

Prevention and Dynamic Risk Adjustment

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Abstract

Risk adjustment deters selection and helps to assure fair and efficient payments among health insurers or capitated provider groups. However, since conventional risk adjustment allocates funds among insurers or regions according to current population health status, it does not reward – indeed, it penalizes – provider preventive efforts that improve population health. This prevention penalty of risk adjustment will become increasingly salient as inter-related trends converge – aging societies, chronic disease epidemics, use of market-based incentives and wider adoption of conventional risk adjustment. We develop a theoretical model of selection and prevention demonstrating this problem with conventional risk adjustment and suggesting a simple alternative that restores incentives for optimal prevention. Dynamic risk adjustment combines conventional risk adjustment with pay-for-performance for prevention.

JEL classification: I1

Keywords: prevention; health promotion; risk adjustment; pay-for-performance

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1 Introduction

We study how to pay for population health improvements when payments to healthcare providers are risk adjusted to compensate for underlying differences in population risk. Risk adjustment is critical to deter selection and to assure fair and efficient payments across differing population groups, including competing insurers or capitated provider groups (van de Ven and Ellis 2000). As healthcare systems around the world experiment with market-based incentives and competition (Cutler 2002), risk adjustment becomes more important. However, existing risk adjustment models are not designed to encourage health promotion and prevention. Rather, conventional formulas allocate funds among insurers, providers, or regions according to current population health status. Such methods fail to take account of and reward provider preventive efforts that improve population health or prevent deterioration of health.

Although no theoretical models have yet addressed this dynamic incentive problem associated with risk adjustment, some researchers have noted the dilemma. For example, in discussing challenges for risk adjustment in the Netherlands, van de Ven, van Vliet, and Lamers (2004) observe that “if (in the future) sickness funds pay providers for their performance – for example, measured by the change in health status of their patients over time – there might be an incentive problem. The better the providers perform in terms of improving health status, the more a sickness fund pays to providers but the lower the next year’s premium subsidies that the sickness fund receives” (p.53).

This paper presents a simple two-period, two-type model of provider risk selection and prevention effort to analyze the prevention disincentives of risk adjustment. We conceive of prevention broadly as any innovation in the technology of health services that slows the pace of health deterioration associated with aging and the natural course of chronic diseases. Thus our model applies to secondary and tertiary forms of prevention as well as primary prevention activities.¹ We illustrate how conventional risk adjustment discourages both selection and prevention. By focusing on current population health, conventional risk adjustment resembles static optimization.

In contrast, dynamic risk adjustment, combining conventional risk adjustment with pay-for-performance on prevention and disease management, enables payers to distinguish between provider activities that make existing patients healthier (prevention) and provider activities that differen-

¹See Kenkel (2000).

tially attract healthier enrollees (risk selection). It deters selection while rewarding innovations in prevention technology and organization. This approach is akin to dynamic optimization, taking account of changes in population risk-mix over time, and encouraging “discovery” of strategies that are not contractible. For diabetes management, for example, interventions that allow more flexible team response to disease progression – such as allowing a pharmacist to adjust medications without awaiting physician approval – have significant (though modest) benefits for glycemic control (Shojania et al. 2006). To encourage experimentation with such disease management “technologies” or organizational innovations, payers need to align payment incentives with quality improvement goals.

In the next section we begin developing our model of provider investment in risk selection and prevention. We show why risk adjustment is necessary to avoid rewarding cream skimming and dumping, but also introduces an incentive problem, discouraging prevention. In our central proposition we define dynamic risk adjustment and show how it combines conventional risk adjustment with a bonus payment for better-than-“expected” prevention performance. The final section discusses related literature, empirical estimation of the dynamic risk adjustment model, analogies to risk adjustment of school vouchers, and theoretical extensions left for future research.

2 A Simple Model of Selection and Prevention

Consider a simple two-period, two-risk type model. In period 0, fraction λ , $0 < \lambda \leq 1$, of the population are L-type patients, and fraction $1 - \lambda$ are H-types. L-types have lower expected costs (c_L) than the H-type patients do (c_H): $c_H > c_L$. The two risk categories can capture a broad range of patient heterogeneity – healthy vs. having a chronic illness, or chronically ill without complications vs. chronically ill with complications. The fraction of the total population who remain low-risk in period 1 depends on the incentives for providers to invest in prevention.

