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Adverse Selection, Moral Hazard, and Outlier Payment Policy

Michel Mougeot
Florence Naegelen

Abstract

In this article, we analyze the rationale for introducing outlier payments into a prospective payment system for hospitals under adverse selection and moral hazard. The payer has only two instruments: a fixed price for patients whose treatment cost is below a threshold $\widehat{C}$ and a cost-sharing rule for outlier patients. We show that a fixed-price policy is optimal when the hospital is sufficiently benevolent. When the hospital is weakly benevolent, a mixed policy solving a trade-off between rent extraction, efficiency, and dumping deterrence must be preferred. We show how the optimal combination of fixed price and partially cost-based payment depends on the degree of benevolence of the hospital, the social cost of public funds, and the distribution of patients severity.

Introduction

Since 1983, the cost reimbursement system of Medicare has been replaced with a Prospective Payment System (PPS) in the United States. Many European countries (Switzerland, France, Portugal, etc.) are currently implementing such a mechanism under which hospitals are paid a fixed amount per admission for a given diagnosis. As this fixed-price contract makes the hospital residual claimant for its cost savings, it is a high-powered contract that gives the hospital socially optimal incentives to reduce costs and to produce care efficiently in a moral hazard setting.

The drawbacks of this policy are well known. First, quality incentives and cost reduction incentives can work in opposite direction. Ma (1994) and Chalkley and Malcomson (1998a) have shown that the first best level of quality can be achieved by paying the hospital a fixed price per patient treated when the number of patients wanting treatment depends on the quality of care offered. However, this result does

Michel Mougeot is at the University of Franche-Comte, CRESE, UFR SJEPG, and IEMS, University of Lausanne. Florence Naegelen is at the University of Franche-Comte, CRESE, UFR SJEPG. The authors can be contacted via e-mail: michel.mougeot@univ-fcomte.fr and florence.naegelen@univ-fcomte.fr, respectively. We are very grateful to an anonymous referee and to the editor Georges Dionne for helpful remarks on a previous version of this article. The usual disclaimer applies.

not hold when patient demand does not reflect quality (Chalkley and Malcomson, 1998b).[1] Second, whereas a fixed-price contract induces the right amount of cost reducing effort, a cost-plus contract is ideal for rent extraction (Laffont and Tirole, 1993). *Under a fixed-price contract*, any exogenous reduction in cost is received by the hospital and *the hospital's rent is very sensitive to patient's severity*. This issue is very important in practice. Each patient admitted to a hospital is classified according to its condition under one of the DRGs, each DRG representing a case type identifying patients with similar diagnosis as well as with similar major performed procedures. However, many DRGs have substantial within-DRG variance. When the fixed price for a given DRG is calculated on the basis of the average cost incurred for that DRG nationally, the hospital may earn a substantial rent when facing a low-cost patient. In contrast, there is a scope for dumping when facing an excessively costly patient. Hence, either the fixed price is high and the hospital does not refuse to admit patients but obtains a high rent or the fixed price is low (or based on an average cost) and the hospital can refuse admission to some patients if it can observe patients' severity.

Reducing the within-group heterogeneity could be achieved by an increase of the number of groups. However, although a system with more groups would be more accurate, according to Newhouse (2002), the chances that it would ever be introduced are uncertain because of the political difficulties of redistributing money in an established program. In practice, Medicare PPS involves some cost-sharing rules that allow hospitals treating costly patients to be paid more (see McClellan, 1997). For instance, PPS includes one feature that introduces retrospective factors for exceptionally costly patients (i.e., outlier patients). For unusually expensive admissions, hospitals receive an additional payment that is made equal to 80 percent of the accounting costs above some threshold. The threshold is set as to be a given amount above each DRG's mean payment rate and such that outliers payments are 5 percent of the total.[2] An outpatient outlier policy is also implemented with a cost threshold of 2.6 times the fixed price and a marginal payment factor of 50 percent.[3] Thus, the actual payment system can be interpreted as a mixture of fully prospective payment system (for low-cost patients) and partially cost-based payment system (for outlier patients). This combination involves a trade-off between cost efficiency and restricting the phenomenon of patients dumping. Then, it makes the Medicare PPS lower powered than a pure PPS system. According to McClellan (1997), the effects of the outlier payment system on the power of the PPS are substantially larger than might be conveyed by its 5 percent share (see Newhouse, 2002).

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[1] Moreover, when monetary transfers between the payer and the hospital are not possible, there is a conflict between rent extraction and efficiency (Mougeot and Naegelen, 2005).

[2] In other countries, this threshold is characterized by various methods based on the statistical distribution of patients (see Roger France, 2003; Cots et al., 2003). Some rules are based on the quartiles and the interquartile range (Belgium, Sweden, China, and Denmark). Other rules are based on the geometric mean length of stay and on the standard deviation (Austria, Ireland, and Australia). In Switzerland, the trim point is based on the 98th percentile of the Gamma distribution whose median and interquartile range coincide with the median and the interquartile range of the length of stay. However, all theses statistical methods lack economic foundations.

[3] However, a 2004 report to the Congress (Medicare Payment Policy) suggests that this policy should be eliminated because services are generally narrowly defined and low cost.

From a theoretical point of view, the outlier payment issue arises because the regulator or the purchaser cannot use the proper optimal cost sharing contract. As a matter of fact, if we assume that the hospital has private information on patients severity and can exert a non observable cost reduction effort, it would be optimal to offer the hospital a menu of incentive contracts. The hospital facing a low-cost patient should not be given the same contract as facing a high-cost patient. If patients' severity is a continuous parameter, the contract should be tailored to the hospital's information. A menu of linear cost-sharing contracts could compromise between productive efficiency, rent extraction, and patient selection. Under such an optimal mechanism, there is no scope for selection of profitable cases. Moreover, the expected payment could be reduced because of the smaller rent received by the hospital. However, as noted by Chalkley and Malcomson (2002), public sector purchasers of health services in both the United States and the United Kingdom have been reluctant to use cost-sharing contracts. All the more, they do not use optimal Laffont–Tirole type contracts and they have only two instruments, a fixed price per DRG for lower cost patients and a cost sharing rule for a small proportion of patients (outliers). They must also define a threshold $\widehat{C}$ above which a patient is considered as an outlier. Hence, taking this lack of suitable policy tools into account, the main issue is *how to regulate hospitals using only these two instruments*.

Two cases can be considered. On the one hand, when the supplier cannot observe patients' severity, outlier payments serve as insurance and protect hospitals against large losses. This issue has been analyzed in several papers. Ellis and McGuire (1988) have suggested replacing individual-level case outlier payments with payments tied to hospital average loss per case. Keeler, Carter, and Trude (1988) have established an outlier payment formula that minimizes risk for hospitals in the absence of moral hazard. On the other hand, when hospitals are able to identify high-cost patients, outlier payments protect patients against discrimination in admission. Yet, they do not induce the right amount of cost-reduction effort. Ma (1994, 1997) has suggested that a combination of a prospective payment equal to $\widehat{C}$ under $\widehat{C}$ and a cost reimbursement above $\widehat{C}$ could provide ideal cost-reduction incentives when the hospital can refuse to treat high-cost patients. However, as Ma does not take a cost of public fund into account, he does not consider the trade-off between efficiency and rent extraction for patients with a low severity. Hence, under this scheme, the hospital gets all the socially costly rent when treating a patient with a cost lower than $\widehat{C}$. Moreover, a necessary condition for the implementation of Ma's mechanism is that the cost-reduction effort only affects the distribution of the less severe cases so that there is no trade-off between productive efficiency and dumping deterrence for patients with a high severity. In other respects, Chalkley and Malcomson (2002) use the Medicare rule in their econometric study but look neither for the optimal value of $\widehat{C}$ nor for the optimal cost-sharing rule. Hence, despite the issue of outlier payment has received a great deal of attention from different perspectives, *there is no general theoretical characterization of this policy showing how the payer can trade off productive efficiency, rent extraction, and dumping deterrence* when this policy is subject to moral hazard and adverse selection. This is the aim of this article.

