Integrated Insurance Design in the Presence of Multiple Medical Technologies

Dana Goldman
RAND Corporation
1776 Main St
Santa Monica, CA 90407-2138
dgoldman@rand.org
(310) 451-7017
Fax: (310) 451-7007

and

Tomas J. Philipson (corresponding author)
The Irving B. Harris Graduate School of Public Policy Studies
University of Chicago
1155 E 60th St
Chicago, IL 60637
t-philipson@uchicago.edu
(773) 502-7773
Fax: (773) 702 0926

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Moral hazard in the context of health care has focused on tradeoff between the incentives and risk in the use of medical services. On the one extreme, full insurance leads to over-consumption *ex-post*, because prices are below cost of production. On the other extreme, having the right incentives *ex-post* through cost-based pricing implies there is too much risk-bearing. Thus, as the argument goes, there is a tradeoff between risk-sharing and appropriate incentives in providing insurance that effects medical care use (Mark V, Pauly 1968; Richard Zeckhauser 1970;). A major implication of the standard theory is that risk-sharing, or co-pays, should be higher the smaller and more certain the risk—since insurance is less valuable—and the more elastic the demand for the medical services, since the cost of over-consumption rises. The RAND Health Insurance Experiment (HIE) demonstrated that elasticities for various types of health care services differ--inpatient and outpatient care was the least elastic, whereas use of dental and mental health services were most responsive to changes in co-payments (Joseph P. Newhouse, 1993). This finding partially explains why virtually every health insurer covers hospital and ambulatory care, but not necessarily these other services. Even when such services are covered, they often have much greater cost-sharing.

The generous adoption of new technologies, such as devices and pharmaceuticals, provides a puzzle that seems hard to explain with the traditional theory of moral hazard. This is because those technologies are more price-sensitive and of lower risk than many other medical services that have higher co-pays. Evidence on the demand for many of the most common classes of pharmaceuticals is quite elastic (Geoffrey F. Joyce et al, 2002; Dana P. Goldman et al, 2005). In addition there is often little uncertainty to insure, as demand is predictable for many of the most common drugs that are for chronic conditions, including treatments for cholesterol, high blood pressure, depression, and diabetes, as well as the certain demand for many childhood vaccines.

In this paper, we argue that the standard theory must be extended to explain the generous adoption of new technologies for which there is certain and highly price-sensitive demand. We argue that one must recognize that the insurance of *multiple goods and services* will imply optimally integrated designs that do not have the same implications for the insurance of the goods separately. The optimally

integrated benefit design differs from the standard single good designs by taking into account cross-price elasticities between the several services and goods insured. Even a highly elastic demand for prescription drugs may therefore have low co-pays when drug consumption lowers the use of other medical services. More precisely, holding other factors constant, if a good insured has many other services insured that are substitutable, then its co-pay will be lower than traditionally argued as raising its co-pay will lead to additional use of those other services. By the same argument, if those other services are complimentary, the co-pay of the initial good will be higher.

In the next section, we first reformulate the standard theory of single good moral hazard in a manner that we believe makes more transparent the tradeoff between risk and over-consumption of the insured good. We then provide its multiple good extension and the role of cross-price substitution effects, and discuss their effects on optimal risk-sharing. We then discuss the evidence in support of the importance of such substitution effects as well as conclude by discussing some of the many new applications raised by optimally integrated benefit designs.

I. A Simple Exposition of Moral Hazard Analysis with One Medical Technology

Without loss of generality, let there be two future states, one of sickness and one of health. Let x denote the amount of health care consumed in each state. Let c in [0,1] be the co-payment which is defined as the percent of medical spending in the sick state paid by the insured. Let $U(x,c)$ denote the expected ex-ante utility of consuming x units of health care when sick at co-pay rate c. For an example of such an ex-ante expected utility function, consider a person that has the utility function over health care and alternative consumption y denoted $\mathrm{U}_1(x,y)$ when sick and $\mathrm{U}_0(y)$ when healthy. Given income z and sickness occurs with probability w, then the ex-ante expected utility is:

$$\mathrm{U}(x,c) = w\cdot \mathrm{U}_1\left(x, z-\pi(x,c)-\mathrm{e}(x,c)\right)+(1-w)\cdot \mathrm{U}_0\left(z-\pi(x,c)\right).$$

Here $\pi(x,c) = (1-c)\, w \cdot p \cdot x$ denotes the actuarially-fair premium for the health insurance expense given health care price of *p*. Also, the term $\mathrm{e}(x,c) = c \cdot p \cdot x$ represents out-of pocket expenses at that price. Generally, we only impose modest assumptions on the ex-ante expected utility function *U* in the remaining analysis, assumptions that hold for this particular example. In particular, we assume that $\mathrm{U}(x,c)$ exhibits a *preference for insurance* defined as the *partial derivative* $\mathrm{U}_c(x,c)$ being decreasing. In other words, holding constant the amount of health care utilized when sick, the individual prefers less risk (lower co-payments) when faced with uneven spending across health states. But moral hazard implies that a change in the co-pay leads to a change in health care use (*x*), and thus the *total derivative* of U with respect to *c* can be positive in which case full insurance is not optimal.

I.A. First Best Benefit Design

The first best allocation of health care utilization and insurance occurs when both can be chosen ex-ante without affecting each other. The first best allocation of health care and insurance, denoted (x_F, c_F) therefore satisfies $(x_F, c_F) = \arg\max_{(x,c)} \mathrm{U}(x,c)$. The first-order conditions of this problem directly implies under a preference for insurance that there is no co-pay under the first best allocation, i.e., $c_F = 0$. Full insurance occurs because—given health care utilization—a preference for insurance implies that there is always value in income smoothing.

I.B. Second Best Benefit Design

The second best design occurs when health care utilization cannot be determined ex-ante but is *induced* by the insurance contract. In other words, the insurance determines how much health care spending there is and therefore the optimal second best insurance must take this effect into account. Given the co-pay rate *c*, let the induced health care in each state be denoted by $\mathrm{x}(c)$. Formally, the second best co-pay rate c_s is then determined by not only how it affects insurance but also how it induces health care

ex-post, i.e. $c_S = \arg\max_{(c)} \mathrm{U}\left(\mathrm{x}\left(c\right), c\right)$. The necessary first order condition satisfies the condition: $\frac{dU}{dx} \cdot \frac{dx}{dc} + \frac{dU}{dc} = 0$. This equation exposes the standard moral hazard tradeoff between incentives (first term) and risk (second term) in a more simple manner than traditionally exposed[1]. In particular, fully insured consumption (c=0) may be undesirable because it insures excessive consumption, and no insurance (c=1) may be undesirable because it incurs too much financial risk. As this simple condition reveals, the first best level of full insurance (c=0) obtains only if demand is inelastic, i.e., $\frac{dx}{dc} = 0$. When demand is elastic, a marginal increase in the co-pay reduces expected utility by inducing risk $\left(\mathrm{U}_c < 0\right)$, but balances this increase in risk with the reduction in excessive consumption ex-post. The latter effect is negative because increasing co-pays reduces consumption $\frac{dx}{dc} < 0$ and this reduction is beneficial when additional consumption has a negative impact on expected utility($\frac{d\,\mathrm{U}}{dx} < 0$), as would be the case when there is over-consumption.

This formulation captures the basic, single-good balance between incentives and risk induced by moral hazard. It implies the well known result of moral hazard; namely, that the optimal co-pay should be higher the lower the financial risk and the more sensitive demand is to the co-pays. We will argue that when there are multiple goods insured, this basic implication fails to hold.

II. Moral Hazard with Multiple Medical Technologies

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[1] It follows immediately that there is a welfare loss induced by moral hazard in the sense that the first best level of expected utility is higher than the corresponding second-best level. This occurs since the first-best case involves an unconstrained choice of (x,c) and the second-best case a constrained choice (x(c),c), one that is always feasible in the unconstrained case, but not necessarily optimal.

We now consider the case when there are multiple services or goods being insured. Let there be a *K*-dimensional vector **x** interpreted as the levels of the *K* number of health services utilized and a vector **c** in $[0,1]^K$ as the integrated benefit design which specifies the co-pay rates on all those *K* different services. We denote the corresponding ex-ante expected utility by $\mathrm{U}(\mathbf{x},\mathbf{c})$. Thus there are *K* goods to be insured with demand functions $\left(\mathrm{x}_1(\mathbf{c}),...,\mathrm{x}_K(\mathbf{c})\right)$ where the entire vector **c** may affect each individual demand function depending on substitution patterns. An example of an ex-ante expected utility function would be the direct generalization of the single good example as in:

$$\mathrm{U}(\mathbf{x},\mathbf{c}) = w\cdot \mathrm{U}_1\left(\mathbf{x}, z-\pi(\mathbf{x},\mathbf{c})-\mathrm{e}(\mathbf{x},\mathbf{c})\right)+(1-w)\cdot \mathrm{U}_0\left(z-\pi(\mathbf{x},\mathbf{c})\right).$$

Here the premium generalizes to $\boldsymbol{\pi}(\mathbf{x},\mathbf{c}) = \boldsymbol{w}\cdot\sum_{\boldsymbol{k}=1}^{\boldsymbol{K}}(1-\boldsymbol{c}_{\boldsymbol{k}})\boldsymbol{p}_{\boldsymbol{k}}\boldsymbol{x}_{\boldsymbol{k}}$ where p_k is the price of the k^{th} technology and where out-of-pocket co-pay expenses generalize to $\mathbf{e}(\mathbf{x},\mathbf{c}) = \sum_{\boldsymbol{k}=1}^{\boldsymbol{K}}\boldsymbol{c}_{\boldsymbol{k}}\cdot\boldsymbol{p}_{\boldsymbol{k}}\cdot\boldsymbol{x}_{\boldsymbol{k}}$. The utility function is now generalized to satisfy a preference for insurance whenever all the partials $\frac{\partial \mathbf{U}}{\partial \boldsymbol{c}_{\boldsymbol{k}}}$ are negative for all *k*.

II.A. First Best Benefit Design with Multiple Medical Technologies

We now consider the first-best integrated benefit design. It follows immediately from the necessary first-order conditions that when there is a preference for insurance there is full insurance, that is, the first-best vector of coinsurance satisfies $\boldsymbol{c}_{\boldsymbol{F}} = (0,...,0)$. Note therefore that there is no discrimination across services in co-pays under first best design; they all are fully covered and there is full "parity" in health care coverage.

II.B. Second Best Benefit Design with Multiple Medical Technologies

As before the second best level of the co-pays occurs when they induce consumption ex-post. Now the first-order conditions (FOC) for the optimal second-best co-payment levels are:

$$\sum_{j=1}^{K} \frac{\partial \mathbf{U}}{\partial \boldsymbol{x}_j} \cdot \frac{\partial \boldsymbol{x}_j}{\partial \boldsymbol{c}_k} + \frac{\partial \mathbf{U}}{\partial \boldsymbol{c}_k} = 0 \text{ for all } k=1,\ldots,K.$$

The second term is still negative as an increase in the co-pay c_k raises (undesirable) risk. However, the first term now differs from the single good case when the goods are gross compliments or substitutes, that is, the cross price elasticities $\frac{\partial \boldsymbol{x}_j}{\partial \boldsymbol{c}_k}$ are non-zero. The optimal co-pay for a good now must take into account these substitution patterns across goods. The direct but important implication is that knowing the demand for the insured good alone is no longer sufficient for designing an optimal benefit plan. More precisely, when insurance leads to ex-post over-consumption ($\frac{\partial U}{\partial x_k} < 0$), then *if an insured good has many other insured services that are substitutable, then its co-pay will be lower as lowering the co-pay will lead to less use of those other services. On the other hand, if those other services are complimentary, then co-pay will be higher*. Moreover, the more over-consumed the technology is on the margin (size of $\frac{\partial U}{\partial x_k}$) the more its substitutability matters in the optimal design.

To illustrate, we consider the case where there are two goods, drugs (k=D) and hospital care (k=H) that are substitutes, so greater co-pays for drugs implies more hospital care, under the assumption that patients with chronic disease who do not take their medications are more likely to be hospitalized. The optimal second-best co-pay for drugs must now take into account that hospital care rises when it the co-pay is increased:

$$\underbrace{\frac{\partial \mathrm{U}}{\partial x_D} \cdot \frac{\partial X_D}{\partial c_D} + \frac{\partial \mathrm{U}}{\partial c_D}}_{\text{marginal net benefit of drugs}} + \underbrace{\frac{\partial \mathrm{U}}{\partial x_H} \cdot \frac{\partial x_H}{\partial c_D}}_{\text{hospital offset}} = 0 \qquad (1)$$

The first part of this equation is the single good FOC that equates reduced excessive spending on drugs *in isolation* with the harm imposed by more risk. But now we have a second term incorporating the cross-price effect. This term induces an additional marginal cost (benefit) and thus lowers (raises) the

optimal co-pay compared to the optimal level for the single good in isolation. When hospital care is substitutable and excessive—i.e., provided below cost—then there is an additional marginal cost of raising drug co-pays.

If the elasticity of drug demand is large and the financial risks from drugs are small, then the single-good theory implies drug co-pays should be high. However, this fails to hold if there are offsets in hospital spending due to the increased co-pay for drugs. For example, in the condition above, the FOC may dictate a zero co-pay, or full drug insurance, even though the own price elasticity of drug demand is very high. The key distinction between the single-good and multiple good theory arises from the cross-price elasticities; the drug co-pay falls with the degree of substitutability between drug consumption and of hospital services.

III. Empirical Importance of Cross-Price Elasticities in the case of Drug Consumption

As our theory implies that optimal co-pays rise with the degree of substitutability of other services. It appears that existing evidence generally support this hypothesis for the case of drugs reducing patients' need for other medical services such as hospitalizations and emergency department visits. Stephen B. Soumerai et al (1991) compare Medicaid patients in New Hampshire—for whom the program had imposed a three-drug limit per patient for 11 months—with those of New Jersey where no such cap was introduced. They found a 35% reduction in drug use and a doubling in nursing home admission rates relative to the control group, although there was no significant differences in hospital admissions. For patients on psychotropic medications (Stephen B. Soumerai et al, 1994), they find the cap led to a 15% to 49% reduction in the use of these drugs, and a 43% to 57% increase in mental health visits and emergency mental health services. Susan D. Horn et al (1996) find that formulary limitations in six health maintenance organizations—a selective form of co-pay increase in which co-pays rise to 100% on certain drugs—were associated with increased emergency department visits and hospitalizations for five disease groups: otitis media, atraumatic arthritis, epigastric pain/ulcers, hypertension and asthma.

These studies contrast with results from others (Richard E. Johnson et al , 1997; Robin Tamblyn et al 2000), who find that increased co-pays in various settings did not significantly increase outpatient visits, hospitalizations, or emergency department visits. Martin Gaynor et al (2005), using a sample of beneficiaries with private insurance, find that higher drug co-payments in a given year lead to increased inpatient/outpatient spending during the following year. Overall, a $1 increase in drug co-payments decreases total spending (drug + inpatient + outpatient) by 0.75% in the first year, but increases it by 0.84% in the second year due to increased inpatient and outpatient spending. However, Frank R.Lichtenberg (1996a, 1996b) estimates that an increase of 100 prescriptions is associated with a reduction of 83 deaths, 1.48 hospitalizations, 16.3 hospital days, and 3.36 surgical procedures. While there is a question of endogeneity—certain diagnosis groups are easily treated with drugs, so physicians prescribe more drugs for these conditions—the results are consistent with disaggregated studies.

In sum, the preponderance of evidence suggests strong negative cross-price elasticities between drugs and other medical spending, at least for patients with chronic disease. The behavioral mechanism is almost surely compliance (John A.Rizzo and W. Robert Simons, 1997; L. Wei et al, 2002). For example, Dana P. Goldman et al (2006) investigated the relationship between compliance and subsequent outcomes for patients who had initiated statin therapy in the previous two to five years. They found that full compliance with cholesterol-lowering therapy reduces use of hospital services by 25% among high risk patients, demonstrating a substantial cross-price elasticity between drugs and hospital services among certain chronically-ill populations and for certain drugs. Other studies find similar effects for asthma and diabetes.

IV. Extensions and Applications

In this section we discuss a few of the many additional issues that are raised by integrated designs that we believe would be fruitfully addressed in future research.

VI.1 The Welfare Gains of Integrated Designs

The welfare gains from integrated designs need to be better understood to assess its quantitative magnitude. Consider denoting by z(**c**) the income paid that would make an individual indifferent between plan c and no insurance. Now denote by $\mathbf{c_0}$ the vector of co-pay rates that are optimal when the substitution patterns of **x(c)** are assumed to have zero cross-partials. This would be the traditional benefit design only taking into account own-good moral hazard effects. The willingness to pay for the second best plan $\mathbf{c_S}$, with the actual substitution patterns, over the non-integrated plan, $z(\mathbf{c_S})-z(\mathbf{c_0})$, would then be the welfare gain from benefit design integration. Estimating such welfare gains should be of importance for future research on the optimal integration of benefits.

VI.2 Integrated Designs and Parity Across Health Services

There is often discussion of whether there should be "parity" across different categories of health services, defined as equality in coverage across different types of services, e.g. mental and physical care. Indeed, advocates of mental health parity many times argue that it will save hospitalizations in the future and implicitly therefore seem concerned with cross-price elasticities. In our model, such parity concerns a *lack of differentiation* in co-pays across goods so that **c**=(c,….c). Clearly, such a constrained full parity structure is inferior to the optimal co-pay structure as the same co-pays across goods is feasible, but not necessarily optimal, under an unconstrained structure. It is clear that demand being elastic is *necessary* condition for there to be a welfare loss from parity as when demand is fully inelastic across all goods optimal insurance is full insurance for all goods; a special case of full parity. Work estimating the welfare losses of parity along similar lines of the welfare losses of non-integrated designs is needed to better understand the welfare consequences of parity legislation.

IV.3 Integrated Designs under Public Financing

Although our discussion concerned different medical services at a given point in time, the time-tested strategy of reinterpreting goods implies many other applications. One way to interpret the goods concerns public versus privately financed. In particular, in the US the recent implementation of drug coverage through Medicare Part D may have important spending implications for other parts of the

program, such as Medicare Part A and B (hospital and physician services). An important area of future research concerns the optimally integrated public and privately financed designs .. Another way to interpret the goods are as current and future consumption and thus the integrated designs may differ depending on patient turnover in the plan.

As we hope this discussion illustrates, the analysis of optimal integrated benefit design offers several future avenues of research, should be of major importance for those interested in understanding how existing plans are structured, how the adopt new technologies that are of great value, and or for those attempting to understand how to change the designs of existing plans to raise economic efficiency.

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