2.1 Selection and prevention

We focus on the selection and prevention choices of a single insurer-provider organization that serves a small fraction of the large population risk pool with average risk characterized by λ .² The

²We refer to the single decision-maker on the supply side as the insurer or provider. Equally appropriate terms would be “regional health authority,” “sickness fund” (as in many European countries), or managed care organization. Analysis of equilibrium competition among multiple insurers is left to future work.

insurer’s total enrollment is assumed to be stable (i.e., in ‘steady state’) and normalized to 1. In period 0, a fraction λ_0 of the insurers’ patients are the relatively healthy L-types. The insurer can invest in measures to attract low-cost patients, so that $\lambda_0 > \lambda$. Examples include locating in a healthier community, selectively advertising, or (in a classic illustration given by Newhouse 1996), stinting on oncologists and employing numerous pediatricians, to avoid expensive cancer patients and attract young families who are better risks. We assume that such selection effort, e , improves the risk-mix of patients, with diminishing returns: $\lambda'_0(e) > 0$, $\lambda''_0(e) < 0$.

For simplicity we conceptualize risk selection as a pure social welfare loss, since creaming and dumping efforts merely redistribute risk among insurer-providers. Thus the socially optimal level of selection is zero.³

In contrast, prevention spending, m , has a true social value: it reduces morbidity loss and saves treatment cost. We assume that consumers transition with probability t from healthy to sick according to a progression of disease influenced by prevention as well as natural factors such as aging. Providers can take some set of preventive actions m that reduce the probability, $t(m)$, that L-types become H-types. Prevention can be primary, secondary, or tertiary. For example, a provider can encourage obese patients to exercise and lose weight to decrease the probability of developing heart disease, diabetes and other related conditions. A provider can also decrease the likelihood of a diabetic person developing complications by regularly monitoring hemoglobin A1c and blood lipid levels, ordering renal screens, etc. Such prevention activities cost the provider m and lower the transition probability at a decreasing rate: $t'(m) < 0$, $t''(m) > 0$. That is, our measure of preventive actions is the provider’s spending on health promotion and screening activities, which exhibits diminishing returns.

A fraction $t(m)$ of consumers becomes sick (H-types) in period two, and fraction $1-t(m)$ remain healthy (L-types). For notational convenience we define $x(m) \equiv 1-t(m)$ to be the probability that low risks remain healthy (L) in the second period. This probability is increasing and strictly concave in prevention: $x'(m) > 0$; $x''(m) < 0$. Figure 1a illustrates the evolution of population risk mix over the two periods of the model, with prevention m increasing the fraction $x(m)$ of L-types who remain L-types in period 1.

³An interesting case to consider would be when some prevention efforts differentially attract low risks and thus constitute selection. Although not explicitly modeled here, this case would be consistent with the design of dynamic risk adjustment, which (as we explain further below) allows providers to use prevention to “buy some selection.” Indeed, the likelihood of overlap between prevention and selection efforts reinforces our argument for linking conventional risk adjustment with payment for prevention.

Adding selection effort, we see in Figure 1b how the provider’s risk mix in period 1 depends on three factors: selection in period 0, the productivity of prevention, and the rate of turnover. Assume that a fraction τ of patients leave after period 0, with $0 \leq \tau < 1$ (i.e., turnover is less than 100%). Since we are modeling a ‘steady state,’ each person who leaves is replaced by a new patient who was treated by a different provider in period 0. The level of prevention among other providers is assumed to be a baseline level, normalized to zero.

For concreteness, think of selection in this model as an up-front investment in the characteristics of the provider-insurer. In addition to the aforementioned example of hiring many pediatricians but few oncologists, selection could mean investing in excellent acute care, but eschewing a reputation for treatment of depression or HIV/AIDS. As a result, selection e attracts the same mix of L and H in both periods. The effect of turnover is not through attracting a different risk mix; the same proportion of L and H enroll in period 1 as in period 0. The effect of turnover occurs completely through differences in prevention between the modeled provider (who chooses m) and other providers (who choose baseline prevention). Turnover means the modeled provider loses some L types who are quite likely to remain L types, and in their place enrolls L types who received a lower level of prevention in period 0 and therefore are more likely to become H-types in period 1.

With these assumptions, the fraction of the provider’s patients who are low risk in period 1 includes both the L who stay and remain L, $x(m)(1 - \tau)$, and those new L who remain L, $x(0)\tau$:

$$\lambda_1(e, m, \tau) = \lambda_0(e) [x(m)(1 - \tau) + x(0)\tau]. \quad (1)$$

If the provider invests in above-average prevention ($m > 0$), then turnover worsens the risk mix: $\frac{\partial \lambda_1}{\partial \tau} = \lambda_0(e) [x(0) - x(m)] \leq 0$, with equality if and only if $m = 0$. Prevention and selection both improve period 1 risk-mix ($\frac{\partial \lambda_1}{\partial m} = \lambda_0(e) x'(m) (1 - \tau) > 0$; $\frac{\partial \lambda_1}{\partial e} = \lambda'(e) [x(m)(1 - \tau) + x(0)\tau] > 0$), although turnover lessens their effectiveness ($\frac{\partial \lambda_1}{\partial m \partial \tau} = -\lambda x' < 0$; $\frac{\partial \lambda_1}{\partial e \partial \tau} = \lambda' [x(0) - x(m)] \leq 0$).

Thus, in the modeled ‘steady state,’ turnover represents “leakage” of prevention investments, the rewards of which accrue to other providers in period 1. This externality from turnover undermines incentives for prevention. An example would be US Medicare benefiting from chronic disease management for the non-elderly. Knowing that Medicare will inherit the risks of the elderly, private provider-insurers have less incentive to invest in disease management that will prevent complications after enrollees turn 65 than the providers would if they themselves continued to bear the risks of

the elderly.

In sum, the overall timing of the model is as follows. Before the game starts, the payer sets the terms of payment. Then the provider chooses selection and prevention, risk-mix evolves accordingly, and the provider receives payments, as follows:

- Period 0 Provider choice of selection determines initial risk-mix $\lambda_0(e)$;
 Provider chooses prevention m ;
 Provider incurs treatment costs (c_L, c_H) and receives payment (π_L, π_H) ;
- Period 1 Turnover of fraction τ of patients, resulting in risk mix $\lambda_1(e, m, \tau)$;
 Provider incurs costs (c_L, c_H) and receives payment with bonus (π_L, π_H, α) .

2.2 Optimal Prevention

The socially optimal level of investments would maximize population benefits B over the two periods, net of the resource cost of producing those health benefits. Low risks enjoy both higher quality of life ($B_L > B_H$) and lower treatment costs ($c_L < c_H$), so that net benefits are higher for low risks: $[B_L - c_L] > [B_H - c_H]$. Recall that the population fraction of low risks is λ . (The remaining patients, $1 - \lambda$, are already high risks in period 0 and therefore would not benefit from prevention.) Social net benefits in period 1 resulting from period 0 prevention are given by

$$\begin{aligned} B(m) &= \lambda(x(m)[B_L - c_L] + (1 - x(m))[B_H - c_H]) \\ &= \lambda[B_H - c_H] + \lambda x(m)([B_L - c_L] - [B_H - c_H]). \end{aligned} \tag{2}$$

Our assumptions guarantee that social benefits are increasing and strictly concave in prevention expenditures: $B'(m) > 0$, $B''(m) < 0$.

Thus a social planner should choose m and e to maximize⁴

$$W = B(m) - m - e. \tag{3}$$

Let m^* and e^* denote the unique optimal levels of selection and prevention, respectively.

Clearly risk selection is counter-productive: selection effort, e , does not yield any social benefit,

⁴If the planner wants to include weight on producer surplus, the uniform profit margin π can be increased above the minimum level needed to assure provider participation.

because it merely redistributes risk among insurer-providers. One provider’s favorable selection is other providers’ adverse selection. At the social optimum, therefore, providers should not choose to invest in risk selection: $e^* = 0$.⁵

The first-order condition defining optimal prevention is

$$\lambda([B_L - c_L] - [B_H - c_H]) x'(m^*) = 1. \quad (4)$$

The marginal benefit of prevention includes better health (i.e., more quality-adjusted life years per low risk, $B_L - B_H$) as well as saving resources on future treatment costs ($c_H - c_L$) for each low risk. Providers should invest in prevention up to the point where the marginal benefit of avoided future morbidity and treatment cost equals the marginal cost of prevention, 1. Re-writing (4), we see that at the social optimum each provider should serve a patient pool reflecting the population average risk, λ , and undertake prevention effort per patient according to

$$x'(m^*) = \frac{1}{\lambda([B_L - c_L] - [B_H - c_H])}. \quad (5)$$

The socially optimal level of prevention is increasing in the fraction of patients who can benefit and the difference in net benefits enjoyed by the healthy relative to the sick. We next turn to the question of how to align provider payment incentives with this goal.

2.3 Provider Objectives, Risk Adjustment Technology, and Payment

We follow the conventional assumption that the provider seeks to maximize expected net revenue.⁶ Given the level and basis of payment for each risk type, net revenues are π_L and π_H for low- and high-risk patients, respectively. With uniform capitation payment and higher expected costs of high risks, there would be a differential in net revenue ($\pi_{LH} \equiv \pi_L - \pi_H > 0$) that gives the provider the financial incentive to serve low risk patients.

We model risk adjustment as a technology that enables the payer to differentiate prospective payments based on risk type. The more accurate risk adjustment technology becomes, the more closely payments can match expected costs, reducing the differential net revenue π_{LH} toward zero.

⁵We could also include choice of treatment. Treatment should be given up to the point where the marginal treatment benefit equals its marginal cost, regardless of the level of prevention.

⁶Our working paper included a model of altruistic providers who seek to maximize patient benefits subject to breaking even. The qualitative conclusions remain the same: conventional risk adjustment embodies a financial penalty on prevention, and can induce even a fully benevolent provider to under-invest in prevention.

Let β reflect the accuracy of conventional risk adjustment, $0 \leq \beta \leq 1$, with $\beta = 0$ representing no risk adjustment (implying maximum $\pi_{LH} = c_H - c_L$), and $\beta = 1$ representing perfect risk adjustment (implying $\pi_{LH} = 0$). As we shall see, the payer would like to implement perfect risk adjustment, but is constrained by the accuracy of currently available risk adjustment technology, as represented by the parameter β .

Note that accurate risk adjustment is consistent with any given level of net revenue per patient, $\pi = \pi_L = \pi_H > 0$, set to fulfill the provider's participation constraint. Risk adjustment merely removes the *differential* profitability of low risks compared to high risks, so that $\pi_L - \pi_H = 0$.

Incentives for selection and prevention will also depend on the basis of payment, i.e., how much is bundled in one prospective payment or unbundled as retrospective reimbursement for claims. Let total payment include a prospective payment, R_i , and reimbursement of fraction $(1 - s)$ of costs, so that the per-patient total payment P_i is given by

$$P_i = R_i(s, \beta) + (1 - s)c_i, \quad i \in \{L, H\}; \quad (6)$$

$$\text{where } R_i(s, \beta) = \pi + \beta s c_i + (1 - \beta) s c_{avg}, \quad (7)$$

$$c_{avg} = \lambda c_L + (1 - \lambda) c_H. \quad (8)$$

The parameter s represents the degree of *supply-side cost sharing*, with $0 \leq s \leq 1$. Full supply-side cost sharing, $s = 1$, represents capitation payment: $P_i = R_i$ and no costs are reimbursed. Cost reimbursement ($s = 0$) is the opposite extreme: $P_i = c_i$. Mixed payment such as $s = 0.5$ implies that the provider receives both a (risk-adjusted) prospective payment and reimbursement for a fraction (in this case, 50%) of actual costs: $P_i = R_i + 0.5c_i$. We assume that payment is set to be expenditure-neutral with respect to the degree of supply-side cost sharing. Accordingly, in the above formula, the higher the fraction of costs that the provider bears, s , the higher the prospective payment R_i . Without risk adjustment ($\beta = 0$), the prospective payment reflects the average cost of the population, c_{avg} . Risk adjustment moves the prospective payment closer to the expected cost of the actual patient according to risk type, c_i .

With these assumptions, it is straightforward to show that net revenue of each patient is given by $\pi_i = \pi + s(1 - \beta)[c_{avg} - c_i]$; the difference in net revenues between low and high risks depends on both the level of supply-side cost sharing and the accuracy of risk adjustment, according to the

following simple formula:

$$\pi_{LH}(s, \beta) = s(1 - \beta)(c_H - c_L). \quad (9)$$

Finally, the payer may consider a bonus payment for prevention activities. This integral component of dynamic risk adjustment is modeled with a payment parameter α . The provider may receive a per-patient bonus of $\alpha[x(m) - x(0)]$ for above-average innovation in prevention and disease management ($x(m) > x(0)$). (The payer may decide whether or not to levy penalties for below-average prevention.) Note that the prevention bonus is based on the difference between risk progression of the provider's period 0 enrollees, $x(m)$, and that of new enrollees, $x(0)$. This means that the payer should base the pay-for-performance on the health improvement or deterioration of continuous enrollees (across two periods), netting out the effect of turnover.⁷

Under these payment rules, the provider chooses to invest in selection and prevention according to the following program:

$$\begin{aligned} \underset{\langle e, m \rangle}{Max} V(e, m) = & \lambda_o(e) \pi_L + (1 - \lambda_o(e)) \pi_H - e - m + \\ & \lambda_1(e, m, \tau) \pi_L + (1 - \lambda_1(e, m, \tau)) \pi_H + \\ & \alpha[x(m) - x(0)]. \end{aligned} \quad (10)$$

The first line represents net revenue per patient in period 0: π_L per low risk and π_H per high risk, less spending on selection and prevention ($e + m$). The second line represents the resulting net revenues in period 2. (We abstract from discounting.) The third line represents what we call *dynamic risk adjustment*: paying the provider, in addition to the risk-adjusted payment per enrollee, a bonus according to the incremental improvement in health – or lower rate of deterioration of health – compared to a benchmark, $x(0)$.

⁷As long as turnover is not too great, estimating the risk mix based on those continuously enrolled should be feasible. Note that empirical implementation would have to take account of non-random turnover, since low risks are more likely to switch providers than high risks are. Adding this wrinkle to the model would allow separate analysis of adverse selection from movers compared to what Altman, Cutler and Zeckhauser (1998) call adverse retention.

2.4 Provider Choice of Selection and Prevention

Seeking to maximize net revenue according to (10), the provider chooses e and m to balance the marginal benefits and costs of each investment, as defined by the following first-order conditions:

$$\begin{aligned}\lambda'(e) \pi_{LH}(s, \beta) [1 + x(0)\tau + x(m)(1 - \tau)] &= 1, \text{ and} \\ x'(m) [\lambda(e)(1 - \tau) \pi_{LH}(s, \beta) + \alpha] &= 1.\end{aligned}\tag{11}$$

The first order conditions can be re-written as follows:

$$\alpha = \frac{1}{x'(m)} + \frac{(\tau - 1)\lambda_o(e)}{[1 + x(0)\tau + x(m)(1 - \tau)] \lambda'_o(e)}; \text{ and}\tag{12}$$

$$s = \frac{1}{(c_H - c_L)(1 - \beta)[1 + x(0)\tau + x(m)(1 - \tau)] \lambda'_o(e)}.$$

Since the provider objective function (10) is strictly concave, these equations define unique levels of selection and prevention for each set of payment parameters and patient turnover: $e(\alpha, s; \beta, \tau)$ and $m(\alpha, s; \beta, \tau)$. The marginal benefit to the provider of selection effort includes two terms: the first, $\lambda'(e) \pi_{LH}(s, \beta)$, represents higher profits per enrolled low risk in period 0; the second, $\lambda'(e) \pi_{LH}(s, \beta) [x(0)\tau + x(m)(1 - \tau)]$, represents the profits from the fraction $(1 - \tau)$ of low risks who are retained in period 1 and who remain low risk, in part thanks for prevention and disease management efforts ($x(m) > x(0)$). When the provider is paid prospectively ($s > 0$) and risk adjustment is not sufficiently accurate to narrow the difference in profits between low and high risks ($\pi_{LH}(s, \beta) > 0$), the provider has financial incentive to invest in selection: $e > e^* = 0$.

The provider invests in prevention and disease management up to the point where the marginal benefit of reduced period 1 treatment cost, net of losses from enrollee turnover, $x'(m) [\lambda(e)(1 - \tau) \pi_{LH}(s, \beta)]$, equals the period 0 marginal cost of 1. The provider will under-invest in prevention if the provider's marginal benefit is less than the social marginal benefit; that is,

$$m < m^* \text{ if } [\lambda(e)(1 - \tau) \pi_{LH}(s, \beta) + \alpha] < \lambda([B_L - c_L] - [B_H - c_H]).\tag{13}$$

This may occur if the productivity of provider prevention efforts ($x'(m)$) is low, the enrollee turnover

rate (τ) is high, and/or the cost savings from maintaining a low risk constitute only a small fraction of the total social benefit from prevention ($\pi_{LH} \ll [B_L - c_L] - [B_H - c_H]$).

Comparative statics reveal the main points of the model (see table). To analyze how differences in the productivity of selection and prevention affect provider choice of investments, let λ' be replaced by $\sigma\lambda'$, and x' be replaced by $\theta x'$. Low levels of σ indicate that provider selection effort is not very successful in attracting a favorable risk mix among new enrollees. Similarly, as θ becomes arbitrarily small, provider investment in prevention becomes less and less productive, so that for any given m fewer and fewer low risks enjoy complication-free health into period 1.

For notational convenience, define the following: $\kappa(m, \tau) \equiv [1 + x(0)\tau + x(m)(1 - \tau)] > 0$, $\psi(e, \tau, \alpha) \equiv [\lambda(e)(1 - \tau)\pi_{LH} + \alpha] > 0$, and $c_H - c_L \equiv c_{HL}$. D denotes the Hessian and is positive by concavity of provider utility: $D = \sigma\lambda''\pi_{LH}\kappa\theta x''\psi - [\sigma\lambda'\pi_{LH}(1 - \tau)\theta x']^2 > 0$.

TABLE OF COMPARATIVE STATIC RESULTS.

Selection, e	Prevention, m
$\frac{de}{d\tau} = \frac{-\sigma\lambda'\pi_{LH}[(x(0)-x(m))\theta x''\kappa+(1-\tau)[\theta x']^2\lambda\pi_{LH}]}{D} < 0$	$\frac{dm}{d\tau} = \frac{\theta x'\pi_{LH}^2[\kappa\sigma\lambda\lambda'+(1-\tau)[\sigma\lambda']^2(x(0)-x(m))]}{D} < 0$
$\frac{de}{d\sigma} = \frac{-\sigma\lambda'\pi_{LH}\kappa\theta x''\psi}{D} > 0$	$\frac{dm}{d\sigma} = \frac{[\sigma\lambda'\pi_{LH}]^2\kappa\theta x'(1-\tau)}{D} > 0$
$\frac{de}{d\theta} = \frac{\sigma\lambda'\pi_{LH}(1-\tau)[\theta x']^2\psi}{D} > 0$	$\frac{dm}{d\theta} = \frac{-\sigma\lambda'\pi_{LH}\kappa\theta x'\psi}{D} > 0$
$\frac{de}{d\beta} = \frac{\sigma\lambda'sc_{HL}[\kappa\theta x''\psi - \pi_{LH}(1-\tau)^2[\theta x']^2\lambda]}{D} < 0$	$\frac{dm}{d\beta} = \frac{\pi_{LH}\kappa\theta x'(1-\tau)sc_{HL}[\sigma\lambda\lambda' - [\sigma\lambda']^2]}{D} < 0$
$\frac{de}{ds} = \frac{\sigma\lambda'(1-\beta)c_{HL}[-\kappa\theta x''\psi + \pi_{LH}(1-\tau)^2[\theta x']^2\lambda]}{D} > 0$	$\frac{dm}{ds} = \frac{\pi_{LH}\kappa\theta x'(1-\tau)(1-\beta)c_{HL}[-\sigma\lambda\lambda' + [\sigma\lambda']^2]}{D} > 0$
$\frac{de}{d\alpha} = \frac{[\theta x']^2\sigma\lambda'\pi_{LH}(1-\tau)}{D} > 0$	$\frac{dm}{d\alpha} = \frac{-\theta x'\sigma\lambda'\pi_{LH}\kappa}{D} > 0$

Factors that encourage both prevention *and* selection are high supply-side cost sharing (e.g., capitation); high productivity of prevention and selection efforts; large difference in net revenue between high and low risks; and low enrollee turnover (high retention rate). Not surprisingly, then, factors that *discourage* both selection *and* prevention include low or no supply-side cost sharing (such as cost reimbursement or fee-for-service); low productivity of prevention and selection efforts; accurate (conventional) risk adjustment, lowering the net revenue difference between low and high risks; and high enrollee turnover (low retention).

Proposition 1 *Conventional risk adjustment discourages both selection and prevention.*

Proof. In the model, an increase in β reflects implementing, or increasing the accuracy of, conventional risk adjustment. Such an increase lowers the net revenue difference between low and high risks: as $\beta \rightarrow 1$, $\pi_{LH} \rightarrow 0$. Totally differentiating the first order condition (11) gives that

$$\frac{de}{d\beta} = \frac{\sigma\lambda' s(c_H - c_L) [\kappa\theta x''\psi - \pi_{LH}(1 - \tau)^2 [\theta x']^2 \lambda]}{D} < 0. \quad (14)$$

As designed and intended, conventional risk adjustment deters selection. However, it also discourages prevention, since

$$\frac{dm}{d\beta} = \frac{\pi_{LH}\kappa\theta x' (1 - \tau) s(c_H - c_L) [\sigma\lambda\lambda'' - [\sigma\lambda']^2]}{D} < 0. \quad (15)$$

QED. ■

By paying more as the population becomes less healthy, conventional risk adjustment discourages prevention. The strength of this disincentive depends on the productivity of provider investments in prevention. Conventional risk adjustment will not be a deterrent to prevention if, as Newhouse (2002) suggests, prevention even in the absence of risk adjustment is at minimal levels because provider efforts are a poor substitute for (or an ineffective complement with) consumer behavioral change. Moreover, many primary prevention efforts, such as immunizations, are readily contractible, so the disincentive from risk adjustment can be readily offset by contracted standards for prevention (ibid).

However, some forms of prevention may be both highly productive and *ex ante* noncontractible. We invoke here a broad definition of prevention, encompassing all innovations that reduce the pace of health deterioration over time. These range from comprehensive risk factor modification programs that ‘reverse heart disease’ (Ornish et al. 1998) to more modest organizational changes, such as processes to improve glycemic control in diabetic patients (Shojania et al. 2006). New processes that promote secondary and tertiary prevention (such as team definition and coordination for disease management) may be far less contractible than primary prevention efforts such as immunizations, yet quite productive for reducing the morbidity and treatment cost burden of chronic diseases. In this case, the negative effect of risk adjustment on prevention presents a serious policy dilemma.

3 Dynamic risk adjustment

As we have noted above, conventional risk adjustment has the unintended side effect of financially penalizing providers who develop successful innovations to manage chronic diseases and prevent complications. This prevention penalty of risk adjustment will only become more and more salient

as three inter-related trends converge – aging societies, chronic disease epidemics, and wider adoption of conventional risk adjustment.

An approach to overcome this incentive problem is what we call *dynamic risk adjustment*. In this section, we first define what we mean by this term. We then discuss how a payer should pay providers – including the degree of supply-side cost sharing and the magnitude of pay-for-performance on prevention – to induce optimal investment in prevention and to discourage selection.

Proposition 2 *Dynamic risk adjustment, combining conventional risk adjustment with pay-for-performance on prevention and disease management, deters selection while rewarding innovations in prevention technology and organization.*

Proof. The previous proposition confirmed that risk adjustment discourages selection. Comparative statics also reveal that pay-for-performance bonuses for above-average prevention counter the effects of risk adjustment on m and can restore incentives for prevention:

$$\frac{dm}{d\alpha} = \frac{-\theta x' \sigma \lambda'' \pi_{LH} \kappa}{D} > 0. \quad (16)$$

QED. ■

Consider the simplest case, of moving from no risk adjustment ($\beta = 0$) to perfect risk adjustment ($\beta = 1$). In other words, risk adjustment technology is so accurate as to match expected costs of each risk type precisely. Implementing conventional risk adjustment would then entirely remove incentive for both selection and prevention. To see this, note that when $\pi_L = \pi_H = \pi$, the provider's maximization problem (10) becomes

$$\begin{aligned} \underset{\langle e, m \rangle}{Max} V(e, m) &= \pi - e - m + & (17) \\ &\pi + \\ &\alpha [x(m) - x(0)]. \end{aligned}$$

In this case, the provider would choose not to invest in selection at all ($e = e^* = 0$), as hoped. However, in the absence of a reward for prevention (that is, if $\alpha = 0$ as it is under conventional risk adjustment), the provider would also choose not to invest in prevention at all ($m = 0 < m^*$). Thus, risk adjustment removes incentive for prevention.

To remedy this problem of conventional risk adjustment, the payer can introduce a reward

for prevention, $\alpha > 0$. The provider will invest in prevention according to the magnitude of α : $\alpha x'(m) = 1$. If the payer sets the bonus α so that it equals the social marginal benefit of prevention, then optimal prevention results (i.e., setting $\alpha = \lambda([B_L - c_L] - [B_H - c_H])$ implements the first best).

More generally, achieving the two policy goals of no selection and optimal prevention requires two policy instruments: conventional risk adjustment, and pay-for-prevention. Risk adjustment technology has been designed to meet the first goal, eliminating incentives for selection. Dynamic risk adjustment introduces a second policy instrument, payment for prevention. We discuss the design and rationale for each instrument in turn.

The payer should choose payment parameters in light of the current level of risk adjustment technology. As previous contributors have noted (Newhouse 1996), the payer can compensate for inaccuracy of conventional risk adjustment by softening supply-side cost sharing. In terms of our model, the payer could set supply-side cost sharing s to increase along with the accuracy of risk adjustment β , according to

$$s^* = \beta. \tag{18}$$

When risk adjustment is very inaccurate ($\beta \approx 0$), the payer relies on reimbursing costs ($s^* \approx 0$) to deter selection. When risk adjustment technology improves, the payer can increase supply-side cost sharing without inducing selection. With perfect risk adjustment ($\beta = 1$), the payer can use full supply-side cost sharing, such as capitation ($s^* = 1$). In this way, the difference in profits from serving a low risk instead of a high risk, (9), will remain a small value regardless of risk adjustment technology, leaving selection a *de minimus* problem.⁸ However, prevention will also be minimal: conventional risk adjustment (or cost reimbursement, as suggested here to supplement inaccurate risk adjustment) removes incentive for selection *and* prevention.

Our contribution is to recognize and correct the penalty on prevention that conventional risk adjustment introduces. Under dynamic risk adjustment, the payer supplements conventional risk adjustment with an extra payment based on population health improvement, $\alpha[x(m) - x(0)]$. Improvement is defined relative to what would be expected under contractible standards of cost-

⁸Setting s equal to β has the extra benefit of making the financial return to selection, proportional to $s(1 - \beta)$, nonlinear in β . This mirrors the empirical finding of Eggleston and Bir (2006) that returns to selection appear to be nonlinear (see their Figure 3): reducing supply-side cost sharing from 1 to 0.5 more than halves the incentives to risk select. Setting $s = \beta$ assures that provider incentives are high-powered only when risk adjustment is very accurate.

effective preventive care for that population, $x(0)$. If the actual fraction of consumers who develop a chronic condition is less than that which would be predicted based on contractible prevention standards, then the provider receives a bonus payment. The optimal payment reflects the patient risk mix (or the severity of disease) in the initial period, as well as changes in disease states from the first period to the second period. A positive bonus rewards better-than-“expected” prevention.

With dynamic risk adjustment, providers or regions should be paid the conventional risk adjusted amount as long as the disease progression observed is as good as expected on average ($x(m) \approx x(0)$). But when the progression of disease is better than one would expect given the health status of a population group ($x(m) > x(0)$), then the incremental payment should be higher than the full cost differential expected for that group.

Under conventional risk adjustment, a provider that attracts lower-than-average risks receives a lower risk-adjusted payment, to discourage ‘creaming’. By contrast, under dynamic risk adjustment, such a provider may not have risk-adjusted payments lowered at all if the health status of continuously enrolled patients reveals that the provider is investing in prevention adequately. In effect, dynamic risk adjustment allows the provider to “buy some selection” by investing in prevention. The pay-for-performance bonus will offset, partially or even fully, the lower payments under conventional risk adjustment. Note that the tendency of ‘stayers’ to be of higher risk than ‘movers’ works in the payer’s favor, to the extent that the provider’s disease management is better targeted on those of higher baseline risk.

4 Related literature and discussion

Theoretical and empirical work on risk adjustment covers many important issues, but so far has not addressed incentives for prevention and disease management, the topic we highlight. Numerous articles present empirical research on risk adjustment in the context of the US multi-payer system, noting the need for refinement along several dimensions (e.g., Burgess 2000; Frank, Glazer and McGuire 2000; Newhouse 2002; Shen and Ellis 2002b; Stafford, Li, Davis and Iezzoni 2004; Zhao et al. 2005). A related literature explores why adoption of risk adjustment among private payers was slow, at least until recently.⁹ Growing experience with risk adjustment in Europe and elsewhere

⁹See articles in a 2001 edition of *Inquiry* (volume 38 number 3), as well as Newhouse 1998 and Blumenthal 2005. For discussion of specific state and federal program experiences with risk adjustment adoption, see for example Dunn 1998 and Weissman, Wachterman and Blumenthal 2005.

also illustrates its usefulness and challenges (e.g., van de Ven and Ellis 2000; Schut, Gress and Wasem 2003; Yuen, Louis, Di Loreto and Gonnella 2003; Antioch and Walsh 2004; van de Ven, van Vliet, and Lamers 2004; Nuscheler and Knaus 2005; Schut and Van de Ven 2005).

The theoretical literature on risk selection and risk adjusting payments to health plans and providers is more limited, but growing.¹⁰ Some contributions touch upon dynamic or multi-period measures (Luft and Dudley 2002 and 2004; Marchand, Motohiro and Schokkaert 2003), quality and pay-for-performance (Ma and McGuire 1997; Chalkley and Malcomson 1998; Rosenthal et al. 2004; Eggleston 2005; Glazer and McGuire 2006; Miller, Eggleston and Zeckhauser 2006). However, none highlight the focus of our paper: the need to link conventional risk adjustment to pay-for-performance for prevention and disease management. Indeed, the conceptual literature on prevention (e.g., Kenkel 2000 and sources cited therein; Byrne and Thompson 2001; Barros and Martinez-Giralt 2003; Dor 2004) has evolved quite independently from that on risk adjustment. We argue that this separation does a disservice to both literatures.

Many factors can motivate providers and insurers to undertake preventive efforts to improve patients' health: professionalism; an altruistic "warm glow" from helping to prevent suffering; ability to charge a higher price or premium for demonstrated prevention quality; or even differentially attracting healthier patients or enrollees. We focus on a separate motivation: net revenue from lower (future) treatment costs when paid prospectively, and a payment bonus for better-than-expected health improvements. Dynamic risk adjustment combines conventional risk adjustment with 'pay-for-performance' on prevention.

Since providers and regions vary considerably in how well they implement health promotion and prevention, aligning payment with the goal of better prevention should be a policy priority. The traditional FFS approach would be to reimburse providers directly for contractible prevention. Unfortunately, this approach fails to promote valuable efforts that are innovative (i.e., currently noncontractible), and may encourage excessive provision of some services. Conventional risk adjustment formulas and capitated payment are intended to eliminate the overprovision incentive of FFS payment, and do not require provider actions to be contractible. Moreover, state-of-the-art diagnosis-based risk adjustment is quite effective in achieving its primary goal, deterring risk selec-

¹⁰See Newhouse 1996 and 2002; Schokkaert, Dhaene and van de Voorde 1998; Selden 1998; van de Ven and Ellis 2000; Glazer and McGuire 2000; Eggleston 2000; Dowd and Feldman 2001; Glazer and McGuire 2002; Shen and Ellis 2002a; Barros 2003; and Schokkaert and van de Voorde 2004.

tion and compensating for adverse selection and adverse retention.¹¹ However, conventional risk adjustment does not create the correct incentives for insurers and providers to invest adequately in preventive care: insurers that experience deterioration in the health status of their population will receive higher payments in the future.

This incentive problem can take many guises. Consider, for example, a provider choosing whether to allocate funds to a high-risk procedure or a low risk procedure. