0.1191**		0.1210**		0.1162**	
	(0.0553)		(0.0553)		(0.0555)	
lDoctors						
d_sep	-0.9095***	-0.9374***	-0.9109***	-0.9394***	-0.9080***	-0.9350***
	(0.1096)	(0.1150)	(0.1106)	(0.1153)	(0.1090)	(0.1151)
lDensity						
lIncome						
d_reservation		0.1015*		0.0982*		0.1034*
		(0.0530)		(0.0538)		(0.0527)
lHospital_beds						
d_central_h						
lDependency						
d_ROS	0.3743***		0.3750***		0.3753***	
	(0.0710)		(0.0713)		(0.0711)	
Constant	-12.8470**	-1.7039	-12.7390**	-1.2680	-12.8422**	-2.1014
	(5.5255)	(7.7330)	(5.5979)	(7.5817)	(5.4743)	(7.8852)
Observations	143	117	143	117	143	117
R-squared	0.8311	0.8526	0.8302	0.8520	0.8317	0.8531

Source: our elaboration on CPI index and data provided by Di Novi et al., (2018).

Notes: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6 - Cost for buying non-healthcare-related services (per capita)

	(1)	(2)	(5)	(6)	(9)	(10)
VARIABLES	lNon_health_serv	lNon_health_serv	lNon_health_serv	lNon_health_serv	lNon_health_serv	lNon_health_serv
CTI	-0.0346	-0.0600				
	(0.0429)	(0.0449)				
CTIIn			-0.0461	-0.0638		
			(0.0389)	(0.0407)		
CTIMaEf					-0.0154	-0.0433
					(0.0432)	(0.0480)
lPop	0.9366	-0.0663	0.9768	-0.0689	0.8867	-0.1082
	(1.0010)	(1.5109)	(0.9847)	(1.4768)	(1.0127)	(1.5524)
lPop2	-0.0394	-0.0023	-0.0409	-0.0021	-0.0373	-0.0007
	(0.0385)	(0.0580)	(0.0379)	(0.0567)	(0.0390)	(0.0596)
lLump_sum_fund	1.9045***	2.5312***	1.8924***	2.5089***	1.9095***	2.5407***
	(0.2642)	(0.3289)	(0.2635)	(0.3324)	(0.2630)	(0.3210)
d_semi_int	-0.2825***	-0.3784***	-0.2803***	-0.3793***	-0.2871***	-0.3816***
	(0.0710)	(0.1001)	(0.0705)	(0.0969)	(0.0711)	(0.1029)
d_int	-0.1816*	-0.3573**	-0.1786*	-0.3565**	-0.1825*	-0.3603**
	(0.0926)	(0.1479)	(0.0926)	(0.1452)	(0.0923)	(0.1502)
d_central	0.2104***		0.2083***		0.2128***	
	(0.0582)		(0.0579)		(0.0585)	
d_sep	-1.7059***	-1.6617***	-1.7072***	-1.6651***	-1.7066***	-1.6596***
	(0.2073)	(0.1770)	(0.2076)	(0.1762)	(0.2058)	(0.1761)
d_central_h	0.2709***	0.1640**	0.2680***	0.1619**	0.2722***	0.1662**
	(0.0853)	(0.0755)	(0.0856)	(0.0759)	(0.0851)	(0.0749)
d_recovery	-0.3566***	-0.2200***	-0.3596***	-0.2213***	-0.3510***	-0.2154***
	(0.0529)	(0.0542)	(0.0511)	(0.0527)	(0.0549)	(0.0562)
lPurch_health_serv	-0.6064***	-0.6379***	-0.6039***	-0.6405***	-0.6134***	-0.6399***
	(0.0863)	(0.1332)	(0.0834)	(0.1294)	(0.0892)	(0.1376)
lPurch_adm_serv	0.0597***	0.0567***	0.0604***	0.0577***	0.0584***	0.0555***
	(0.0209)	(0.0211)	(0.0209)	(0.0211)	(0.0210)	(0.0209)
lDoctors		-0.9626**		-0.9665**		-0.9457**
		(0.3842)		(0.3902)		(0.3769)
lPaediatricians		0.3779***		0.3756***		0.3773***
		(0.1266)		(0.1249)		(0.1284)
lDependency						
lForeigners						
lIncome						
d_ROS	0.3646***		0.3628***		0.3683***	
	(0.0932)		(0.0923)		(0.0936)	
Constant	-15.9543***	-12.8354	-16.1108***	-12.6733	-15.7242***	-12.6505
	(5.8541)	(8.8649)	(5.7813)	(8.6914)	(5.9252)	(9.1659)
Observations	143	117	143	117	143	117
R-squared	0.8997	0.9178	0.9001	0.9181	0.8994	0.9173

Source: our elaboration on CPI index and data provided by Di Novi et al., (2018).

