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Payment contracts in a preventive health care system: A perspective from Operations Management

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ABSTRACT

We consider a health care system consisting of two noncooperative parties: a health purchaser (payer) and a health provider, where the interaction between the two parties is governed by a payment contract. We determine the contracts that *coordinate* the health purchaser–health provider relationship; i.e. the contracts that maximize the population's welfare while allowing each entity to optimize its own objective function. We show that under certain conditions (1) when the number of customers for a preventive medical intervention is verifiable, there exists a gate-keeping contract and a set of concave piecewise linear contracts that coordinate the system, and (2) when the number of customers is not verifiable, there exists a contract of bounded linear form and a set of incentive-feasible concave piecewise linear contracts that coordinate the system.

1. Introduction

The purchaser–provider relationship is prevalent in health care delivery systems. In this relationship, a health purchaser (e.g. health insurer) and a health provider (e.g. hospital) enter into a contractual agreement in which the health provider agrees to deliver service to the population being covered, and receive reimbursement from the health purchaser according to a prespecified contract (payment system).

To design health care payment systems, the interactions between the health purchaser and health provider are usually modeled in principal–agent frameworks (Laffont and Martimort, 2001), where a principal (e.g. health purchaser) delegates a task (e.g. providing medical service to the population) to an agent (e.g. health provider). The health purchaser's problem is then to design a contract that provides sufficient incentives to motivate the health provider toward a set of desired actions, such as, the level of treatment intensity that maximizes the patient's prospective health outcomes.

In this paper, we investigate the problem of health care contract design from an Operations Management perspective. We focus on *coordinating contracts*, which have gained significant attention in the Operations Management literature and have proven to be successful in many real-world applications. These are contacts among entities of a system in which a Nash equilibrium optimizes the global system (Cachon, 2003; Weng, 1995; Chick et al., 2008). Here, we extend the notion of coordinating contracts to a preventive health delivery system. In this context, such contracts maximize the population's welfare while allowing both the health purchaser and the health provider to optimize their own objective functions.

1.1. Motivating example

This work is primarily motivated by the influential role of insurer–provider contracts in the utilization of cancer screening tests, with a focus on colorectal cancer screening. Like many other cancers, colorectal cancer (CRC) typically becomes symptomatic once the cancer has progressed to advanced stage and the chance of survival is low. CRC screening tests can identify the cancer at an earlier stage leading to improved survival outcomes and considerably lower treatment costs (Levin et al., 2008; Pignone et al., 2002).

There are several screening tests available for CRC, including the fecal occult blood test (FOBT), flexible sigmoidoscopy, combination of FOBT and flexible sigmoidoscopy, and colonoscopy. The different performance levels of CRC screening tests in terms of cost and effectiveness are well examined in the literature (for instance, refer

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to Levin et al., 2008). The preferred screening test for each individual is determined according to a number of risk factors, such as age, race, gender, and family history of CRC. Take, for instance, an individual with a family history of CRC or previous incidence of adenoma, Colonoscopy is the preferred screening alternative since it yields the best outcomes in terms of costs and life-years saved for this risk category (Levin et al., 2008). Despite this, patient preference for CRC screening is highly sensitive to out-of-pocket costs, including copayments and indirect costs of obtaining the screening tests (Pignone et al., 1999). Therefore, many individuals may select a screening test associated with an inferior outcome or even opt out of screening altogether (Swan et al., 2003; American Cancer Society, 2007).

One solution for improving cancer prevention and early detection practice is to reduce or eliminate co-payments for preventive screening tests (Harvard Center for Cancer Prevention, 2008; Ward et al., 2008). This strategy may aggravate the moral hazard effect especially when providers are reimbursed by fee-for-service contracts. Therefore, health purchasers tend to maintain copayments under these contacts which results in two forms of inefficiency. First, many individuals who would benefit from screening tests are not screened solely because they cannot afford the copayments, and second, many people are induced to undergo testing, despite not benefiting enough from the screening tests.

In addition, in health care markets, providers may have characteristics that are not visible to health purchasers; for instance, different health providers have different cost structures and may serve patients with different risk distributions. These types of heterogeneity in health providers makes designing contracts even more complex, since the data needed to enforce a contract under these conditions become prohibitively costly to collect.

1.2. Research themes

One stream of research on health payment systems focuses on the inefficiencies caused by *hidden information*, such as a case when the purchaser has imperfect knowledge about the cost structure of the provider. These studies aim at identifying incentive-compatible contracts to reduce such inefficiencies (Boadway et al., 2004; Jack, 2005; Shleifer, 1985). Another stream of research focuses on the *hidden action* problem, which occurs when the purchaser cannot observe the provider's actions, such as, the *intensity* of treatment (Fuloria and Zenios, 2001; Ma and McGuire, 1997) or the *quality* of the delivered care (Jack, 2005; Chalkley and Malcomson, 1998; Ma, 1994). Monitoring the quality of treatment and the physician's effort are either not possible or too costly to be worthwhile, and hence usually treated as hidden actions.

When the main objective is to optimize the *global* system, the problem of moral hazard and asymmetric information may be accommodated through "coordinating contracts." Coordinating contracts have gained significant attention in the Operations Management literature (for a comprehensive review, refer to Cachon, 2003). Different types of coordinating contracts have been introduced and investigated including wholesale price contracts (Cachon, 2003), payback contracts (Pasternack, 1985), revenue-sharing contracts (Cachon and Lariviere, 2005), and quantity-discount contract (Weng, 1995). Nonetheless, most of these contracts are developed specifically for manufacturer–supplier or supplier–retailer paradigms, with limited application in health care payment systems.

In this paper, we consider a health care system consisting of a health purchaser and health providers who serve a defined population. The population is assumed to be at risk of contracting or developing a disease for which a preventive medical intervention is available. The population is assumed to be *heterogeneous* with individuals bearing different risks of contracting the disease and different expected morbidity from the disease if acquired. To each individual, we assign a number, called "rank," based on her risk or expected level of morbidity from the disease. During a contractual period, a random number of individuals visit the health provider to potentially consume the preventive medical intervention if prescribed by the health provider. Having observed the health purchaser's contract, the health provider specifies a *threshold* (hidden from the health purchaser) and administers the intervention to individuals of rank below that threshold. The health purchaser then reimburses the health provider based on the number of people who used the preventive intervention during the contractual period.

Our model is a mixed model of *moral hazard* and *asymmetric information*. It is a problem of moral hazard since the threshold specified by the health provider is hidden from the health purchaser, and it is a problem of asymmetric information since the distribution of risk categories in a heterogeneous population served by each health provider is not observable by the health purchaser. In addition, the health purchaser is faced with two-dimensional asymmetric information when the number of customers is not verifiable and the distribution of risk categories is unobservable. Assuming that the health purchaser maximizes her net monetary benefit while the health provider maximizes his profit, we derive coordinating contracts that maximize the population's welfare.

The remainder of this paper is organized as follows: Section 2 details the model and defines the coordinating contracts in the underlying system. In Section 3, we characterize the coordinating contracts and formulate a principal–agent model to determine a set of incentive-compatible coordinating contracts to be offered to the health providers with different patient textures. The models proposed in Section 3 assume that the number of customers is verifiable. In Section 4, we relax this assumption and find the coordinating contracts when the number of customers for the medical intervention is not verifiable by the health purchaser. Section 5 discusses future extensions and concludes the paper.

2. The model and coordinating contracts

We consider a population whose members are at risk of contracting or developing a disease. The population can undergo a preventive intervention, at a price, in order to reduce the risk of developing the disease or to mitigate disease morbidity if acquired. To each individual in the population, we assign a continuous value $\theta \in [0, 1]$, called "rank," such that $100\theta\%$ of population expects to be at a higher risk of contracting the disease or to be affected more severely by the disease. In the context of cancer, for example, an individual with a higher (lower) rank expects less (greater) suffering from cancer, since by definition a higher (lower) percentage of population expects to be affected more severely. Or in immunization against infectious diseases, an individual who is believed to be at trivial risk of contracting the infection is assigned a high rank (close to 1). The details of such rank assignment are given in (Yaesoubi and Roberts, 2010).

Let $q_j(\cdot) \in \Re^+$ be a function returning the expected health of a patient with rank θ who uses alternative $j \in \{0, 1\}$, where $j = 0$ and $j = 1$ denote 'not using' and 'using' the intervention, respectively. The function $q_j(\cdot)$ includes health-related losses that may occur due to the disease or an invasive intervention. Let $v_j(\cdot) \in \Re^+$ be a function returning the expected treatment costs incurred due to the disease for a patient of rank θ who uses alternative $j \in \{0, 1\}$, excluding the cost of the preventive intervention $j = 1$, if obtained.

Let the random variable N denote the number of individuals who visit the health provider during a contractual period to use the preventive medical intervention if prescribed by the health provider.