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

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Abstract

This study analyzes the effect of the content of report cards on the optimal incentivized payment for physicians. Our analysis assumes that report card disclosure builds a reputation regarding physicians' ability among patients who do not have the expertise to know better. Furthermore, we assume that the insurer designs a payment scheme that designates high-ability physicians to provide advanced treatments and low-ability physicians to provide conventional treatments. We compare the benchmark (no disclosure) with two disclosure policies: detailed, where patients can recognize what service was provided and the outcome of the advanced treatment for all physicians, and limited, where patients can distinguish only the physicians who provided the advanced treatment successfully. Our analysis shows that detailed disclosure requires a higher expected payment than the benchmark, and the insurer can save it by limiting the informativeness of the report. Intuitively, then, detailed disclosure conveys physician type more precisely, and the insurer must pay an additional wage for the conventional treatment provided by low-ability physicians. Our result implies that non-monetary incentivization (report card) may have the opposite effect on reducing healthcare payments.

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1 Introduction

Pay-for-performance schemes have been in existence in healthcare markets to incentivize service providers for decades. However, recent large-scale empirical studies have pointed out that such monetary incentives by regulatory authorities have had no significant effects since the report card disclosure system was introduced and has become mandatory in many regions and cases (James, 2012). The report card leads patients to form a perception about the providers' ability and thus reputation; it also stimulates providers to exert an effort. This phenomenon implies 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 of the state and worldwide. Proponents of report card disclosure argue that it reinforces the incentivization of hospitals and physicians so that they would provide higher-quality healthcare services more positively. On the flip side, as opponents point out, report card disclosure increases the dumping of high-severity patients.[1] Similarly, Narins et al. (2005) and Joynt et al. (2012) find that disclosure of performance reports increases the cases of withdrawal of advanced treatment for high-severity patients to avoid a bad reputation by failure. This happens because performance reports contain verifiable information, such as 30-day mortality and readmission rates. By contrast, the dumped patients' volume and severity are not verifiable or even non-observable. Therefore, 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 view of their financial loss due to their injured reputation in treating high-severity patients.

Another possible problem is physicians' excessive risk-taking due to performance disclosure. In the literature on organizational economics, it is known that agents' reputation-concerned pref-

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

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

An important discussion in the healthcare market on the report card relates to how detailed it should be. Brook et al. (2002) point out that consumers, as potential patients, need help to understand the contents of the report card, and they cannot utilize the report card as a reference in selecting a hospital (see also Marshall et al., 2003). Therefore, they concluded that it is necessary to improve the readability and clarity of the report by, for example, reducing some information on the card. From the perspective of economic theory, a reduction and abstraction of information on the report card may change the patient's belief in the providers' ability. Moreover, this change triggers a metamorphosis in physicians' strategic behavior. Policymakers, especially those concerned with reducing healthcare payments, must consider how to design the report card content while considering the effect of their strategic environment change.

To study these issues, we develop a principal–agent model wherein the principal is an insurer, and the agent is 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 brings an inevitable outcome to patients independent of the physician's ability; however, the advanced is more challenging and requires some specialized equipment. We assume that the physician cannot always provide it due 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 patients can distinguish only 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 to no disclosure, detailed disclosure requires a higher payment for conventional treatment, while there is no change in 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 to 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. 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. Then, we find that the insurer needs to pay some additional reward for the conventional payment. This effect offsets the payment saving effect for the advanced treatment by the report card.

By contrast, limited disclosure, which conveys the physicians' ability relatively more 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 since they may find it difficult to mimic high-ability physicians. Then, 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 the report card may both increase or decrease healthcare payment depending on the report card's information content. We conclude that the insurer must pay attention to the details of the report card

information.

This study considers that report card disclosure builds the reputation of physicians and their ability and affects their treatment method choice. In this sense, our research closely relates to the literature on the reputation concern model presented by Holmström (1999), which analyzes an environment wherein agents who do not know their ability underinvest in risky projects. In addition, Chen (2015) find that agents' knowledge of their ability leads to an excessively high investment in risky projects. Moreover, Fu and Li (2014) analyze 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 the healthcare payment within the task allocation constraint. We reflect on the modeling that, especially in the healthcare market, consumers usually cannot acquire aggregative information about physicians' outcomes without any report card due to their lack of expertise. Second, we focus on how the insurer designs the healthcare payment contract to induce the physicians (agents) to provide the desired treatment. We discuss how the report card content that builds the agent's reputation should be designed to account for these.

Some studies have also discussed how information design affects an agent's reputation. For example, Rodiana (2020) explores an environment wherein the principal can manipulate the output, which helps develop agents' reputation based on their ability. In addition, Mak (2017) compares report card disclosure policies and concludes that a statistically adjusted report card triggers 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 the sake of the physicians' reputation. However, our study examines the physician's treatment selection and analyzes the incentive design to achieve appropriate task allocation, which the previous studies do not consider.

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, we refer to the former as H-type, and the latter as L-type). The physician-type ratio is common knowledge, but the individual ability is private information. We assume two treatment methods (t) for a given disease: conventional ($t = t^c$) and advanced ($t = t^a$). 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, let us 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, not just the physician's ability. However, they can reduce this uncertainty by investing in such equipment. Thus, 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 $K > 0$.

Next, we 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 to 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 look at examples of conventional and advanced treatments to understand better 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 to administer, is more routine, and its outcomes are relatively consistent. As it is not physician-dependent, there is no reporting system for it. On the other hand, robotic surgery or other novel therapeutic interventions require sophisticated delivery systems, and

[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.

the outcome is relatively uncertain. It is also highly dependent on the physician's competence. Hence, the regulator then provides the procedure-based report card that tells 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 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: 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 or not. 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 favorable outcome (s), omitting both failed advanced treatments (f) and conventional treatments (c). As a result, patients can distinguish between physicians with successful advanced treatments and those with other outcomes, but cannot differentiate between failed advanced treatments and conventional treatments. Thus, the report card under limited disclosure is less informative than detailed disclosure. However, from the physician's perspective, limited disclosure helps to conceal their ability level, which is particularly beneficial for low-ability (L-type) physicians.[4] Finally, the benchmark

[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.

[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. In contrast, the limited disclosure policy only reveals the number of patients treated, omitting information about 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

is the no-disclosure policy ($\Omega = n$), where the insurer issues no report card and patients cannot infer anything about the physician's ability.[5] For 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 so without the insurer's report card. This assumption reflects that the insurer can gather and interpret the outcome, whereas the consumer cannot due 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 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.

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. In addition, the insurer pays the physician for healthcare expenditures based on the wage contract.

treatment outcomes, thus 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.

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.

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

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

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

Since 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,

[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 conveys no information about the physician's type under any disclosure policies, rendering our analysis insignificant. To maintain our focus, we will 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 since 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).

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

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 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 the 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. Thus, 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 means 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 the advanced treatment to be perceived certainly as H-type, and simply providing the advanced treatment is not enough. Then, the L-type is not incentivized to provide the advanced treatment and stays on to provide the conventional treatment without monetary compensation.

For 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 since $\phi_s^d = \phi_f^d = \phi_s^l = 1$. The reputational benefit incentivizes the H-type physician instead of the monetary one. Note that limited disclosure gives the physician a risk that it is not conceived as H-type in case of failure, while it can be reported surely as H-type under detailed disclosure. Therefore, due 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. Since 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 challenging 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, we must consider an information disclosure policy that makes the low-ability physicians' ability ambiguous for healthcare payment reduction. Moreover, such 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 have assumed 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 leads to the diffusion of advanced treatment. Analyzing how the report card changes a physician's incentive to invest in human capital is meaningful in this sense. 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 $C'(q) > 0$ and $C"(q) > 0$. Subsequently, the physician's expected payoff under disclosure policy Ω is:

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

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 since the physician loses or earns reputational utility. Concretely, the insurer must increase the payment for the conventional treatment by $r(1) - r(\phi_c^d)$ since the L-type physician loses reputational utility under the disclosure policy d. Furthermore, the insurer can save the payment for the advanced treatment by $r(1) - r(\phi^l)$ since the H-type physician earns reputational utility under the disclosure policy l. As a result, the expected monetary factor is identical across the disclosure policies (the first term and the second term 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 since the wages for the conventional treatment w_c^d is compensated with $r(1)$ as a reference, which is constant and independent of q. Put differently, 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

In the previous sections, we analyzed the institutional design of disclosing the report card for a single patient to show that detailed information leads to 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

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: 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:

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

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

Since 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

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

Next, we derive wages under detailed disclosure ($\Omega = d$). As in the baseline model, the physician who provided the 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 the advanced treatment on one patient but failed is undoubtedly perceived as the H-type physician. Then, we obtain

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

For $\Omega = l_2$ 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 an 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 since the consumers cannot distinguish the physician who performed the advanced in failed or the conventional provided.

For 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 to the benchmark because the task-allocation effect completely offsets the payment-saving one. In contrast, the insurer can save w_s^Ω for the two limited disclosure policies. Compared to 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. Because the difficulty level of each treatment is different, the question of

which treatment should be assigned to the L-type physician is also critical. The second issue to be considered is the reimbursement system when task allocation deviates from the first-best. In this study, we consider 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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