Notes: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

7. Conclusion

This paper studied the relevance of transparency in the public sector and in particular it measures a transparency index for the Italian Local Health Authorities. Moreover, we put in relation transparency with four cost functions (total expenditure, administrative expenditure, the cost for purchasing goods, and the cost for buying non-healthcare-related services) for the Italian LHA in 2012 looking at the role played by transparency

As we can see from the results, transparency index matters on the performance and it is costly.

Our results show that for what concerns the total expenditure (per capita) CTIs indicators present the expected negative sign which means that more transparency implies less total costs for the administration. CTI and CTI*MaE*f are both significant but CTI*In* is not. Moreover, we find no significant difference between ORD and SSR

For the Administrative expenditure (per capita) we see ambiguity for the expectation of the sign of transparency on the administrative costs considering that both directions are quite reasonable, meaning that more transparency implies more administrative and bureaucracy costs for the administration. We find a positive and, for the sub-sample of LHAs in ORD, significant impact. In fact, we find a significant difference between ORD and SSR.

The cost of purchasing goods (per capita) is with the expected negative sign but not significant even if there is a significant difference between ORD and SSR.

For the last cost function, we find that the cost of buying non-healthcare-related services (per capita) have the expected negative sign but not significant. Instead, there is a significant difference between ORD and SSR

However, for the sake of our analysis, we must take in consideration the wide heterogeneity in displaying the data among the different LHAs, some problems related to the incompleteness of information and, last but not least, the high grade of LHA managers' discretionally.

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Chapter 2

Medical Malpractice Liability and Physicians' Behavior: Experimental Evidence[10]

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)*

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Abstract

Medical liability has been suspected of increasing health expenditure insofar as it induces 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. Our behavioural 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' behaviour; laboratory experiment.

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' 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 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' behaviour 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 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 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. 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 overprovision 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.

Finally, we also find that medical students respond stronger to the introduction of malpractice liability pressure as compared to non-medical students. This result would seem to suggest that subjects with a medical background are more sensitive than non-medical subjects about the risk of being sued for medical malpractice.

This study complements the previous empirical research on the effect of liability pressure on physicians' behaviour 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 results 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' behaviour 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' behaviour. Finally, our study integrates the growing literature that employs the experimental approach to study health-related behaviours. We briefly discuss these strands of literature in turn.

2.1 Medical liability and physicians' behaviour

There is widespread economic literature studying the effect of liability pressure on physicians' behaviour. 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' behaviour

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' 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). 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 recent years. In particular, a growing experimental literature has been devoted to investigating how different payment structures affect medical service provision.[11] In their pioneering work, Hennig-Schmidt et al. (2011) study the effects of FFS and CAP under controlled laboratory conditions and find

[11] 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).

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) behaviour 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 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' behaviour under different payment systems.

3. Theoretical framework and behavioural predictions

In this section we lay out a simple theoretical model of physicians' behaviour 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' behaviour, 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' behaviour 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:

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

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[12]:

$$R'(q^*) + \alpha B'(q^*) = C'(q^*) \qquad (2)$$

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 behaviour affects this risk. In this respect, the most reasonable assumption to make is that the *ex-ante* probability of being sued for medical malpractice, $Pr(q)$, decreases with the amount of medical services provided, $Pr'(q) < 0$. The simple intuition of this assumption, which is also fully coherent with the idea of defensive medicine (Studdert et al., 2005; Baicker et al.,

[12] 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.

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:

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

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.[13] Then, the optimal quantity of medical services with the risk of being sued for medical malpractice, $q^{\#}$, is given by:

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

By comparing (2) and (4), we can make the following hypothesis to be tested in the experiment regarding the physician behavior[14]:

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.*

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[13] 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".

[14] 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 $Pr'(q^{\#})H$, 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 $\frac{\partial q^{\#}}{\partial H} > 0$.

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 $R_{FFS} = pq$.

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).[15] Therefore, the efficient quantity of medical services, q^E, is given by:

$$B'(q^E) = C'(q^E) \qquad (5)$$

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 $\alpha < 1$:

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

[15] 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).

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:

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

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

In both systems, not surprisingly, the optimal quantity of medical services is higher than without malpractice concerns.[16] 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

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

(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:

Behavioural 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.*

Behavioural 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 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. 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

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.[17] 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:

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

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

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 $L = 10$. 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.

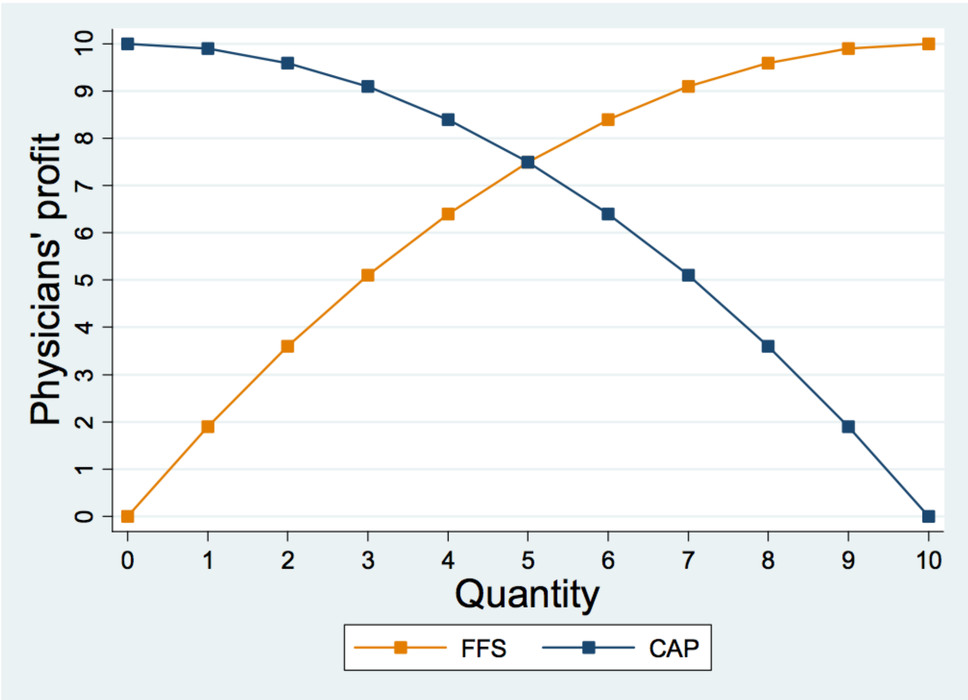

Figure 1. Physicians' profit by the payment system

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.

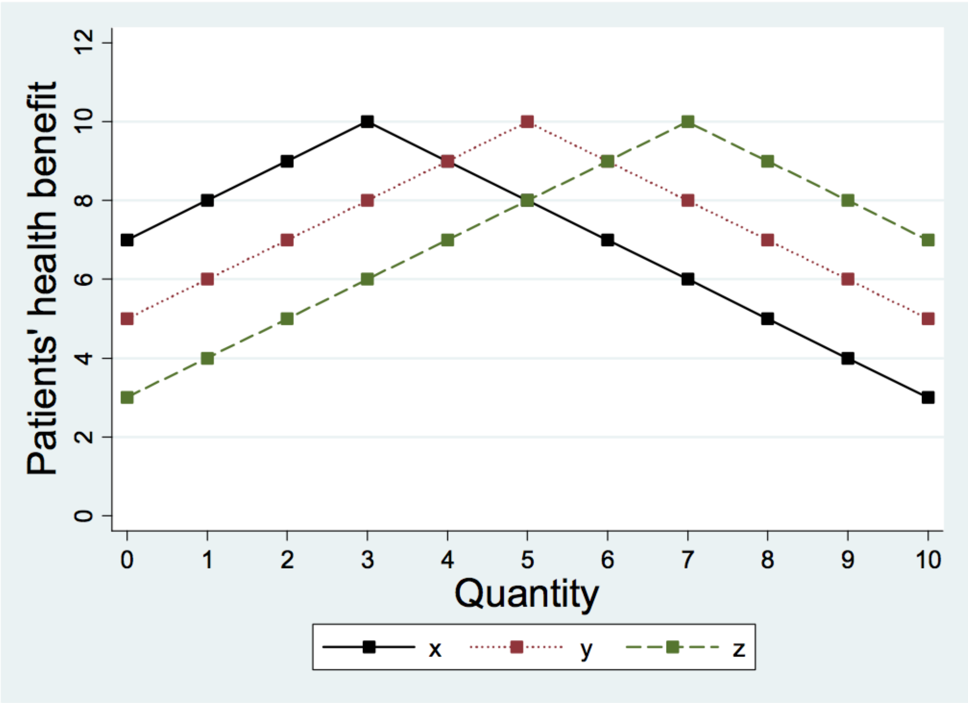

Figure 2. Patients' health benefit by the severity of illness

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, $Pr^s(q)$, 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 $Pr^{s\prime}(q) < 0 \; \forall \, s$, for each quantity the probability of being sued is higher for more severe patients, that is $Pr^x(q) < Pr^y(q) < Pr^z(q) \; \forall \, q$. Formally, the *ex-ante* probability of being sued for medical malpractice employed in the experiment is given by:

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

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.

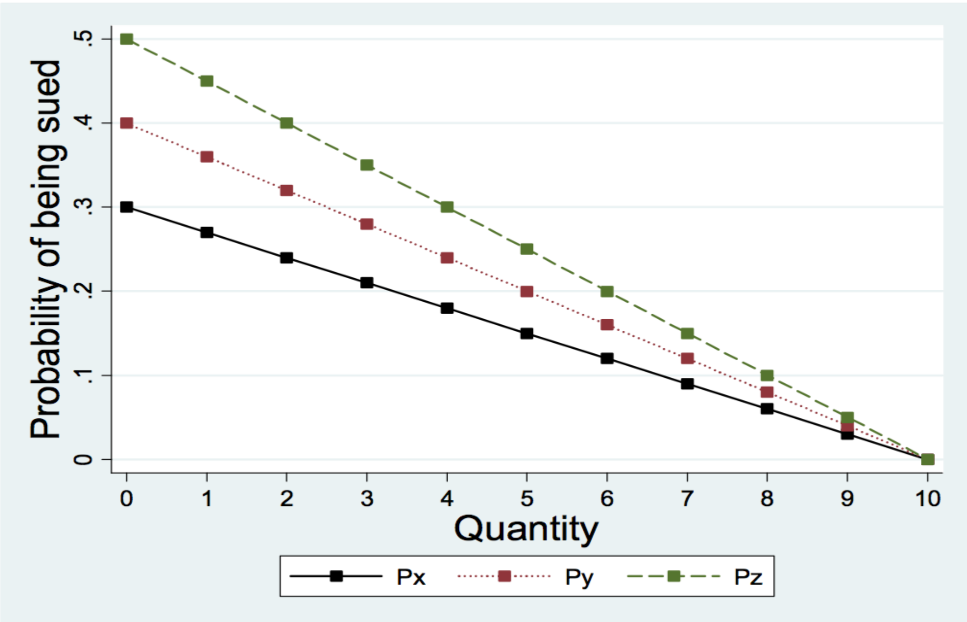

Figure 3. Probability of being sued by the severity of illness

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 behaviour, 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 $Pr(X = 1)$ 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 loss 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 *ex-ante* probability of being sued through their behaviour.

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	*Pr of* $sued_x$	30%	27%	24%	21%	18%	15%	12%	9%	6%	3%	0%
	Pr of $sued_y$	40%	36%	32%	28%	24%	20%	16%	12%	8%	4%	0%
	Pr 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; *Pr of sued*: probability of being sued; *B*: patients' health benefit.

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

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

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 behavioural data resulting from our experiment by employing both non-parametric and regression analysis. 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 behavioural predictions.

5.1 Non-parametric analysis

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. 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.

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.

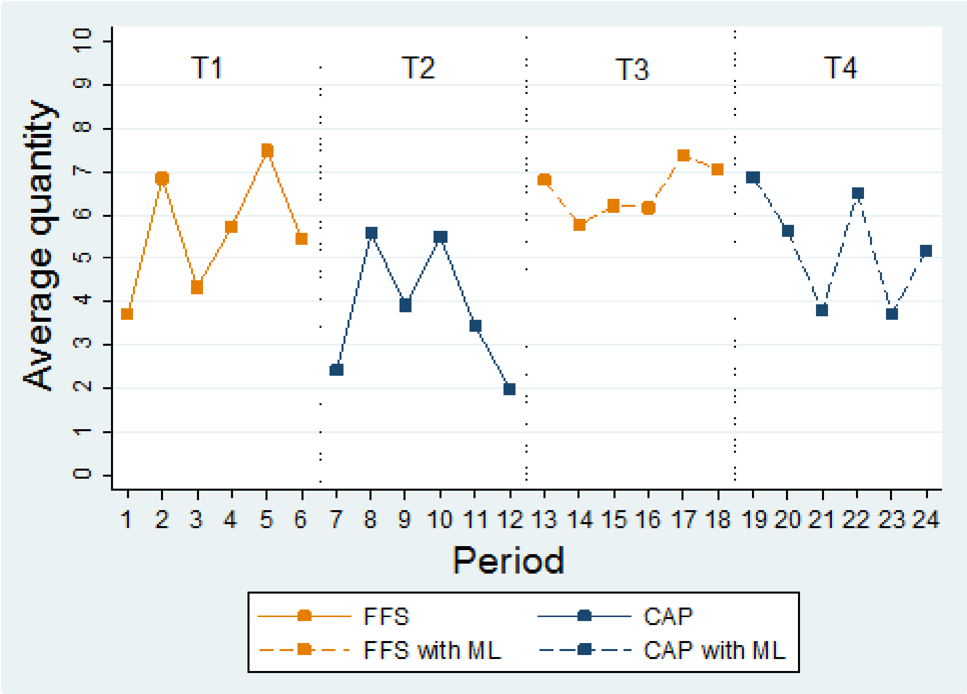

Figure 4. Average quantity of medical services across treatments

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 behavioural 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 ($p_{high\ vs.\ low} = 0.001$, $p_{high\ vs.\ medium} = 0.001$). 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 behavioural 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.

5.2 Regression analysis

We further check in some regression analyses whether the level of medical services provided by physicians in the lab is affected by the introduction of medical liability, along with the adopted payment system (FFS *vs.* CAP), the subject pools (medical *vs.* non-medical subjects), patients' characteristics in the experiment (severity of illness, gender) and subjects' demographics (gender, age). In Table 4, we estimate two OLS regression models (left panel of Table 4) and two corresponding Tobit models (right panel of Table 4), to account for the left (i.e. $q = 0$) and right (i.e. $q = 10$) censoring of the dependent variable. In the first model, in line with the previous literature (e.g., Brosig-Koch et al., 2016, 2017), we check the role of payment system in affecting medical provision regardless of the presence of medical liability. To this purpose, in the model (1) we include a dummy *FFS* equal to 1 when physicians are paid by FFS, along with controls for medical student, physician, subject's gender and age, patient's gender and severity of illness[19]. Consistent with our non-parametric analysis, the estimation results show that significantly more medical services are provided in FFS compared to CAP. In addition, we find that older subjects tend to provide less medical services, that the higher the severity of illness the more medical prescriptions are provided and that when the patient is female the level of medical services sent by physicians slightly lowers. Overall, these results confirm what reported in the previous literature in this field.

More importantly in our analysis, to capture the effect of medical liability on service provision, in the model (2) we add a dummy *Liability* equal to 1 if subjects can be sued for medical malpractice and 0 otherwise. Given that the liability condition has been tested under both payment systems, we get rid of the dummy *FFS* in model (2). The estimates in Table 4 show that liability plays a significant role, increasing the level of medical service provision. Then, the corresponding Tobit regressions in Table 4 yield very similar results. Hence, our first behavioural hypothesis is clearly confirmed by regression analysis too.

[19] The variable *Severity of illness* in our estimates is built as an ordinal variable which takes values 1, 2 and 3 reflecting the three patients' severity of illness (x, y, and z, respectively).

Table 4. Effect of medical liability on medical service provision

	Quantity *q*			
	OLS		Tobit	
	(1)	(2)	(3)	(4)
FFS	1.781***		1.880***	
	(0.176)		(0.197)	
Medical student	0.277	0.277	0.294	0.295
	(0.217)	(0.216)	(0.227)	(0.227)
Physician	-0.022	-0.022	-0.036	-0.038
	(0.158)	(0.158)	(0.164)	(0.164)
Age	-0.019**	-0.019**	-0.021***	-0.021***
	(0.008)	(0.008)	(0.008)	(0.008)
Subject gender	0.147	0.147	0.164	0.164
	(0.123)	(0.123)	(0.129)	(0.129)
Severity of illness	1.469***	1.469***	1.506***	1.507***
	(0.059)	(0.059)	(0.059)	(0.059)
Patient gender	-0.224***	-0.224***	-0.232***	-0.232***
	(0.055)	(0.055)	(0.058)	(0.059)
Liability		1.422***		1.504***
		(0.119)		(0.125)
Constant	2.105***	2.284***	2.056***	2.242***
	(0.257)	(0.253)	(0.263)	(0.258)
Observations	2,544	2,544	2,544	2,544
Number of cluster	106	106	106	106
R^2 and Pseudo-R^2	0.383	0.335	0.101	0.084

Columns (1) to (2) report results from OLS regressions and columns (3) to (4) results from Tobit regressions (lower and upper limits are 0 and 10, respectively). Standard errors in parentheses are clustered at the subject level for 106 subjects. FFS is a dummy variable equal to 1 if subjects are paid by FFS and 0 if they are paid by CAP. Medical student and Physician are dummy variables equal to 1 for medical students and physicians, respectively. Subject gender and Patient gender are dummy variables equal to 1 if subjects and patients, respectively, are female and 0 if they are male. Severity of illness is an ordinal variable which takes values 1, 2 and 3 reflecting the three patients' severity of illness (x, y, and z, respectively). Liability is a dummy variable equal to 1 if subjects can be sued for medical malpractice and 0 otherwise. ***, **, and * denote significance at the 1%, 5%, and 10% level.

To investigate whether liability pressure is more salient for subjects with a medical background, in Table 5 we run similar regressions adding the interaction term *Liability_Medical* between liability and medical students. Consistent with our non-parametric analysis, the estimation results suggest that medical students respond stronger to the introduction of liability pressure, suggesting that subjects with a medical background are more sensitive than non-medical subjects about the risk of being sued for medical malpractice.

Table 5. Differential effect of medical liability (Medical *vs.* Non-medical students)

	Quantity *q*			
	OLS		Tobit	
	(1)	(2)	(3)	(4)
Medical student	0.278	0.046	0.298	0.045
	(0.216)	(0.202)	(0.226)	(0.203)
Age	-0.019**	-0.019**	-0.021***	-0.021***
	(0.008)	(0.008)	(0.008)	(0.008)
Subject gender	0.145	0.145	0.160	0.160
	(0.120)	(0.121)	(0.127)	(0.127)
Severity of illness	1.469***	1.469***	1.507***	1.507***
	(0.059)	(0.059)	(0.059)	(0.059)
Patient gender	-0.224***	-0.224***	-0.232***	-0.232***
	(0.055)	(0.055)	(0.059)	(0.059)
Liability	1.422***	1.352***	1.504***	1.427***
	(0.119)	(0.134)	(0.125)	(0.141)
Liability_Medical		0.466**		0.510**
		(0.231)		(0.253)
Constant	2.286***	2.321***	2.245***	2.242***
	(0.256)	(0.257)	(0.261)	(0.258)
Observations	2,544	2,544	2,544	2,544
Number of cluster	106	106	106	106
R^2 and Pseudo-R^2	0.335	0.336	0.084	0.085

Columns (1) to (2) report results from OLS regressions and columns (3) to (4) results from Tobit regressions (lower and upper limits are 0 and 10, respectively). Standard errors in parentheses are clustered at the subject level for 106 subjects. FFS is a dummy variable equal to 1 if subjects are paid by FFS and 0 if they are paid by CAP. Medical student and Physician are dummy variables equal to 1 for medical students and physicians, respectively. Subject gender and Patient gender are dummy variables equal to 1 if subjects and patients, respectively, are female and 0 if they are male. Severity of illness is an ordinal variable which takes values 1, 2 and 3 reflecting the three patients' severity of illness (x, y, and z, respectively). Liability is a dummy variable equal to 1 if subjects can be sued for medical malpractice and 0 otherwise. ***, **, and * denote significance at the 1%, 5%, and 10% level.

Then, to better analyze the effect of medical liability in the two payment systems and, thus, to test our behavioural hypothesis 2a, we run OLS regression models on the two balanced subsamples of FFS treatments (left panel of Table 6) and CAP treatments (right panel of Table 6). Overall, the estimation results in Table 6 confirm the previous findings, with the only difference being that the effect of subject gender seems to fade away when moving from FFS to CAP. As for the coefficients of *Liability*, we can see that the point estimate in CAP is slightly higher than that in FFS, though the two coefficients are not statistically different. Therefore, the regression analysis provides only mild support to our behavioural hypothesis 2a.

Table 6. Effect of medical liability under different payment systems

	Quantity *q*			
	OLS: FFS system		OLS: CAP system	
	(1)	(2)	(3)	(4)
Medical student	0.214	0.215	0.338	0.338
	(0.373)	(0.373)	(0.276)	(0.276)
Physician	-0.250	-0.250	0.205	0.205
	(0.397)	(0.397)	(0.263)	(0.263)
Age	-0.059**	-0.059**	0.020**	0.020**
	(0.010)	(0.010)	(0.010)	(0.010)
Subject gender	0.423*	0.423*	-0.129	-0.129
	(0.210)	(0.210)	(0.167)	(0.167)
Severity of illness	1.374***	1.374***	1.565***	1.565***
	(0.071)	(0.071)	(0.064)	(0.064)
Patient gender	-0.333***	-0.333***	-0.115*	-0.115*
	(0.077)	(0.077)	(0.063)	(0.063)
Liability		1.389***		1.454***
		(0.139)		(0.148)
Constant	5.077***	4.382***	0.914***	0.187
	(0.405)	(0.395)	(0.333)	(0.335)
Observations	1,272	1,272	1,272	1,272
Number of cluster	106	106	106	106
R^2	0.284	0.374	0.336	0.442

Columns (1) to (2) report results from OLS regressions for FFS subsample and columns (3) to (4) results from OLS regressions for CAP subsample. Standard errors in parentheses are clustered at the subject level for 106 subjects. Medical student and Physician are dummy variables equal to 1 for medical students and physicians, respectively. Subject gender and Patient gender are dummy variables equal to 1 if subjects and patients, respectively, are female and 0 if they are male. Severity of illness is an ordinal variable which takes values 1, 2 and 3 reflecting the three patients' severity of illness (x, y, and z, respectively). Liability is a dummy variable equal to 1 if subjects can be sued for medical malpractice and 0 otherwise. ***, **, and * denote significance at the 1%, 5%, and 10% level.

Finally and most interestingly from a policy perspective, we investigate how the introduction of medical liability pressure affects the deviation from the efficient quantity of medical services (i.e. $q - q^E$, as defined in Section 4) in the two payment systems (e.g., Brosig-Koch et al., 2017). Table 7 reports the results of regression models with the same covariates as those previously adopted, specifically the left panel for FFS sample and the right panel for CAP sample. Table 7 shows that, under the CAP system, medical liability fosters medical service provision significantly counterbalancing the underprovision in CAP, as indicated by the negative average deviation from the efficient quantity (i.e. *Constant*). In fact, in model (4) the deviation from the efficient quantity gets closer to zero when the medical liability is at play. Differently, under the FFS, the introduction of medical liability causes a further increase in the level of medical provision strongly exacerbating the overprovision in FFS. In model (2), in fact, the deviation from the efficient quantity increases further when the medical liability is at play. Indeed, these findings provide strong support to our behavioral hypothesis 2b. Consistent with our non-parametric analysis, the regression results in Table 7 clearly suggest that, while the increase in the level of medical services induced by the introduction of medical liability in CAP should be welfare enhancing (i.e. getting closer to the efficient level), the increase in FFS should push medical services further away from the welfare maximizing level (i.e. leading to stronger overprovision).

Table 7. Effect of medical liability on overprovision and underprovision

	Deviation from efficient quantity $q - q^E$			
	OLS: FFS system		OLS: CAP system	
	(1)	(2)	(3)	(4)
Medical student	0.215	0.215	0.338	0.338
	(0.373)	(0.373)	(0.276)	(0.276)
Physician	-0.250	-0.250	0.205	0.205
	(0.397)	(0.397)	(0.263)	(0.263)
Age	-0.059***	-0.059**	0.020**	0.020**
	(0.010)	(0.010)	(0.010)	(0.010)
Subject gender	0.423*	0.423*	-0.129	-0.129
	(0.210)	(0.210)	(0.167)	(0.167)
Severity of illness	0.374***	0.374***	0.565***	0.565***
	(0.071)	(0.071)	(0.065)	(0.064)
Patient gender	-0.333***	-0.333***	-0.115*	-0.115*
	(0.077)	(0.077)	(0.063)	(0.063)
Liability		1.390***		1.454***
		(0.139)		(0.148)
Constant	2.744***	2.049***	-1.420***	-2.149***
	(0.405)	(0.395)	(0.333)	(0.335)
Observations	1,272	1,272	1,272	1,272
Number of cluster	106	106	106	106
R^2	0.079	0.187	0.067	0.207

Columns (1) and (2) report results from OLS regressions for FFS subsample and columns (3) to (4) results from OLS regressions for CAP subsample. Standard errors in parentheses are clustered at the subject level for 106 subjects. Medical student and Physician are dummy variables equal to 1 for medical students and physicians, respectively. Subject gender and Patient gender are dummy variables equal to 1 if subjects and patients, respectively, are female and 0 if they are male. Severity of illness is an ordinal variable which takes values 1, 2 and 3 reflecting the three patients' severity of illness (x, y, and z, respectively). Liability is a dummy variable equal to 1 if subjects can be sued for medical malpractice and 0 otherwise. ***, **, and * denote significance at the 1%, 5%, and 10% level.

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' behaviour. 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 behavioural 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 overprovision 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' behaviour. 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' behaviour and induces defensive medical practices, by providing evidence in an experimental setting where it is easier to identify the causal effect on subjects' behaviour 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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Appendix A : Instructions

(Treatment T3: FFS 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.

<u>Experimental Design</u>

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.

<u>Stage III</u>

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 *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 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

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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 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 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.

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 sofware z-Tree during the four treatment of each experimental session. Each treatment is made up by six periods representing the six types of patients involved in the research.

In all the four treatment, subjects are paid thanks to pure payment system, namely Fee-for-Service and Capitation. In the treatment 1 and treatment 2 they face no risk of being sued for medical malpractice, in the treatment 3 and treatment 4 the face the risk of being sued for medical malpractice, according to the following probability function.

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.

Treatment 1 – pure payment system fee-for-service without risk

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 – pure payment system capitation without 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;}   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= 10-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 – 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;}   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 ((10-cost*power(q,2))-sued*10 >0) {Profit=(10-cost*power(q,2))-sued*10;} else {Profit=0;};

Chapter 3

Does medical malpractice liability matter for physicians' behaviour? An experimental evidence for mixed payment systems[20]

[20] This research, is a joint work with Massimo Finocchiaro Castro (University of Reggio Calabria), Calogero Guccio (University of Catania) and Domenico Lisi (University of Catania).

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' 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 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 analyze 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), analyzing 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 behavior 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 analyze 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 analyze 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 analyze the role of medical responsibility in influencing the behavior 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 analyze 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, π(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 ∈ [0,10] for 6 hypothetical patients, heterogeneous in terms of both the severity of illness s ∈ {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:

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

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:

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

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).[21] 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 ($p_{T1FFSvsT2} = p_{T1CAPvsT2} = 0.001$).

[21] 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).

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 (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.

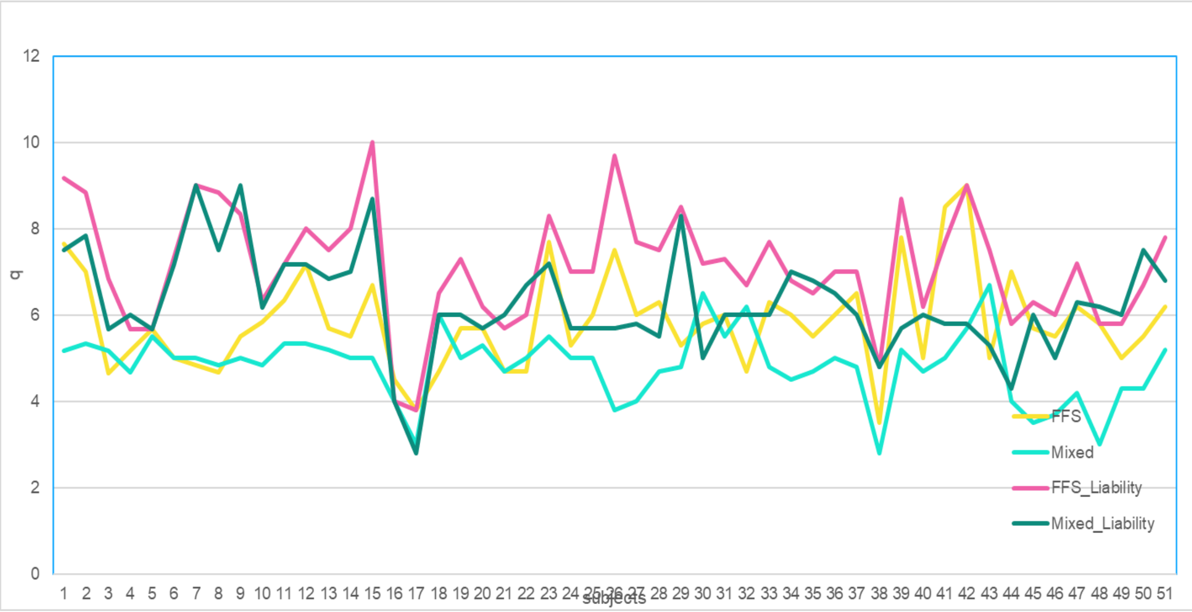

Figure 1 – Part 1

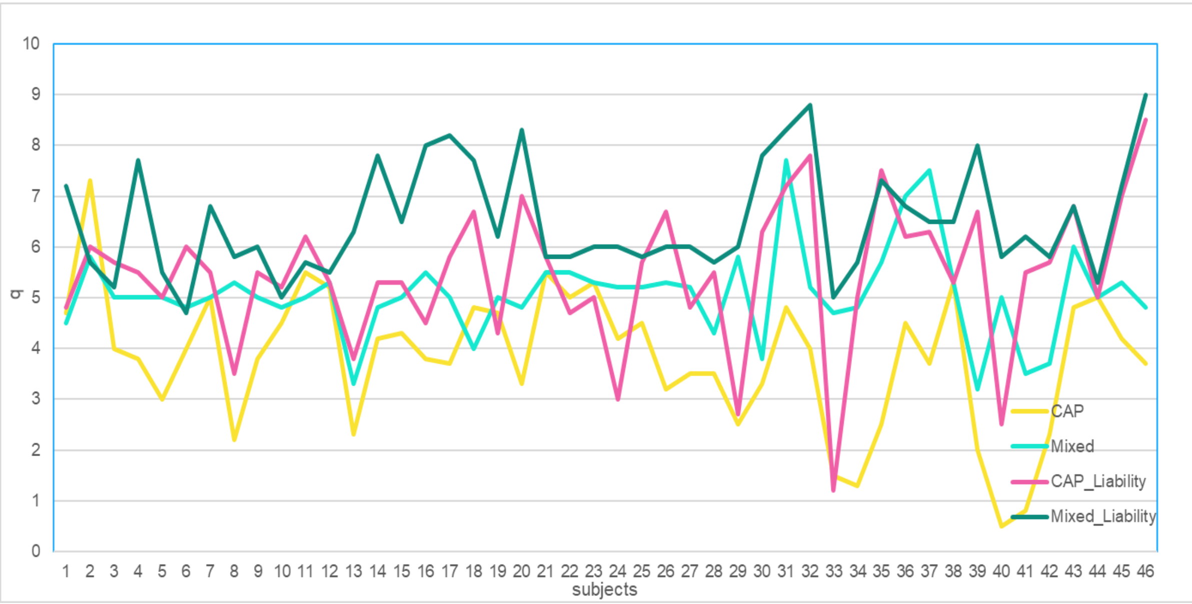

Figure 2 – Part 2

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.

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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;};