Designing the report card content for healthcare payment reduction[*‡]

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Abstract

We analyze the effect of the content of report cards on the optimal incentivized payment for physicians. We assume that report card disclosure builds a reputation among patients regarding physicians' ability. We compare two disclosure policies: detailed, where patients can recognize which service was provided and the outcome of the advanced treatment; and limited, where patients can distinguish only the physicians who provided the advanced treatment successfully. Our analysis shows detailed disclosure requires a higher expected payment than limited disclosure. Our results imply that non-monetary incentivization (report card) may hurt reducing healthcare payments.

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1 Introduction

Pay-for-performance schemes to incentivize service providers have existed in healthcare markets for decades. However, recent large-scale empirical studies have pointed out that monetary incentives from regulatory authorities have had insignificant effects since the report card disclosure system was introduced, which has become mandatory in many regions (James, 2012). The report card drives patients to form a perception about the providers' ability, and consequently, reputation, which stimulates providers to put in an effort. This mechanism suggests that report card disclosure and pay-for-performance may play substitutive roles. This study analyzes how performance report disclosure and content design affect the healthcare payment system.

The disclosure of hospital report cards for cardiovascular surgery began in 1989 in New York State hospitals and has since spread rapidly outside the state and worldwide. Proponents of report card disclosure argue that it reinforces the incentivization of hospitals and physicians into providing higher-quality healthcare services. However, opponents such as Dranove et al. (2003) noted that report card disclosure increases the dumping of high-severity patients.[1] Similarly, Narins et al. (2005) and Joynt et al. (2012) found that the disclosure of performance reports increases cases of withdrawal of advanced treatment for high-severity patients to avoid a bad reputation for the providers owing to failure. This is because performance reports contain verifiable information, such as 30-day mortality and readmission rates, while the dumped patients' volume and severity are non-verifiable or even non-observable. Then, healthcare providers can manipulate report cards by strategically dumping patients or withdrawing advantageous treatment (Mak, 2017). Therefore, when the regulator discloses provider performance in the report card, providers may need additional payments for advanced treatment in the face of financial loss owing to the potential damage to their reputation from treating high-severity patients.

Another concern is physicians' excessive risk-taking owing to performance disclosure. The literature on organizational economics asserts that agents' reputation-concerned preferences distort

[1] Dranove et al. (2003) empirically showed that the disclosure of performance reports in New York State resulted in out-of-state transfers of high-severity patients.

their task choices leading them to declare that they provide challenging services beyond their competencies (Chen, 2015); therefore, the regulator needs adjustment for healthcare payment in consideration of the avoidance of physicians' reckless behavior. In other words, in light of the report card disclosure policy, additional reimbursement is possibly necessary for conventional treatment. Consequently, report cards may not always help reduce healthcare payments and may require additional reimbursement for physicians. Therefore, this study examines how report cards can change the healthcare payment system with appropriate incentives.

An important discussion in the healthcare market relates to how detailed the report card should be. Brook et al. (2002) stated that consumers, as potential patients, need help to understand the contents of the report card; they cannot utilize this card as a reference to select a hospital (see also Marshall et al., 2003). Therefore, they recommended improving the readability and clarity of the report, for example, by reducing some information on the card. From the perspective of economic theory, some reduction and abstraction of information on the report card may change the patient's belief in the providers' ability, which in turn may trigger a metamorphosis in physicians' strategic behavior. Policymakers, especially those concerned with healthcare payments, then need to consider how to design the report card content, taking into account the effect of a change in their strategic environment.

To examine these issues, we develop a principal–agent model in which the principal is an insurer and the agent, a physician. The insurer does not know the physician's abilities and offers a healthcare payment contract. We consider an environment where two treatment methods exist for a specific disease: conventional and advanced. In the model, the physician can always provide the conventional treatment, which yields an inevitable outcome to patients independent of the physician's ability. However, the advanced treatment is more challenging and requires some specialized equipment. We assume that the physician cannot always provide it owing to the lack of such equipment and that the treatment outcome varies depending on the physician's ability: the low-ability physician is more likely to fail the treatment than the high-ability physician. For such cases, the insurer designs the wage contract to minimize payment within the task allocation constraint such that

advanced treatment is performed only by the high-ability physician, and conventional treatment is performed by the low-ability physician. Under such circumstances, we compare the insurer's payment for two disclosure policies: i) detailed and ii) limited. Under detailed disclosure, the insurer discloses the physician's treatment choice and outcome, even if the physician fails in the advanced treatment. Under limited disclosure, the insurer issues the report card so that patients can distinguish the physician who successfully provided the advanced treatment from the physician with other outcomes (failed in the advanced and provided the conventional treatment).

Through the analysis, we show that, compared with no disclosure, detailed disclosure requires a higher payment for conventional treatment, while there is no change in the payment for advanced treatment. Additionally, limited disclosure saves the payment for the advanced treatment, and the conventional treatment remains the same as under no disclosure. The mechanism behind this result is that the report card damages the reputation of the low-ability physician but helps build the reputation of the high-ability physician. The former effect increases the optimal wage for the conventional treatment, and the latter decreases it for the advanced treatment. Moreover, considering treatment allocation, increasing payment for one treatment requires additional payment for the other. A detailed disclosure depicts the physician type precisely so that the low-ability physician is incentivized to challenge the advanced treatment to avoid reputation damage via report card if there is no monetary compensation for the conventional treatment. Further, the insurer needs to pay some additional reward for the conventional payment, and this effect offsets the payment saving effect for the advanced treatment owing to the report card.

By contrast, limited disclosure, which conveys the physicians' ability relatively vaguely, eases the reputational damage to the low-ability physician owing to the report card. It makes advanced treatment less attractive to low-ability physicians, who may find it difficult to mimic the high-ability ones. Consequently, the insurer does not need to make an additional payment for conventional treatment and can save it for an advanced treatment. Our results suggest that, depending on its information content, the report card may lead to an increase or decrease in healthcare payments. We conclude that the design of report card content is central to aligning physician incentives and

controlling healthcare payments– more information is not always better.

Our analysis contributes to the literature on healthcare information design by clarifying how reputational incentives interact with disclosure policies in shaping optimal payment contracts. A key insight is that greater transparency leads to higher costs: detailed disclosure can backfire by distorting physician incentives and requiring higher payments to sustain efficient task allocation. By contrast, limited disclosure–though less informative–can better align physician incentives with payer objectives.

While patient dumping to improve report card performance is a well-recognized and well-analyzed issue in healthcare markets, we abstract from this behavior in our model. Our focus is on the incentive effects of disclosure content under fixed physician types, homogeneous patients, and full treatment coverage. Addressing patient selection, although beyond the scope of the present study, is a complementary issue for future research.

This study considers that report card disclosure builds the reputation of physicians' abilities while affecting their treatment method choice. In this sense, our study closely relates to the literature on the reputation concern model presented by Holmström (1999), which analyzes an environment wherein agents are unaware of their ability to underinvest in risky projects. Additionally, Chen (2015) found that agents' knowledge of their ability drives an excessively high investment in risky projects. Fu and Li (2014) analyzed the case in which politicians (as agents of citizens) can implement reforms concerning the reputation of their abilities. Their study shows the existence of a semi-separating equilibrium such that low-ability politicians may implement reforms, which is a socially undesirable situation to mimic a high-ability one.

Our research has two key differences from these studies. First, the principal can control the agent's reputation by changing the report card content, and we analyze how the insurer should design the report card content to minimize healthcare payment within the task allocation constraint. Second, we model the joint design of the payment contract and the report card. We show that the content of the report card, shaping the agent's reputation, plays a central role in aligning incentives and should be chosen accordingly.

Some studies have also discussed how information design affects an agent's reputation. For example, Rodiana (2020) explored an environment in which the principal can manipulate the output, which helps develop agents' reputations based on their ability. Additionally, Mak (2017) compared report card disclosure policies and concluded that a statistically adjusted report card triggered more patient dumping than a non-adjusted one. Our study is closely related to these studies, as it considers that the principal can manipulate the contents of the report card for physicians' reputations. However, it goes beyond them to examine the physician's treatment selection and analyze the incentive design to achieve appropriate task allocation.

2 The Model

Consider an environment where an insurer is a principal and a physician is an agent. They are risk-neutral, and the utility of the outside option is normalized to zero. The physician has high ability ($i = H$) with probability $q \in (0, 1)$ and low ability ($i = L$) with probability $1 - q$ (hereafter referred to as H-type and L-type, respectively). The physician-type ratio is common knowledge, but the individual ability is private information. We assume two treatment methods (t), conventional ($t = t^c$) and advanced ($t = t^a$), for a given disease. Conventional treatment consistently brings a certain therapeutic outcome regardless of the physician's ability; however, the result of an advanced treatment t^a is uncertain and depends on the physician's competence. Specifically, the advanced treatment's probability of success is given as p_i with $0 < p_L < p_H < 1$. For notational convenience, we define τ as the outcome for a patient treated by the physician; $\tau = s$, $\tau = f$, and $\tau = c$ denote the success of the advanced treatment, failure of the advanced treatment, and provision of the conventional treatment, respectively.

We further assume an uncertainty regarding the executability of the advanced treatment. The physician cannot provide treatment if a patient's disease does not match the equipment the hospital already has because advanced treatments often require special equipment or facilities, rather than just the physician's ability. However, they can reduce this uncertainty by investing in such

equipment. Therefore, we assume that advanced treatment t^a can be executable with probability $\underline{\theta} \in (0, 1)$, which can be increased to $\bar{\theta} \in (\underline{\theta}, 1)$ by investment at cost $K > 0$.

We further define the physician's payoff function as follows:

$$u := w_\tau + r(\phi) - \alpha K,$$

where w_τ represents the healthcare expenditure paid for by the insurer for outcome τ. $r(\phi)$ is the benefit to the physician owing to their reputation. $\phi \in [0, 1]$ is the probability that the public assumes the physician has high ability. Naturally, being perceived as a H-type physician brings utility, such as self-satisfaction and future patient growth; then, we assume $r'(\cdot) > 0$. Finally, α is an indicator function; if the physician invests in executing the advanced treatment, $\alpha = 1$; otherwise, $\alpha = 0$.

We assume that the insurer is a public organization, and its objective considers both the patient's benefit and loss of the healthcare payment. We define the insurer's expected payoff as follows:

$$\bar{\pi}_i(t) - w_t,$$

where $\bar{\pi}_i(t)$ is the patient's expected utility receiving treatment t by the type-i physician. Concretely, $\bar{\pi}_i(t^a) = p_i\pi(s) + (1 - p_i)\pi(f)$, and $\bar{\pi}_i(t^c) = \pi(c)$, where $\pi(\tau)$ is the patients' utility by outcome τ. To restrict our attention to an interesting case, we assume the following:

Assumption 1.

$$\bar{\pi}_H(t^a) >> \bar{\pi}_H(t^c),\ \bar{\pi}_L(t^c) >> \bar{\pi}_L(t^a).$$

This assumption is satisfied when the following two conditions hold: 1) p_H is high enough and p_L is low enough, and 2) the damage caused by the failure of t^a is sufficiently significant compared with the benefit of t^c. This means that an H-type physician's choice of t^a and the L-type physician's choice of t^c greatly benefit the patients. This assumption ensures that the insurer's objective is to

minimize healthcare expenditure under the task allocation constraint so that the H-type physician executes the advanced treatment, and the L-type physician executes the conventional treatment.[2]

We consider examples of conventional and advanced treatments to better understand how the model applies to healthcare markets. For example, there are many ways to treat ischaemic heart disease. Among these, out-of-hospital medication management with prescription drugs does not require highly specialized equipment, is more routine, and its outcomes are relatively consistent. As it is not physician-dependent, a reporting system is lacking. However, robotic surgery or other novel therapeutic interventions require sophisticated delivery systems, and the outcome is relatively uncertain. It is also highly dependent on the physician's competence. Hence, the insurer provides the procedure-based report card that conveys to consumers which doctors or hospitals performed the procedure.[3]

In this context, our model examines how the insurer designs the payment scheme to incentivize high-ability physicians to provide advanced treatments while encouraging low-ability physicians to focus on conventional treatments. This task allocation minimizes the financial burden on the healthcare system while maintaining or improving patient outcomes. Our purpose is not to prevent physicians from performing any surgery, but rather, to examine the effect of the information content of the report card on the aligned incentives so that physicians undertake procedures that match their competencies.

The insurer also designs the report card's content, which is procedure-based, focusing on the advanced treatment. This study compares two disclosure policies namely detailed ($\Omega = d$) and limited ($\Omega = l$). Under detailed disclosure, the insurer reveals whether the physician performed the advanced treatment and, if so, whether the outcome was successful. Although the report card is procedure-based, patients can identify physicians who performed the conventional treatment because no report card is issued for them.

Under limited disclosure, the insurer reports only on physicians who achieved the most favor-

[2]Note that this assumption ensures that the insurer should design the health care payment system to encourage the H-type physician to invest in equipment for advanced treatment.

[3]For the sake of notation, we call the physician who should not provide the advanced treatment low-type. However, it can provide the conventional treatment with certainty, and has the minimum competence of a physician.

able outcome (s), omitting both failed advanced (f) and conventional treatments (c). Consequently, patients can distinguish between physicians with successful advanced treatments and those with other outcomes, but they cannot differentiate between failed advanced and conventional treatments. Therefore, the report card under limited disclosure is less informative than detailed disclosure. However, from the physician's perspective, limited disclosure helps conceal their ability level, which is particularly beneficial for low-ability (L-type) physicians.[4] Finally, the benchmark is the no-disclosure policy ($\Omega = n$), where the insurer does not issue a report card, and patients cannot infer anything about the physician's ability.[5] Regarding the analysis, we define ϕ_τ^Ω as the probability that patients perceive the physician as high-ability given the outcome τ under the disclosure policy Ω.

We additionally assume that the information on the outcome τ is verifiable, but consumers cannot observe that without the insurer's report card. This assumption reflects that the insurer can gather and interpret the outcome, whereas the consumer cannot owing to lack of expertise and ability. This assumption allows us to consider that the wage contract is conditional on outcome τ, and we denote the wages for the physician with outcome τ under disclosure policy Ω as w_τ^Ω. Finally, we assume the insurer must consider the limited liability constraint of the physician such that $w_\tau^\Omega \geq 0$ for any $\tau = \{s, f, c\}$ and $\Omega = \{d, l, n\}$.

We acknowledge that patients' heterogeneity, such as severity or attribution, is usually assumed. The literature on the report card in healthcare markets discusses how the institutional designer should adjust the index, which is expected to represent the performance of healthcare providers. However, we assume the patient is homogeneous because we focus on how the report card content affects physicians' incentives.

[4]The detailed disclosure assumed in this model reveals both the number of patients the physician treated and the number of patients admitted after treatment. Conversely, the limited disclosure policy only reveals the number of patients treated, omitting information regarding patient admissions. Although this differs from real-world report cards, such as CABG report cards that often report detailed quality indicators (e.g., mortality rates or readmission rates), the core insight of this model is that limiting information—whether about admissions or other aspects of performance—can help reduce healthcare payments. In this context, limited disclosure benefits low-ability physicians by concealing treatment outcomes, therefore reducing reputational damage and the need for higher compensations.

[5]Other disclosure patterns could distinguish physicians who performed conventional treatments or failed the advanced treatment, but these would either be equivalent to detailed disclosure or require higher expected payments.

The timing of the game is as follows:

1. The insurer decides the disclosure policy, Ω, and offers wage contract $\{w_s^\Omega, w_f^\Omega, w_c^\Omega\}$.

2. The physician decides on the facility investment θ.

3. If advanced treatment becomes executable, the physician decides which treatment to execute. If not, the physician executes the conventional treatment.

4. The outcome is realized, and a report card is issued based on the disclosure policy. Additionally, the insurer pays the physician for healthcare expenditures based on the wage contract.

3 Analysis

The insurer must establish two constraints on the wages.[6] The first is an incentive constraint on investment.[7] The optimal wage must satisfy the following constraint to induce the H-type physician to invest for an increase in the feasibility of the advanced treatment.

$$\Delta\theta(p_H[w_s^\Omega + r(\phi_s^\Omega)] + (1 - p_H)[w_f^\Omega + r(\phi_f^\Omega)] - [w_c^\Omega + r(\phi_c^\Omega)]) \geq K, \tag{1}$$

where $\Delta\theta = \bar{\theta} - \underline{\theta} > 0$.

The second constraint is the task choice constraint. The optimal wage must satisfy the following constraint to induce the H-type physician to execute the advanced treatment.

$$p_H[w_s^\Omega + r(\phi_s^\Omega)] + (1 - p_H)[w_f^\Omega + r(\phi_f^\Omega)] \geq w_c^\Omega + r(\phi_c^\Omega). \tag{2}$$

[6]It is optimal to separate treatment for each type of physician as long as Assumption 1 is satisfied. If Assumption 1 is not met, the pooling wage contract, which requires all physicians to provide the same treatment, minimizes payment. However, in this case, the report card does not convey any information about the physician's type under any disclosure policies, rendering our analysis insignificant. To maintain our focus, we eliminate scenarios where Assumption 1 is not satisfied.

[7]Note that the principal does not need to consider the investment IC for the L-type physician as it should not provide the advanced treatment under Assumption 1. Moreover, the L-type physician has no incentive to invest under task choice constraint (3).

Moreover, we consider a constraint wherein L-type physician executes the conventional treatment as follows:

$$w_c^\Omega + r(\phi_c^\Omega) \geq p_L[w_s^\Omega + r(\phi_s^\Omega)] + (1 - p_L)[w_f^\Omega + r(\phi_f^\Omega)]. \tag{3}$$

Given that we have already assumed that the physician is risk-neutral and the wage contract must be under limited liability, the optimal wage for the failure of the advanced treatment is zero, independent of the disclosure policy ($w_f^\Omega = 0$ for any $\Omega = \{n, d, l\}$).[8] We find that (1) always satisfies (2). Then, the binding constraints for the optimal wage are (1) and (3). By solving these constraints, we obtain the optimal wage as follows:

$$w_s^\Omega = -r(\phi_s^\Omega) + r(\phi_f^\Omega) + \frac{K}{\Delta\theta\Delta p}, \tag{4}$$

$$w_c^\Omega = r(\phi_f^\Omega) - r(\phi_c^\Omega) + \frac{p_L K}{\Delta\theta\Delta p}, \tag{5}$$

where $\Delta p = p_H - p_L > 0$. Referring to (4) and (5), we find that making a difference in the reputational utility for outcome τ affects the optimal wage. In the next section, we compare the reputational utility of each disclosure policy with the accompanying optimal wage.

4 Disclosure Policy and Optimal Wage

This section derives the optimal wage under each disclosure policy and investigates how the disclosure changes wages.

No disclosure (Benchmark; $\Omega = n$) Under no disclosure, the insurer does not issue any report card. Therefore, the consumer's belief in the physician's ability is not updated independently of

[8] This nature ensures that the physicians participate in the wage contract without considering additional constraints as the expected wage is always positive, and the utility of the outside option is zero.

the outcome, and

$$\phi_s^n = \phi_f^n = \phi_c^n = q$$

holds. By substituting the above equation into (4) and (5), we obtain the optimal wage as follows:

Lemma 1.

$$w_s^n = \frac{K}{\Delta\theta\Delta p},\ w_c^n = \frac{p_L K}{\Delta\theta\Delta p}.$$

Detailed disclosure ($\Omega = d$) Under the detailed disclosure policy, the insurer issues the report card containing the physician's complete information regarding the outcome. Note that (2) and (3) ensure that all physicians that provided the advanced treatment are of H type, regardless of success or failure. Moreover, the report card indicating that the physician provided conventional treatment shows that the physician was a L-type physician or a H-type physician, but failed to execute the advanced treatment. Therefore, the consumer's updated belief in the physician's ability is:

$$\phi_s^d = \phi_f^d = 1, \phi_c^d = \frac{q(1-\bar{\theta})}{q(1-\bar{\theta}) + (1-q)}.$$

By substituting the belief into (4) and (5), we obtain the optimal wage under detailed disclosure as:

Lemma 2.

$$w_s^d = \frac{K}{\Delta\theta\Delta p},\ w_c^d = \frac{p_L K}{\Delta\theta\Delta p} + [r(1) - r(\phi_c^d)].$$

Limited disclosure ($\Omega = l$) Under the limited disclosure policy, the insurer issues a report card highlighting only the physician with outcome success s. Then, consumers cannot distinguish between physicians with outcomes f and c. Therefore, the following physicians cannot be determined: the H-type physician who failed in the advanced treatment $q\bar{\theta}(1-p_H)$, H-type physicians who invested in but failed to execute the advanced treatment $q(1-\bar{\theta})$, and the L-type physician

$(1-q)$. Therefore, the consumer's updated belief about the physician's ability is as follows:

$$\phi_s^l = 1, \phi_f^l = \phi_c^l = \frac{q[\bar{\theta}(1-p_H) + (1-\bar{\theta})]}{q[\bar{\theta}(1-p_H) + (1-\bar{\theta})] + (1-q)} := \phi^l. \tag{6}$$

By substituting the updated belief into (4) and (5), we obtain the optimal wage under the limited disclosure policy as follows:

Lemma 3.

$$w_s^l = \frac{K}{\Delta\theta\Delta p} - [r(1) - r(\phi^l)],\ w_c^l = \frac{p_L K}{\Delta\theta\Delta p}.$$

We obtain the following result by comparing the optimal wage for each disclosure policy summarized in Lemma 1 to 3:

Proposition 1. $w_s^n = w_s^d > w_s^l,\ w_c^d > w_c^n = w_c^l$.

As (5) shows, the insurer must pay an additional wage for the conventional treatment for the detailed disclosure. This is because performing the conventional treatment indicates that the provider is more likely to be of L-type, damaging the physician's reputation. Additionally, the physician who provided the advanced treatment can be certainly interpreted as H-type by the task allocation constraint, even with a failure outcome. Therefore, the L-type physician is strongly incentivized to mimic the H-type physician by performing advanced treatment regardless of success or failure. Consequently, the insurer needs an additional payment for the conventional treatment so that the L-type physician can provide it. However, we find that no monetary compensation is needed for limited disclosure. Intuitively, the physician who provided the conventional treatment is less perceived as L-type under the limited disclosure than under the detailed ($\phi_c^l > \phi_c^d$), and the damage by the report card is lessened. Moreover, the physician must succeed in advanced treatment to be perceived certainly as H-type; simply providing advanced treatment is not enough. Then, the L-type is not incentivized to provide advanced treatment and continues to provide the conventional treatment without monetary compensation.

Regarding advanced treatment, the report card has two effects on the payment. Under the first, the payment-saving effect, the report card reduces the expected payment as $\phi_s^d = \phi_f^d = \phi_s^l = 1$. The reputational benefit incentivizes the H-type physician instead of the monetary one. Notably, limited disclosure gives the physician a risk that it is not conceived as H-type in the case of failure, while it can be surely reported as H-type under detailed disclosure. Owing to this effect, the insurer can reduce w_s^Ω more under detailed disclosure policy than under limited disclosure. The second effect is the task-allocation effect: w_c^Ω changes w_s^Ω. Even considering reputational utility, the H-type physician would provide the conventional treatment if w_c^Ω is high enough. To ensure task allocation, the insurer must increase w_s^Ω in proportion to the increase in w_c^Ω. Combining the effects, we can conclude that the latter effect offsets the former under detailed disclosure, while the former effect continues under limited disclosure.

The report cards can incentivize physicians to provide advanced treatments without monetary burden to the insurers. Our results additionally highlight the importance of the information on the report cards. Given that the detailed information clears the competence of low-ability physicians, the reputational damage caused by the report card is severe. However, they can compensate for the damage by attempting to provide treatments beyond their competence. Given the physicians' ambition to mimic high ability, insurers must make the extra payment for conventional treatment, which leads to increasing payment for advanced treatment. Therefore, an information disclosure policy that makes the ability of low-type physicians ambiguous for healthcare payment reduction is required. Moreover, such a disclosure policy can make them give up mimicking high-ability physicians. Consequently, insurers can save on the payment for both conventional and advanced treatments.

5 Extension 1: Ex-Ante Effort by Physicians

In the baseline model, we assume that the physician's ability is fixed. However, in practice, its competence can be developed with effort, such as investment in human capital. Ex-ante investment

by physicians is particularly desirable for patients as it drives the diffusion of advanced treatment. In this sense, analyzing how the report card changes a physician's incentive to invest in human capital is meaningful. This section examines the effect of changes in the disclosure policy of report cards on the ex-ante investment level.

We assume that the physician can be an H-type physician with probability q at cost $C(q)$, where $C'(q) > 0$, $C"(q) > 0$, $C(0) = 0$, and $\lim_{q\to 1} C(q) = \infty$. Subsequently, the physician's expected payoff under the disclosure policy Ω is:

$$\begin{aligned} u^{\Omega} := q\left[\bar{\theta}(p_H[w_s^{\Omega} + r(\phi_s^{\Omega})] + (1-p_H)r(\phi_f^{\Omega})) + (1-\bar{\theta})[w_c^{\Omega} + r(\phi_c^{\Omega})] - K\right] \\ + (1-q)[w_c^{\Omega} + r(\phi_c^{\Omega})] - C(q). \end{aligned}$$

By substituting the optimal wage (w_s^{Ω} and w_c^{Ω}) and equilibrium belief of consumers (ϕ_τ^{Ω}) in each disclosure policy, we obtain the following expected payoff.

$$\begin{aligned} u^n &= q\left[\bar{\theta}\left(p_H\left[\frac{K}{\Delta\theta\Delta p} + r(q)\right] + (1-p_H)r(q)\right) + (1-\bar{\theta})\left[\frac{p_L K}{\Delta\theta\Delta p} + r(q)\right] - K\right] \\ &\quad + (1-q)\left[\frac{p_L K}{\Delta\theta\Delta p} + r(q)\right] - C(q) \\ &= [q\bar{\theta}p_H + (1-q\bar{\theta})p_L]\frac{K}{\Delta\theta\Delta p} - qK + r(q) - C(q), \qquad (7) \\ u^d &= q\left[\bar{\theta}\left(p_H\left[\frac{K}{\Delta\theta\Delta p} + r(1)\right] + (1-p_H)r(1)\right) + (1-\bar{\theta})\left(\frac{p_L K}{\Delta\theta\Delta p} + [r(1) - r(\phi_c^d)] + r(\phi_c^d)\right) - K\right] \\ &\quad + (1-q)\left[\frac{p_L K}{\Delta\theta\Delta p} + [r(1) - r(\phi_c^d)] + r(\phi_c^d)\right] - C(q) \\ &= [q\bar{\theta}p_H + (1-q\bar{\theta})p_L]\frac{K}{\Delta\theta\Delta p} - qK + r(1) - C(q), \qquad (8) \\ u^l &= q\left[\bar{\theta}\left(p_H\left[\frac{K}{\Delta\theta\Delta p} - [r(1) - r(\phi^l)] + r(1)\right] + (1-p_H)r(\phi^l)\right) + (1-\bar{\theta})\left[\frac{p_L K}{\Delta\theta\Delta p} + r(\phi^l)\right] - K\right] \\ &\quad + (1-q)\left[\frac{p_L K}{\Delta\theta\Delta p} + r(\phi^l)\right] - C(q) \\ &= [q\bar{\theta}p_H + (1-q\bar{\theta})p_L]\frac{K}{\Delta\theta\Delta p} - qK + r(\phi^l) - C(q). \qquad (9) \end{aligned}$$

Under the no-disclosure policy, the insurer pays as $w_s^n = \frac{K}{\Delta\theta\Delta p}$ and $w_c^n = \frac{p_L K}{\Delta\theta\Delta p}$. Once the report card

is disclosed, the wages are adjusted along the incentive constraints because the physician loses or earns reputational utility. Concretely, the insurer must increase the payment for the conventional treatment by $r(1) - r(\phi_c^d)$ because the L-type physician loses reputational utility under the disclosure policy d. Furthermore, the insurer can save the payment for the advanced treatment by $r(1) - r(\phi^l)$ because the H-type physician earns reputational utility under the disclosure policy l. Consequently, the expected monetary factor is identical across the disclosure policies (the first and second terms are identical between (7), (8), and (9)). Moreover, the expected reputational factor for each outcome is identical under the same disclosure policy (therefore, the coefficient of the third term in (7), (8), and (9) is one.).

Next, the physician's optimization problem is as follows:

$$\max_q u^\Omega.$$

Furthermore, we obtain the first-order conditions for each disclosure policy as follows:
No disclosure ($\Omega = n$):

$$\frac{\bar{\theta}K}{\Delta\theta} - K + r'(\cdot) = C'(q^n).$$

Detailed disclosure ($\Omega = d$):

$$\frac{\bar{\theta}K}{\Delta\theta} - K = C'(q^d).$$

Limited disclosure ($\Omega = l$):

$$\frac{\bar{\theta}K}{\Delta\theta} - K + r'(\cdot)\frac{\partial\phi^l}{\partial q} = C'(q^l).$$

Here, $\frac{\partial\phi^l}{\partial q} = \frac{1-\bar{\theta}p_H}{[q[\bar{\theta}(1-p_H)+(1-\bar{\theta})]+(1-q)]^2} > 0$. By comparing the left-hand side of the first-order conditions, we obtain the following relations for the ex-ante effort q^Ω under the disclosure policy Ω.

Proposition 2.

$$\min\{q^n, q^l\} > q^d.$$

As mentioned, the monetary factor is identical between disclosure policies, but the reputational factor is not. For detailed disclosure, the ex-ante effort by the physician is less beneficial because the wages for conventional treatment w_c^d is compensated with $r(1)$ as a reference, which is constant and independent of q. In other words, the effort will be meaningless for the physician who fails to be H-type, and will provide the conventional treatment. Conversely, the increase in the H-type physician ratio is beneficial for limited disclosure, even for the L-type physician as (6) depicts. In summary, detailed disclosure is disadvantageous from the perspective of payment reduction and the physician's human resource accumulation.

6 Extension 2: Multiple Patients

The previous sections analyze the institutional design of disclosing the report card for a single patient to show that detailed information drives higher healthcare expenditure. We now extend the analysis to consider multiple patient visits and, consequently, variations in the limited disclosure policy. For instance, the insurer issues the report card, highlighting the physician who successfully provided advanced treatment for all or a section of patients.

6.1 The model

We consider the simplest environment where two patients visit the physician. We assume that the patients are homogeneous, and the physician does not change the treatment between patients. Under this assumption, there can be four outcomes namely success with two patients ($\tau = s$), success with only one patient ($\tau = sf$), failure with two patients ($\tau = f$) in advanced treatment, and conventional treatment provided for two patients ($\tau = c$). The limited disclosure policy can

be further divided into two categories, the first allowing patients to identify whether the physician succeeds with at least one patient ($\Omega = l_1$), and the second allowing consumers to identify whether the physician succeeds for two patients ($\Omega = l_2$).

6.2 Analysis

We still put Assumption 1 in this extension analysis. Therefore, we must consider the incentive constraints that prompt the H-type physician to invest, and the L-type physician to provide the conventional treatment as follows:

$$\Delta\theta(p_H^2[w_s^\Omega + r(\phi_s^\Omega)] + 2p_H(1-p_H)[w_{sf}^\Omega + r(\phi_{sf}^\Omega)] + (1-p_H)^2[w_f^\Omega + r(\phi_f^\Omega)] - [w_c^\Omega + r(\phi_c^\Omega)]) \geq K, \tag{10}$$

$$w_c^\Omega + r(\phi_c^\Omega) \geq p_L^2[w_s^\Omega + r(\phi_s^\Omega)] + 2p_L(1-p_L)[w_{sf}^\Omega + r(\phi_{sf}^\Omega)] + (1-p_L)^2[w_f^\Omega + r(\phi_f^\Omega)]. \tag{11}$$

Given that the physician is risk-neutral and faces limited liability, it is optimal to set the wage as $w_{sf}^\Omega = w_f^\Omega = 0$. Moreover, by solving (10) and (11), we obtain the wages w_s^Ω and w_c^Ω as follows:

$$w_s^\Omega = -r(\phi_s^\Omega) + 2\left(1 - \frac{1}{p_H + p_L}\right) r(\phi_{sf}^\Omega) - \left(1 - \frac{2}{p_H + p_L}\right) r(\phi_f^\Omega) + \frac{K}{\Delta\theta\Delta P}, \tag{12}$$

$$w_c^\Omega = \frac{2p_H p_L}{p_H + p_L} r(\phi_{sf}^\Omega) + \frac{p_H + p_L - 2p_H p_L}{p_H + p_L} r(\phi_f^\Omega) - r(\phi_c^\Omega) + \frac{p_L^2 K}{\Delta\theta\Delta P}, \tag{13}$$

where $\Delta P = p_H^2 - p_L^2 > 0$.

6.3 Optimal wage contract

We now derive and compare the optimal wage contract under each disclosure policy.

No disclosure ($\Omega = n$) and detailed disclosure ($\Omega = d$) Under the no-disclosure policy, there is no update about the consumers' belief in the physician's ability for any outcome, as follows:

$$\phi_s^n = \phi_{sf}^n = \phi_f^n = \phi_c^n = q.$$

By substituting this belief into (12) and (13), we obtain the wages as

$$w_s^n = \frac{K}{\Delta\theta\Delta P}, w_c^n = \frac{p_L^2 K}{\Delta\theta\Delta P}.$$

We further derive wages under detailed disclosure ($\Omega = d$). As in the baseline model, the physician who provided advanced treatment is H-type, independent of the outcome. Therefore, the beliefs updated by the report are

$$\phi_s^d = \phi_{sf}^d = \phi_f^d = 1,\ \phi_c^d = \frac{q(1-\bar{\theta})}{q(1-\bar{\theta}) + (1-q)}.$$

By substituting the beliefs into (12) and (13), we obtain the optimal wages as follows:

$$w_s^d = \frac{K}{\Delta\theta\Delta P}, w_c^d = \frac{p_L^2 K}{\Delta\theta\Delta P} + [r(1) + r(\phi_c^d)].$$

Limited disclosure policy ($\Omega = l_1,\ l_2$) Under limited disclosure, consumers' beliefs regarding the physician who failed with only one patient differ for $\Omega = l_1$ and $\Omega = l_2$. In $\Omega = l_1$ policy, the physician who performed advanced treatment on one patient but failed is undoubtedly perceived as the H-type physician. Then, we obtain

$$\phi_s^{l_1} = \phi_{sf}^{l_1} = 1, \phi_f^{l_1} = \phi_c^{l_1} = \frac{q[\bar{\theta}(1-p_H)^2 + (1-\bar{\theta})]}{q[\bar{\theta}(1-p_H)^2 + (1-\bar{\theta})] + (1-q)} := \phi^{l_1}.$$

Regarding $\Omega = l_2$ policy, the physician who failed with only one patient cannot be distinguished as an L-type or H-type physician. Therefore, consumers' beliefs are as follows:

$$\phi_s^{l_2} = 1, \phi_{sf}^{l_2} = \phi_f^{l_2} = \phi_c^{l_2} = \frac{q[\bar{\theta}(1-p_H^2) + (1-\bar{\theta})]}{q[\bar{\theta}(1-p_H^2) + (1-\bar{\theta})] + (1-q)} := \phi^{l_2}.$$

By substituting the updated belief, we obtain the optimal wage for limited disclosure as

$$
\begin{aligned}
w_s^{l_1} &= \frac{K}{\Delta\theta\Delta P} - \left(\frac{2}{p_H + p_L} - 1\right)[r(1) - r(\phi^{l_1})], \\
w_c^{l_1} &= \frac{p_L^2 K}{\Delta\theta\Delta P} + \frac{2p_H p_L}{p_H + p_L}[r(1) - r(\phi^{l_1})], \\
w_s^{l_2} &= \frac{K}{\Delta\theta\Delta P} - [r(1) - r(\phi^{l_2})], \\
w_c^{l_2} &= \frac{p_L^2 K}{\Delta\theta\Delta P}.
\end{aligned}
$$

We compare the wage schemes and obtain the following relations:

Proposition 3. $\max\{w_s^{l_1}, w_s^{l_2}\} < w_s^d = w_s^n$*; in addition,* $w_s^{l_2} > w_s^{l_1}$ *if and only if* $p_H + p_L < \frac{2[r(1)-r(\phi^{l_1})]}{2r(1)-r(\phi^{l_2})-r(\phi^{l_1})}$*. Moreover,* $w_c^n = w_c^{l_2} < w_c^{l_1} < w_c^d$ *holds for any* $0 < p_L < p_H < 1$.

Regarding w_c^Ω, detailed disclosure requires a high wage for the conventional treatment to prevent the L-type physician from providing advanced treatment because the report card strongly damages the physician's reputation, as in the baseline model. Conversely, a more ambiguous report eases the damage caused by the report card because the consumers cannot distinguish the physician who performed advanced treatment in failed or provided the conventional treatment.

Regarding w_s^Ω, the effects of the report card are similar to the baseline model: payment-saving and task-allocation effects. The insurer cannot reduce w_s^d compared with the benchmark because the task-allocation effect completely offsets the payment-saving one. Conversely, the insurer can save w_s^Ω for the two limited disclosure policies. Compared with the two limited disclosure policies, we find that there exists a case where $w_s^{l_1} < w_s^{l_2}$. Intuitively, the physician can be perceived as H-type with higher probability under l_1 policy than under l_2 policy. Then, the insurer benefits from the payment-saving effect by choosing l_1. However, this is possible only when the H-type physician is more likely to obtain the outcome sf than the L-type physician, that is, $p_H + p_L$ is low enough. Otherwise, l_1 policy requires the increase of $w_c^{l_1}$ and $w_s^{l_1}$ to allocate the tasks, which is not optimal in minimizing the payment.

7 Conclusion

This study examines how the optimal reimbursement system changes depending on the completeness of the report cards in the healthcare market. It reveals that limited information disclosure lowers insurance reimbursement. This result suggests that abstracted report card disclosure, currently the subject of intense debate, is desirable for reducing reimbursement.

Future extension studies may consider the following issues. First, they may examine optimal contracting in the case of multiple procedures. Typically, multiple treatments are available for a particular disease. Given that the difficulty level of each treatment differs, the question of which treatment should be assigned to the L-type physician is critical. The reimbursement system when task allocation deviates from the first-best should also be considered. This study considers the first-best task allocation for the primary insurer. However, increasing the reimbursement for this task allocation is necessary because a trade-off between task allocation and reimbursement is implied. Allowing task distortion may reduce fees.

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