In this article, we analyze *the rationale for introducing outlier payments into a PPS system when hospitals can observe patients' severity* and we show what principles should guide the characterization of a mixture of PPS and partially cost-based payment system. We look for a socially optimal policy when the payer cannot observe patients' severity and cannot observe cost reduction effort when this costly effort reduces treatment cost. We assume that the payer has the same three instruments as Medicare: a fixed price p for patients whose treatment cost is below a threshold $\widehat{C}$, the threshold $\widehat{C}$, and a cost-sharing rule a for patients whose treatment cost is greater than $\widehat{C}$. Thus, we look for the optimal values of p, $\widehat{C}$, and a under moral hazard and adverse selection. Our article shows that hospital altruism is a key issue. Our main results are the following. *When the hospital is sufficiently benevolent, a fixed-price policy dominates a mixed policy from a social welfare point of view*. As altruism reduces the hospital's willingness to dump high-cost patients, productive efficiency is the only goal for the payer when the hospital budget is balanced. In contrast, *when the hospital is less benevolent, the mixed policy must be preferred*. According to the degree of benevolence, we show that the payer must solve either a trade-off between efficiency and dumping deterrence or a trade-off between rent extraction, efficiency, and dumping deterrence. In both cases, we characterize the optimal policy, i.e., the optimal level of the fixed price, the optimal threshold, and the optimal cost-sharing rule for outlier patients.

The article is organized as follows. First, the basis model is presented. Then, the optimal piecewise linear mechanisms are analyzed and some extensions are considered. Conclusions are drawn in the last section.

THE MODEL

We consider a health care system in which a public payer (an insurer or a public regulator) has to choose the contract to be offered to a hospital for treatment of patients with a specific diagnosis. We assume that the specified medical conditions are defined by a national DRG classification system and that the within-group heterogeneity in cost is high.[4] Then, under a fixed-price policy, the outlier question can occur. As patients differ according to their treatment cost, the hospital can dump a patient if it observes her severity before choosing to treat her. Thus, the contract offered to the hospital must specify a payment rule such that dumping is deterred.

Assumptions

As we do not consider the quality issue in this article, patients are passive and demand is a random variable. Each patient is characterized by a parameter β that denotes the severity of her illness. β is distributed over $[\underline{\beta}, \overline{\beta}]$ according to a cumulative distribution function $F(.)$ with a continuously differentiable density function $f(.) > 0$, such that $F(.)/f(.)$ is nondecreasing in β.[5] To illustrate some of the basic trade-offs that the payer has to take into account, we assume that the cost to the hospital of treating a type β patient is $C = c + \beta - e$, where e is the cost reduction effort that the hospital manager can exert and c is a common knowledge cost common to all patients.[6] Hence, cost-reduction effort affects the cost level for all levels of severity,

[4] In practice, outlier payments are concentrated in particular DRGs such as high-intensity-treatment DRGs.

[5] This assumption ensures that second-order conditions are satisfied in our model. In contract theory, it ensures the monotonicity of the optimal mechanism.

[6] Our insights carry over to more general settings (see Appendix B).

in contrast to the analysis of Ma (1997). When the hospital can exert effort level e, it incurs a disutility $\varphi(e)$ (in monetary terms) with $\varphi(e)$ differentiable, increasing, strictly convex and such that $\varphi(0) = 0$ and $\varphi'''(e) \geq 0$. As in Laffont and Tirole (1993), we assume that the functional forms of C, F, and φ are common knowledge and that the payer observes the *ex post* cost of treatment. However, he does not know the true value of the severity β and does not monitor the level of cost-reduction effort e. Then, as the optimal contract is subject to moral hazard and adverse selection, the payer cannot disentangle the various components of cost. To focus on the characterization of the outlier payment, we assume that accounting manipulations are perfectly and costlessly monitored and that there is no cost padding.[7]

We assume that the screening costs are small and can be neglected in the analysis.[8] Then, when a patient presents herself for a treatment, the hospital is able to determine the severity before treatment. In contrast, the payer observes only the patient's DRG and the *ex post* cost of treatment. We assume that the payer attaches benefit $V(\beta)$ to having a patient with severity β treated and maximizes an expected utilitarian social welfare function EW equal to the expected value of the sum of the net benefit of the treatment and the hospital's utility $U(e, \beta)$. As health care expenditure is financed by distortionary taxes, transfers from the regulator to the hospital have to be multiplied by $(1 + \lambda)$ where $\lambda > 0$ is the shadow cost of public funds.

When regulation is subject to adverse selection and moral hazard, the optimal mechanism design procedure has been defined by Laffont and Tirole (1993) in the procurement case. In our setting, it consists of a payment rule conditioned on the patient's type announced by the hospital. It involves that the hospital makes truthful announcement and chooses a second best level of effort decreasing with the patient's severity and equal to the full information level of effort for $\beta = \underline{\beta}$. If it is worth treating all patients for the payer, the hospital does not refuse to admit high-cost patients and no specific payment rule for the outliers is necessary. Though this mechanism implies an optimal trade-off between efficiency and rent extraction, it could be costly to implement. As a matter of fact, one does not observe health care authorities offering menu of contracts in practice. Therefore, in the following, we look for the optimal contract that a payer could design when the set of policy tools it can use is restricted to the Medicare rule, i.e.,

1. for patients with cost lower than or equal to a threshold $\widehat{C}$, a fixed price p is paid to the hospital,
2. for outlier patients, i.e., patients with cost higher than a threshold $\widehat{C}$, the hospital receives a payment $t = p + a(C - \widehat{C})$, where C is the realized cost and a is a cost-sharing parameter, with $0 \leq a < 1$.

We assume that the hospital is partially benevolent and trades off its benefit and the benefit for the patients. Let us denote by α the degree to which the hospital takes the

[7] The effect of cost padding on incentives is considered by Laffont and Tirole (1992).

[8] When the screening costs are high, the hospital must decide to incur these costs to be better informed about patients' severity, as in Sappington and Lewis (1999).

patient's interest $V(\beta)$ into account.[9] According to the Hippocratic Oath, physicians have to do everything possible to care patients, which can result in a monetary loss. Under the imperfect agency assumption (Ellis and Mc Guire, 1990), the provider undervalues benefits to the patients relative to its profit, which corresponds to $\alpha < 1$. In the case of a profit-maximizing hospital, this ethical parameter is equal to 0.

Under this mechanism, hospital utility can be written, when a patient of type β is treated and when the hospital exerts an effort level e:

$$U_p(p, \beta, e) = p - c - \beta + e - \varphi(e) + \alpha V(\beta) \quad \text{if } c + \beta - e \leq \widehat{C} \tag{1}$$

$$U_t(p, \beta, e, \widehat{C}, a) = p + (a - 1)(c + \beta - e) - a\widehat{C} - \varphi(e) + \alpha V(\beta) \quad \text{if } c + \beta - e > \widehat{C}. \tag{2}$$

The form of $V(\beta)$ is an open question. For instance, de Fraja (2000) considers that the social benefit decreases with patients' severity. In contrast, there are probably kinds of DRGs where a reasonable benevolent payer would value remedying a larger deficit more than a smaller. Then $V(\beta)$ may be increasing or decreasing. However, we assume that $U'(\beta) < 0$ for all β. This assumption implies that monetary plus nonmonetary cost rises with β faster than benefit $V(\beta)$.[10] Normalizing the hospital's outside opportunity level of utility to 0, the hospital's individual rationality constraint is $U(\beta) \geq 0$.

Medicare Payment Scheme and Hospital Decisions

If $c + \beta - e \leq \widehat{C}$, the hospital faces the fixed-price contract and chooses a first-best level of cost-reduction effort such that

$$\frac{\partial U_p(.)}{\partial e} = 1 - \varphi_e(e^*) = 0. \tag{3}$$

If $c + \beta - e > \widehat{C}$, the hospital faces the outlier payment rule and chooses a level $e^o(a)$ of cost reduction effort such that

$$\frac{\partial U_t(.)}{\partial e} = 1 - a - \varphi_e(e^o) = 0. \tag{4}$$

Then, the hospital faces the fixed-price contract for $\beta \leq \widehat{C} - c + e^*$ and the outlier payment rule for $\beta > \widehat{C} - c + e^o$. As $\varphi_e(.)$ is increasing in e, $e^o < e^*$. As we have ruled out cost padding, the hospital treating a patient with severity β can influence the payment rule only by changing its effort. When $\beta \leq \widehat{C} - c + e^o$, changing the effort from e^* to e^o cannot influence the payment rule, which is the fixed price. In the same way, when $\beta \geq \widehat{C} - c + e^*$, changing the effort from e^o to e^* cannot influence the payment rule. Changing the effort can only influence the payment rule

9 In this article, we assume that the benefit for the patients is evaluated according to the same function by the payer and the hospital. Taking different benefit functions does not change the main results of the article.

10 If $V(\beta)$ is decreasing with β (as in De Fraja, 2000), it is always true. If the payer takes more care of high-cost patients in its objective, it is satisfied for some functions $V(\beta)$.

when $\widehat{C} - c + e^o < \beta < \widehat{C} - c + e^*$. Hence, there exists a unique value $\widehat{\beta}$, $\widehat{C} - c + e^o < \widehat{\beta} < \widehat{C} - c + e^*$, such that the hospital is indifferent between the fixed price and the outlier payment. Taking (1), (2), (3), and (4) into account, $\widehat{\beta}$ is such that $p - c - \widehat{\beta} + e^* - \varphi(e^*) + \alpha V(\widehat{\beta}) = p + (a-1)(c + \widehat{\beta} - e^o) - a\widehat{C} - \varphi(e^o) + \alpha V(\widehat{\beta})$. Then

$$\widehat{\beta} = \widehat{C} - c + e^o + \frac{e^* - \varphi(e^*) - e^o + \varphi(e^o)}{a} \tag{5}$$

$\forall \beta < \widehat{\beta}$, $U_p(p, \beta, e^*) > U_t(p, \beta, e^o, \widehat{C})$, and $C(\beta, e^*) < \widehat{C}$. When $\beta > \widehat{\beta}$, $U_p(p, \beta, e^*) < U_t(p, \beta, e^o, \widehat{C})$ and $C(\beta, e^o) > \widehat{C}$. From (5), there is a one-to-one relationship between $\widehat{\beta}$ and $\widehat{C}$ and $\widehat{C} - c + e^o < \widehat{\beta} < \widehat{C} - c + e^*$.[11]

Consider now the expected welfare achieved when the payer designs the Medicare payment scheme with a fixed price p, a cost-sharing parameter a, and a threshold $\widehat{C}$. It can be written, after excluding altruistic preferences of the hospital to avoid undesirable double counting:[12]

$$\begin{aligned} EW &= \underset{\beta}{E}\, V(\beta) + \int_{\underline{\beta}}^{\widehat{\beta}} \{-(1+\lambda)p + \Pi_p(\beta, e^*)\} f(\beta) d\beta \\ &\quad + \int_{\widehat{\beta}}^{\overline{\beta}} \{-(1+\lambda)(p + a(C - \widehat{C})) + \Pi_t(\beta, e^o)\} f(\beta) d\beta \\ &= \underset{\beta}{E}\, V(\beta) + \int_{\underline{\beta}}^{\widehat{\beta}} \{-(1+\lambda)(C(\beta, e^*) + \varphi(e^*)) - \lambda \Pi_p(\beta, e^*)\} f(\beta) d\beta \\ &\quad + \int_{\widehat{\beta}}^{\overline{\beta}} \{-(1+\lambda)((C(\beta, e^o) + \varphi(e^o)) - \lambda \Pi_t(\beta, e^o)\} f(\beta) d\beta, \end{aligned} \tag{6}$$

with $\Pi_p(\beta, e^*) = U_p(\beta, e^*) - \alpha V(\beta)$ and $\Pi_t(\beta, e^o) = U_t(\beta, e^o) - \alpha V(\beta)$. Note that according to (6), the payer dislikes leaving a monetary rent to the hospital. Then, *rent extraction is one of the payer's goal*. To avoid dumping, a straightforward solution could be to define a fixed price such that the patient $\overline{\beta}$ is not dumped. This contract would induce the optimal level of effort. But, under adverse selection, the hospital would obtain a substantial rent when treating a patient with severity $\beta < \overline{\beta}$. As this rent is costly, the contract must compromise between productive efficiency and rent extraction. Taking (1) and (2) into account, we obtain

$$\begin{aligned} EW &= \underset{\beta}{E}\, V(\beta) - \lambda p - c - E(\beta) + e^* - \varphi(e^*) + \lambda a \int_{\widehat{\beta}}^{\overline{\beta}} F(\beta)\, d\beta \\ &\quad + (1 - F(\widehat{\beta}))(1+\lambda)(e^o(a) - \varphi(e^o(a)) - e^* + \varphi(e^*)) + \lambda a(\widehat{\beta} - \overline{\beta}). \end{aligned} \tag{7}$$

[11] From (5), $\widehat{C} - c + e^o < \widehat{\beta}$ because $e^* - \varphi(e^*) - e^o + \varphi(e^o) > 0$ from the convexity of φ: $\varphi(e^*) - \varphi(e^o) < \varphi_e(e^*)(e^* - e^o) = (e^* - e^o)$. In the same way, $\widehat{\beta} < \widehat{C} - c + e^*$ can be written $\varphi(e^*) - \varphi(e^o) > (1-a)(e^* - e^o)$, which is verified because $\varphi(.)$ is strictly convex: $\varphi(e^o) - \varphi(e^*) < \varphi'(e^o)(e^o - e^*) = (1-a)(e^o - e^*)$.

[12] See Hammond (1987).

For simplicity, we assume in the following that the social value of treating a patient β is so high that it is worth treating it for any $\beta \in [\underline{\beta}, \overline{\beta}]$ and for any value of α.

OPTIMAL PIECEWISE LINEAR MECHANISMS

When designing the outlier payment policy, the payer must choose a threshold $\widehat{\beta} \le \overline{\beta}$, a price p, and a cost-sharing parameter a, $0 \le a \le 1$ maximizing EW in (7) subject to three sets of constraints:

1. The participation (or no dumping) constraints with respect to the lower cost patients. For all patients with severity $\beta \le \widehat{\beta}$, hospital utility must be non negative:

$$U_p(p, \beta, e) = p - c - \beta + e^* - \varphi(e^*) + \alpha V(\beta) \ge 0 \;\forall \beta \le \widehat{\beta}. \tag{8}$$

2. The participation constraints with respect to the outlier patients. For all outlier patients to be treated, hospital utility must be non negative. Then, from (2) and (5):

$$U_t(p, \beta, e, \widehat{C}, a) = p - c + (a - 1)\beta - a\widehat{\beta} + e^* - \varphi(e^*) + \alpha V(\beta) \ge 0 \;\forall \beta \ge \widehat{\beta}. \tag{9}$$

3. The expected budget constraint including hospital's manager compensation:

$$\begin{aligned} B(p, \alpha, \widehat{\beta}, a) = &\int_{\underline{\beta}}^{\widehat{\beta}} \{p - c - \beta + e^* - \varphi(e^*)\} f(\beta) d\beta \\ &+ \int_{\widehat{\beta}}^{\overline{\beta}} \{p + (a - 1)(c + \beta - e^o) - a(c + \widehat{\beta} - e^o) \\ &+ e^* - \varphi(e^*) - e^o + \varphi(e^o) - \varphi(e^o)\} f(\beta) d\beta \ge 0. \end{aligned} \tag{10}$$

Taking our previous results into account, (10) can be written as

$$B(p, \alpha, \widehat{\beta}, a) = p - c - E\beta + e^* - \varphi(e^*) - a \int_{\widehat{\beta}}^{\overline{\beta}} F(\beta) d\beta + a(\overline{\beta} - \widehat{\beta}) \ge 0. \tag{11}$$

As $U(\beta)$ is decreasing in β, $\alpha V'(\beta) < 1 - a \;\forall \beta$. Then the sets of constraints (8) and (9) are satisfied when $U_t(\overline{\beta}) \ge 0$ and can be replaced with

$$U_t(p, \overline{\beta}, e, \widehat{C}, a) \ge 0. \tag{12}$$

Taking (11) into account, expected social welfare can be rewritten as

$$\begin{aligned} EW = \underset{\beta}{E} V(\beta) &- (1 + \lambda)(c + E(\beta) - e^* + \varphi(e^*)) - (1 + \lambda)(1 - F(\widehat{\beta}))(e^* - \varphi(e^*) \\ &- e^o(a) + \varphi(e^o(a))) - \lambda B(p, \alpha, \widehat{\beta}, a). \end{aligned} \tag{13}$$

According to (13), expected social welfare is the difference between the expected value of the benefit of treatment for all patients as perceived by the payer and the hospital and (1) the expected value of the total treatment cost when the hospital exerts the optimal effort level as perceived by the taxpayers plus, (2) the efficiency loss on the outliers as perceived by the taxpayers, and (3) the hospital's monetary rent multiplied by the shadow cost of public funds. Note that the two first terms in (13) are constant.

In the absence of distributional concern ($\lambda = 0$), the optimal mechanism is a fixed-price mechanism for all patients ($\widehat{\beta} = \overline{\beta}$) with $p = c + \overline{\beta} - e^* + \varphi(e^*) - \alpha V(\overline{\beta})$, i.e., with a unit price equal to the cost of the highest cost patient including the disutility of effort less the benefit of this patient as perceived by the hospital. When rent extraction matters ($\lambda > 0$), each of the two constraints (11) and (12) may be active or inactive at the optimum. When (11) is binding and (12) is slack, we have only to consider a budget balancing mechanism. This happens in the case of a strongly benevolent hospital. When (12) is binding and (11) is slack, budget is not balanced. To ensure that outliers are treated, the participation constraint must be binding for the highest cost patient. This happens when the hospital is weakly benevolent. In the intermediate case, both constraints (11) and (12) are binding. Let us consider these three cases.

Strongly Benevolent Hospital

When the budget constraint (11) is binding, expected welfare can be rewritten as

$$\begin{aligned} EW = \underset{\beta}{E}\, V(\beta) &- (1+\lambda)(c + E(\beta) - e^* + \varphi(e^*)) \\ &- (1+\lambda)(1 - F(\widehat{\beta}))(e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a))). \end{aligned} \tag{14}$$

Suppose that the no dumping constraint (12) is slack. As EW is increasing with $\widehat{\beta}$ and decreasing with a, the optimal mechanism is characterized by $a_1 = 0$, $\widehat{\beta}_1 = \overline{\beta}$, and $p_1 = c + E\beta - e^* + \varphi(e^*)$[13] for any value of $\lambda > 0$. The optimal values a_1, $\widehat{\beta}_1$, and p_1 do not depend on the shadow cost of public funds because there is no costly rent of the provider. To ensure budget balancing, *p is equal to the mean value of the DRG's total cost* ($C(E\beta, e^*) + \varphi(e^*)$).[14] As the participation constraint (12) is not binding, we must have

$$\alpha V(\overline{\beta}) > \overline{\beta} - E\beta.$$

As α is the ethical parameter that represents the constant marginal rate of substitution between profit and patient's benefits from treatment, a fixed-price mechanism is optimal under budget balancing when the hospital has a high degree of concern for the patient's benefit (i.e., when α is "high"). Proposition 1 summarizes these results.

Proposition 1: *When the hospital has a high degree of concern for the patient's benefits ($\alpha V(\overline{\beta}) > \overline{\beta} - E\beta$), the optimal mechanism is a fixed-price mechanism, with a price equal to the mean value of the DRG's total cost.*

When the hospital has a sufficient degree of concern for the patient's benefits, prospective payment does not result in dumping. The main reason is that deterring dumping of high-cost patients is less costly than in the case of a weakly benevolent hospital.

[13] Second-order conditions are satisfied for $a_1 = 0$ and $\widehat{\beta} = \overline{\beta}$.

[14] Using a different model without heterogeneity of patients, Ma (1997) shows that the payment is identical to average cost pricing when demand depends on quality and when the degree of altruism is large.

Altruism reduces the hospital's willingness to dump high-cost patients even if it is not reimbursed for its cost provided budget is balanced.[15] Thus, the hospital agrees to losses on high cost patients being offset by gains on low-cost patients as long as the budget is balanced. As the fixed price is equal to the mean value of the total cost $C(e^*) + \varphi(e^*)$ under optimal effort, *high-cost patients are subsidized by low-cost patients*.

This pricing scheme promotes cost reduction, induces the optimal level of effort, and extracts the hospital expected monetary rent. The only rent earned by the supplier is the nonmonetary rent $\alpha E_\beta V(\beta)$ that depends on the degree to which altruism enters the objective function of the hospital. As the hospital is partially benevolent and as its concern for patient's benefit is sufficiently strong, *rent extraction is not a concern*. There is no trade-off between rent extraction, productive efficiency, and dumping deterrence. As productive efficiency is the only goal of the payer, a fixed-price contract is optimal. In this case, expected welfare can be written

$$EW^* = \underset{\beta}{E}V(\beta) - (1+\lambda)(c + E\beta - e^* + \varphi(e^*)).$$

Hence, the expected welfare is equal to the average value of the benefit of treatment for all patients evaluated by both the payer and the hospital less the mean value of the total cost as perceived by the taxpayers.

Weakly Benevolent Hospital

When the hospital has a lower degree of concern for the patient's benefit, i.e., when $\alpha V(\overline{\beta}) < \overline{\beta} - E\beta$, it does not accept high-cost patients being cross-subsidized by low-cost patients. Assume that the participation constraint (12) is binding for $\beta = \overline{\beta}$ and that the budget constraint is slack. After elimination of the multiplier γ associated with (12), the first-order conditions with respect to $\widehat{\beta}$ and $a > 0$ can be written, with $\frac{d(-e^o(a)+\varphi(e^o(a)))}{da} = -a\frac{d(e^o(a))}{da}$

$$-\lambda a F(\widehat{\beta}) + f(\widehat{\beta})(1+\lambda)(e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a))) = 0. \tag{15}$$

$$a\frac{d(e^o(a))}{da}(1+\lambda)(1 - F(\widehat{\beta})) + \lambda\int_{\widehat{\beta}}^{\overline{\beta}} F(\beta)d\beta = 0. \tag{16}$$

Equations (15) and (16) define implicitly the optimal values of the cost-sharing parameter a_2 and of the threshold $\widehat{\beta}_2$. This solution $\{\widehat{\beta}_2 < \overline{\beta}, a_2 > 0\}$ is associated with an outlier policy and must satisfy the second-order conditions.[16] The maximization

[15] The intuition is the same as in Chalkley and Malcomson (1998b), though our model considers the hospital's willingness to dump instead of its willingness to stint on quality.

[16] Sufficient second-order conditions are satisfied under the nondecreasing hazard rate assumption when $\varphi'''(e) \geq 0$ and when

$$\left(e^* - \varphi(e^*) - e^o(a_2) + \varphi(e^o(a_2))\frac{F(\widehat{\beta}_2)f'(\widehat{\beta}_2) - f^2(\widehat{\beta}_2)}{F(\widehat{\beta}_2)}a_2^2(1 - F(\widehat{\beta}_2)\right)\frac{de^o(a_2)}{da_2}$$
$$\times\left(1 + a_2\frac{\varphi'''(e^o(a_2))}{\varphi''^2(e^o(a_2))}\right) > f^2(\widehat{\beta}_2)(e^* - \varphi(e^*) - e^o(a_2) + \varphi\left(e^o(a_2) + a_2\frac{de^o(a_2)}{da_2}\right)^2.$$

Condition $\varphi'''(e) \geq 0$ is usual in incentive theory. It ensures the concavity of the objective function of the principal taking an incentive compatibility constraint into account.

problem has another solution $\{\widehat{\beta}_2 = \overline{\beta}, a = 0\}$, which is a local maximum satisfying the necessary second-order condition. We show in Appendix A that this fixed-price policy is welfare dominated by the outlier policy.

When the hospital treating the highest cost patient gets a utility equal to zero and when the budget constraint is slack, we have $\alpha V(\overline{\beta}) < \overline{\beta} - E\beta - a_2 \int_{\widehat{\beta}_2}^{\overline{\beta}} F(\beta)d\beta$ with a_2 and $\widehat{\beta}_2$ solution of (15) and (16). This is the case of a *low degree of concern for the patient's benefit*. Our results are summarized in Proposition 2 where $\widehat{C}_2$ is the cost threshold associated with $\widehat{\beta}_2$.

Proposition 2: *When the hospital has a low degree of concern for the patient's benefit and when $\varphi'''(e) \geq 0$, the optimal mechanism is characterized by a threshold $\widehat{C}_2$, a cost-sharing rule a_2 for the outlier patients and by a fixed price $p_2 = c + \overline{\beta} - e^* + \varphi(e^*) - \alpha V(\overline{\beta}) + a_2(\widehat{\beta}_2 - \overline{\beta}) = (1 - a_2)C(\overline{\beta}, e^o) + a_2\widehat{C}_2 + \varphi(e^o) - \alpha V(\overline{\beta})$ for patients with cost $C \leq \widehat{C}_2$, where a_2 and $\widehat{\beta}_2$ are solution of (15) and (16).*

These results deserve some comments. The outlier issue arises because of an insufficient concern of the hospital for the patient's benefit. On the one hand, dumping deterrence matters. On the other hand, as the socially costly hospital's rent is positive, *productive efficiency and rent extraction are in conflict*. If the payer selects a fixed price, it must cover the cost of the patient with the highest severity less the benefit of this patient as perceived by the hospital to avoid dumping. Then, $p(\overline{\beta}) = c + \overline{\beta} - e^* + \varphi(e^*) - \alpha V(\overline{\beta})$. Hence, the payer must leave a high rent to the hospital treating a low-cost patient. Under a piecewise mechanism, the fixed-price component $p_2(\widehat{\beta}_2) = p(\overline{\beta}) + a_2(\widehat{\beta}_2 - \overline{\beta})$ is lower than $p(\overline{\beta})$. This involves a lower rent on the patients with severity lower than $\widehat{\beta}_2$ but a higher cost when treating the outliers (because the effort e^o is lower than e^*). This is the result of a *trade-off between productive efficiency, rent extraction, and patient dumping deterrence*: the effort of the hospital is distorted downward for the outliers to reduce the fixed price paid for the patients with low severity and limit the rent earned on these patients. Though our setup is very different, our conclusions are in the line of the results of Ellis and McGuire (1986): *the payer can offset the hospital's decreased weight on patient benefit by increasing the proportion of patients elective to the outlier payment*.[17] In this mechanism, $\widehat{\beta}_2$ and a_2 do not depend on the degree of concern for the patient's benefit whereas the fixed price decreases with the degree of altruism α.[18] However they depend on the probability distribution $F(.)$ and on the social cost of public funds. Differentiating (15) and (16) with respect to λ, it can be shown that $\widehat{\beta}_2$ is decreasing and a_2 is increasing in λ.

Note that Proposition 2 shows that the mechanism proposed by Ma (1997) with $a = 1$ and $p = C(\widehat{\beta})$ is never optimal under our assumptions. With cost reimbursement for $\beta \geq \widehat{\beta}$, $e^o(1) = 0$. Then, from (16), $\widehat{\beta}$ must be equal to $\overline{\beta}$. But this solution cannot

[17] In Ellis and McGuire (1986), the fraction of cost that is reimbursed is equal to the weight on patient benefit.

[18] We have assumed that it is worth treating any patient for any value of α. However, if the expected welfare EW_1 achieved with a strongly benevolent hospital is very low, straightforward computations show that the expected welfare achieved with a weakly benevolent hospital EW_2 is lower than EW_1. In this case, it might be optimal for the payer to let some of the very high cost patients be dumped.

be obtained when the payer has distributional concern. Thus, Ma's result is closely linked to his restrictive assumptions (no social cost of public funds, no effect of cost reduction effort on high costs) implying that there is no trade-off between productive efficiency, rent extraction, and dumping deterrence in his model.

Intermediate Degree of Benevolence

Assume now that both constraints (11) and (12) are binding. This happens when $\overline{\beta} - E\beta - a_2 \int_{\widehat{\beta}_2}^{\overline{\beta}} F(\beta)d\beta \leq \alpha V(\overline{\beta}) \leq \overline{\beta} - E\beta$, i.e., for an *intermediate degree of concern for the patients' benefit*. After elimination of the Kuhn and Tucker multiplier, the threshold $\widehat{\beta}_3$ and the cost-sharing parameter a_3 maximizing expected welfare are given by the solutions of the following system:

$$a_3^2 \frac{\partial e^o}{\partial a}(1 - F(\widehat{\beta}_3)) + \frac{\big(e^* - \varphi(e^*) - e^o(a_3) + \varphi\big(e^o(a_3)\big)\big) f(\widehat{\beta}_3)}{F(\widehat{\beta}_3)} \int_{\widehat{\beta}_3}^{\overline{\beta}} F(\beta)\, d\beta = 0 \quad (17)$$

$$a_3 \int_{\widehat{\beta}_3}^{\overline{\beta}} F(\beta)\, d\beta - \overline{\beta} + E\beta + \alpha V(\overline{\beta}) = 0. \quad (18)$$

According to (18), a fixed-price mechanism cannot be a solution for $\alpha V(\overline{\beta}) < \overline{\beta} - E\beta$. Taking (10) into account, $p(\widehat{\beta}_3) = c + \overline{\beta} - e^* + \varphi(e^*) - \alpha V(\overline{\beta}) + a(\widehat{\beta}_3 - \overline{\beta})$. As second-order conditions are satisfied for $\widehat{\beta}_3$ and a_3 when $\varphi'''(.) \geq 0$, we obtain Proposition 3 where $\widehat{C}_3$ is the cost threshold associated with $\widehat{\beta}_3$.

Proposition 3: *When the hospital has an intermediate degree of concern for the patient's benefit and when $\varphi'''(e) \geq 0$, the optimal mechanism is characterized by a threshold $\widehat{C}_3$, a cost-sharing rule a_3 for the outlier patients and by a fixed price $p_3 = c + \overline{\beta} - e^* + \varphi(e^*) - \alpha V(\overline{\beta}) + a_3(\widehat{\beta}_3 - \overline{\beta}) = (1 - a_3)C(\overline{\beta}, e^o) + a_3\widehat{C}_3 + \varphi(e^o) - \alpha V(\overline{\beta})$ for patients with cost $C \leq \widehat{C}_3$, where a_3 and $\widehat{\beta}_3$ are solutions of (17) and (18).*

As in case 3.1, rent extraction is not a concern. The payer has only to solve a trade-off between efficiency and dumping deterrence. As there is no rent, the optimal values $\widehat{\beta}_3$ and a_3 do not depend on the social cost of public funds. Under our assumptions

$$a_2 \int_{\widehat{\beta}_2}^{\overline{\beta}} F(\beta)d\beta \geq a_3 \int_{\widehat{\beta}_3}^{\overline{\beta}} F(\beta)\, d\beta.$$

The comparison of $\widehat{\beta}_2$ and a_2 with $\widehat{\beta}_3$ and a_3 depends on λ. As a_2 increases with λ and $\widehat{\beta}_2$ decreases with λ, for "high" values of the shadow cost of public funds, $\widehat{\beta}_3$ will be greater than $\widehat{\beta}_2$ and a_3 lower than a_2. For "low" values of the shadow cost of public funds, it is the contrary. Then, there is a value $\widetilde{\lambda}$ under which the piecewise mechanism is characterized by a higher cost-sharing parameter for an intermediate degree of concern for the patient benefit than in the case of a weakly benevolent hospital. Note that in this case, the fixed price, the cost-sharing parameter, and the cost threshold depend on the degree of concern for the patient's benefit.

EXTENSIONS OF THE MODEL

The general principles derived above extend to more realistic settings. First, we have considered the case of a regulated monopoly hospital with a linear cost function. We show in Appendix B how these principles apply to the case of a convex cost function.

To obtain closed-form solutions, we resort to specific assumptions on $C(.)$. Second, one can ask if these results can be applied in a private health insurance system and if a regulator is necessary to implement the optimal linear piecewise mechanism. To answer to this question, assume that there is a single hospital and a single private health insurer. When contracting with the hospital, the insurer faces the same problem as the regulator in our model. However, the insurer does not maximize social surplus and does not take the social cost of public funds into account. Instead, as the insurer is the agent of the patients in this relationship, we can assume that the insurer maximizes the net patients' surplus. In this case, if the insurer designs the payment rule, it is easy to check that the results are unchanged when the hospital has either a strong or an intermediate degree of benevolence. When the supplier is weakly benevolent, the optimal outlier payment policy is given by the solution of the following system:

$$-a F(\widehat{\beta}) + f(\widehat{\beta})(e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a))) = 0$$
$$a \frac{d(e^o(a))}{da}(1 - F(\widehat{\beta})) + \int_{\widehat{\beta}}^{\overline{\beta}} F(\beta)\, d\beta = 0.$$

Comparing these conditions with (15) and (16) shows that the cost sharing parameter should be lower when the policy is applied by a private insurance.

A more complex issue could be a joint analysis of insurance policy and of hospital pricing policy. In our model, we have implicitly assumed that the payer have contracted *ex ante* with the insured patients. If they do not know their health status at the insurance stage, they do not know if they can be low- or high-cost patients. As the optimal outlier payment policy can reduce the payment to the hospital, the cost borne by the insurer is reduced and the insurance premium can be lower. Even in the case of a strongly benevolent supplier, the insureds can *ex ante* accept that low-cost patients subsidize high-cost patients. On the contrary, if the insured agent is better informed on his health status than the insurer (for instance, he knows the probability that he is an outlier if he is ill), the insurer might offer auto selective contracts revealing the health status for any cost of treatment. On the other hand, he might offer different contracts to the hospitals for any distribution of the severity. In this case, it could be better to analyze the insurance policy and the pricing policy simultaneously. As the insurance could act as a platform connecting health care providers and patients under competition, another kind of model based on the two-sided market approach should be used.[19]

Conclusion

In this article, we have characterized the optimal outlier payment policy when a public regulator has only two instruments, a fixed price per DRG for patients with low severity and a cost-sharing contract for outliers. Under moral hazard and adverse selection, the payer must trade off productive efficiency, rent extraction and dumping deterrence. Our results show that the degree α to which the hospital takes the patient's interest into account plays a prominent part. When α is high, hospital's willingness to dump patients with exceptionally high costs is reduced. As the hospital agrees to subsidize high-cost patients by low-cost patients provided its budget is balanced,

[19] On two sided-markets, see, for instance, Rochet and Tirole (2003).

a fixed-price contract is optimal and the outlier issue vanishes. When the hospital is *weakly altruistic,* a fixed-price contract could still be used to induce efficient cost-reduction effort. In order to avoid dumping, the price would be high and this would be costly in terms of rent extraction. Then, *a combination of a fixed-price contract for lower cost patients and of a cost-sharing contract for the outliers must be preferred*. We characterize this policy in two cases according to the value of α. When α is sufficiently high, budget can be balanced. Hence, the optimal threshold and the cost-sharing parameter do not depend on the shadow cost of public funds. When α is low, the regulator must leave a monetary rent to the hospital. *The higher the shadow cost of public funds, the lower the threshold and the higher the cost-sharing parameter*. However, a combination of prospective and cost reimbursement payments (as in Ma, 1997, under restrictive assumptions) is never optimal.

As in Ellis and McGuire (1986), the choice of the optimal policy depends on the degree to which the hospital takes the patient's interests into account. For a profit-maximizing hospital, the optimal policy is analogous to Medicare policy: a fixed price for patients with low severity and a cost-sharing contract for the outliers. For a not-for-profit hospital, the optimal policy depends on the degree of benevolence. According to Newhouse (2002), this parameter may at first not seem to be a policy instrument but several policies debates turn on this issue. α may differ between not-for-profit and for-profit hospitals but also between hospitals with market power and hospitals in a competitive market. As the fixed-price component of the hospital mechanism depends on $\alpha V(\overline{\beta})$, its implementation requires the knowledge of α and of the value to society of treating highest cost patients.[20]

The analysis of this article could be extended in a number of directions. First, as shown in Appendix B, the general principles derived from the linear case extend to more general cost functions. Second, the socially optimal outlier policy could be analyzed under alternative assumptions. For instance, instead of assuming that hospitals observe patient's severity, we could assume that hospitals do not observe patient's severity before accepting the contract. Then the optimal outlier policy should trade off risk sharing, moral hazard, and dumping deterrence. Third, we could consider that screening patients is costly, as Sappington and Lewis (1999). Under an outlier policy, a hospital must decide whether to incur the cost to be better informed about patients' severity. These issues will be considered in further research.

APPENDIX A

Proof of Proposition 2

Taking the first-order conditions (15) and (16) into account, we have to prove that the outlier policy $\{\widehat{\beta}_2 < \overline{\beta},\ a_2 > 0\}$ welfare dominates the fixed-price policy $\{\widehat{\beta}_2 = \overline{\beta},\ a_2 = 0\}$. As (10) is binding, $p_2(\widehat{\beta}_2) = c + \overline{\beta} - e^* + \varphi(e^*) - \alpha V(\overline{\beta}) + a_2(\widehat{\beta}_2 - \overline{\beta}) = p_2(\overline{\beta}) + a_2(\widehat{\beta}_2 - \overline{\beta}) < p_2(\overline{\beta})$. The fixed-price component of the piecewise linear mechanism is lower than the previous fixed price $p_1(\overline{\beta})$. Note that when $\widehat{\beta}_2 = \overline{\beta}$:

[20] The importance of physicians' altruism has been pointed out by Jack (2005), who assumes that the degree of altruism is private information. He derives conditions for the optimal nonlinear cost-sharing mechanisms in the presence of this kind of asymmetric information and shows how it can sometimes be implemented through a menu of linear cost-sharing schemes.

$$EW(\overline{\beta}) = \underset{\beta}{E}V(\beta) + \int_{\underline{\beta}}^{\overline{\beta}} \big(-\lambda p_2(\overline{\beta}) - c - \beta + e^* - \varphi(e^*)\big) f(\beta)\, d\beta,$$

whereas when the payer selects an outlier policy with $\widehat{\beta}_2 < \overline{\beta}$

$$\begin{aligned} EW(\widehat{\beta}_2) &= EW(\overline{\beta}) + \lambda a_2(\overline{\beta} - \widehat{\beta}_2) + \int_{\widehat{\beta}_2}^{\overline{\beta}} \big((1+\lambda)\big(e^o(a_2) \\ &\quad - \varphi\big(e^o(a_2)\big) - e^* + \varphi(e^*)\big) + \lambda a_2(\widehat{\beta}_2 - \beta)\big) f(\beta)\, d\beta \\ &= EW(\overline{\beta}) + (1+\lambda)(1 - F(\widehat{\beta}_2))\big(e^o(a_2) - \varphi\big(e^o(a_2)\big) \\ &\quad - e^* + \varphi(e^*)\big) + \lambda a_2 \int_{\widehat{\beta}_2}^{\overline{\beta}} F(\beta)\, d\beta \end{aligned}$$

Taking (16) into account, we have

$$\begin{aligned} \Delta EW &= EW(\widehat{\beta}_2) - EW(\overline{\beta}) \\ &= \left(e^o(a_2) - \varphi\big(e^o(a_2)\big) - e^* + \varphi(e^*) - a_2^2 \left.\frac{de^o(a)}{da}\right|_{a=a_2} \right)(1+\lambda)(1 - F(\widehat{\beta}_2)). \end{aligned}$$

As $\varphi(e)$ is strictly convex

$$\begin{aligned} \Delta EW &= \left(e^o(a_2) - \varphi\big(e^o(a_2)\big) - e^* + \varphi(e^*) - a_2^2 \left.\frac{de^o(a)}{da}\right|_{a=a_2} \right)(1+\lambda)(1 - F(\widehat{\beta}_2)) \\ &> \left(e^o(a_2) - e^* + \varphi_e\big(e^o(a_2)\big)\big(e^* - e^o(a_2)\big) - a_2^2 \left.\frac{de^o(a)}{da}\right|_{a=a_2} \right)(1+\lambda)(1 - F(\widehat{\beta}_2)) \end{aligned}$$

Then $\Delta EW > (a_2(e^o(a_2) - e^*) - a_2^2 \frac{de^o(a)}{da}|_{a=a_2})(1+\lambda)(1 - F(\widehat{\beta}_2))$. But from (4), $a_2 = 1 - \varphi_e(e^o(a_2)) = \varphi_e(e^*) - \varphi_e(e^o(a_2))$ and $\frac{de^o(a)}{da}|_{a=a_2} = -\frac{1}{\varphi_{ee}}|_{e=e^o}$. Therefore,

$$a_2 \left(e^o(a_2) - e^* - a_2 \left.\frac{de^o(a)}{da}\right|_{a=a_2} \right) = a_2 \left(e^o(a_2) - e^* + \frac{\varphi_e(e^*) - \varphi_e\big(e^o(a_2)\big)}{\varphi_{ee}\big(e^o(a_2)\big)} \right) \geq 0$$

if the marginal disutility of effort is convex, i.e., if $\varphi'''(e) \geq 0$. Thus, a threshold $\widehat{\beta}_2 < \overline{\beta}$ results in a higher welfare than a threshold $\overline{\beta}$. Q.E.D.

APPENDIX B

The Convex Cost Function Case

Let us assume that $C(\beta, e) = c + \beta^3 - e$, where c is a common knowledge cost parameter. Then we obtain the following relationship between $\widehat{C}$ and $\widehat{\beta}$:

$$\widehat{\beta} = \left(\frac{e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a)) + a\widehat{C} - ac + ae^o(a)}{a} \right)^{\frac{1}{3}}.$$

When the payer designs the Medicare payment scheme, expected welfare can be written

$$\begin{aligned} EW = \underset{\beta}{E} V(\beta) - (1+\lambda)(c + E(\beta^3) + e^* - \varphi(e^*)) \\ - (1+\lambda)(1 - F(\widehat{\beta}))(e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a))) - \lambda B(p, \alpha, \widehat{\beta}) \end{aligned}$$

with

$$B(p, \beta, \widehat{\beta}, a) = p - c - E(\beta^3) + e^* - \varphi(e^*) - a \int_{\widehat{\beta}}^{\overline{\beta}} 3\beta^2 F(\beta)\, d\beta + a(\overline{\beta}^3 - \widehat{\beta}^3) \geq 0$$

and

$$U_t(p, a, \widehat{\beta}, a) = p - c + e^* - \varphi(e^*) + (a-1)\beta^3 - a\widehat{\beta}^3 + \alpha V(\beta) \geq 0.$$

As previously, we can distinguish three cases.

(i) When the hospital is *strongly benevolent*, i.e., when $\alpha V(\overline{\beta}) > \overline{\beta} - E\beta^3$, the optimal mechanism is a fixed-price mechanism with a price equal to the mean value of the total cost: $p_1 = c + E\beta^3 - e^* + \varphi(e^*)$.

(ii) When the hospital is *weakly benevolent*, the optimal mechanism is characterized by a threshold $\widehat{\beta}_2$, a cost-sharing rule a_2 for the outlier patients, and by a fixed price $p(\widehat{\beta}_2) = c + \overline{\beta}^3 - e^* + \varphi(e^*) - \alpha V(\overline{\beta}) + a_2(\widehat{\beta}_2^3 - \overline{\beta}^3)$ for the other patients, where a_2 and $\widehat{\beta}_2$ are solutions of

$$\begin{aligned} -3\lambda a \widehat{\beta}^2 F(\widehat{\beta}) + f(\widehat{\beta})(1+\lambda)(e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a))) = 0 \\ a\frac{d(e^o(a))}{da}(1+\lambda)(1 - F(\widehat{\beta})) + \lambda \int_{\widehat{\beta}}^{\overline{\beta}} 3\beta^2 F(\beta)\, d\beta = 0 \end{aligned}$$

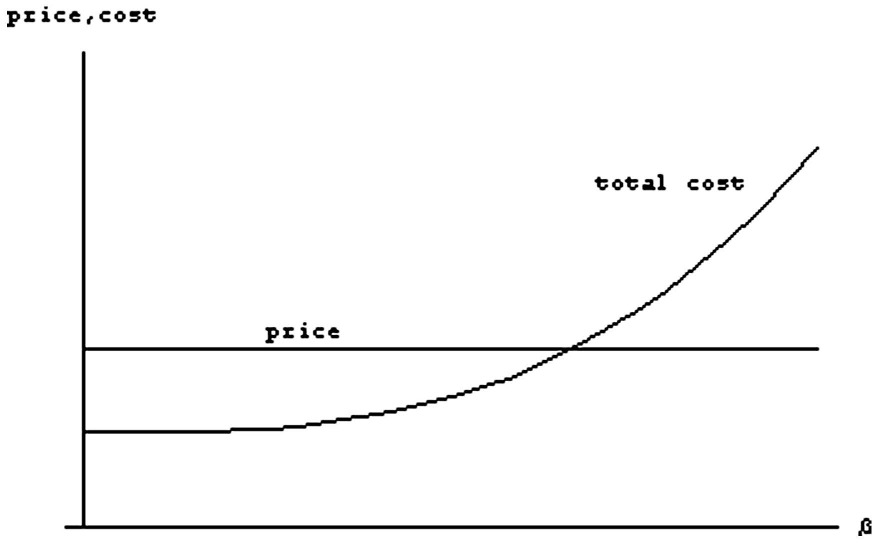
This happens when $\alpha V(\overline{\beta}) < \overline{\beta} - E\beta^3 - a_2 \int_{\widehat{\beta}_2}^{\overline{\beta}} 3\beta^2 F(\beta)\, d\beta$.

(iii) In the intermediate case, the optimal mechanism is characterized by a threshold $\widehat{\beta}_3$, a cost-sharing rule a_3 for the outlier patients, and a fixed price $p(\widehat{\beta}_3) = c + \overline{\beta}^3 - e^* + \varphi(e^*) - \alpha V(\overline{\beta}) + a_3(\widehat{\beta}_3^3 - \overline{\beta}^3)$ for the other patients, where a_3 and $\widehat{\beta}_3$ are solutions of

$$a_3^2 \frac{\partial e^o}{\partial a}(1 - F(\widehat{\beta}_3)) + \frac{(e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a)))f(\widehat{\beta}_3)}{F(\widehat{\beta}_3)} \int_{\widehat{\beta}_3}^{\overline{\beta}} 3\beta^2 F(\beta)\, d\beta = 0$$

$$a_3 \int_{\widehat{\beta}_3}^{\overline{\beta}} 3\beta^2 F(\beta)\, d\beta - \overline{\beta} + E\beta^3 + \alpha V(\overline{\beta}) = 0.$$

FIGURE B1
Strongly Benevolent Hospital



To illustrate these optimal solutions, let us consider an example with $\lambda = \frac{1}{4}$ and $\varphi(e) = \frac{e^3}{3}$. Under a fixed-price mechanism, $e^* = 1$ whereas $e^o(a) = \sqrt{1-a}$ when the hospital faces the outlier payment rule. Hence, $e^* - \varphi(e^*) - e^o(a) + \varphi(e^o(a)) = \frac{2-(a+2)\sqrt{1-a}}{3}$. Let us assume that the severity parameter β is distributed on [0,1] according to a Beta distribution with parameter $m = 5$ and $n = 3$. The density function is given by $f(\beta) = 105\beta^4(1-\beta)^2$ and the cumulative distribution function is $F(\beta) = 21\beta^5 - 35\beta^6 + 15\beta^7$. When $\alpha V(\overline{\beta}) > \frac{17}{24}$, the optimal mechanism is a fixed-price mechanism with $p_1 = 5/8 = 0.625$. This mechanism and total costs are represented in Figure B1.

When the hospital is weakly benevolent ($\alpha V(\overline{\beta}) < 0.397$), let us assume that $\alpha V(\overline{\beta}) = 0.2$. The optimal mechanism is a fixed price $p_2 = 0.816$ for patients with cost $C \leq 0.89$ or severity $\beta < 0.856$ and a cost-sharing rule $t_2 = 0.816 + 0.852(C - 0.89) = 0.816 + 0.852(\beta^3 - 0.275)$ for the outliers whose cost is greater than $\widehat{C} = 0.89$. This mechanism and total costs are represented in Figure B2.

In the intermediate case, i.e., when $17/24 > \alpha V(\overline{\beta}) > 0.397$, let us assume that $\alpha V(\overline{\beta}) = 0.5$. Then the fixed price is $p_3 = 0.624$ for patients with $C < 1$ or severity $\beta \leq 0.908$ and the cost-sharing rule is $t_3 = 0.624 + 0.835(C - 1) = 0.624 + 0.835(\beta^3 - 0.410)$ for the outliers whose cost is greater than $\widehat{C} = 1$. This mechanism and total costs are represented in Figure B3.

In this example, 9.2 and 2.1 percent of the patients are, respectively, elective to outlier payments. Taking total payment $pF(\widehat{\beta}) + \int_{\widehat{\beta}}^{\overline{\beta}} t(\beta) f(\beta)\, d\beta$ and payment reserved for outlier patients into account show that the outlier payments are, respectively, 9.3 and 3.1 percent of the total (whereas the percentage reserved by Medicare for outlier payments is equal to 5 percent).

FIGURE B2
Weakly Benevolent Hospital

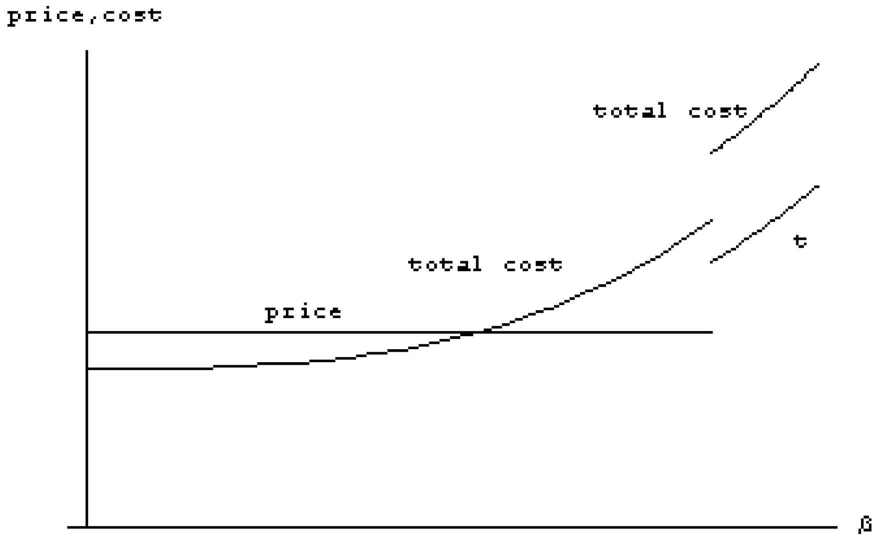
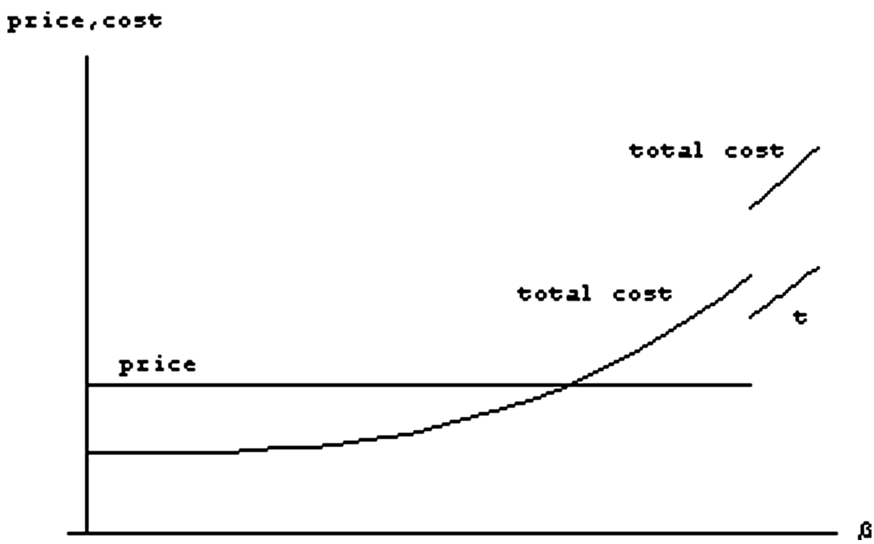


FIGURE B3
Intermediate Degree of Concern for the Patient's Benefit



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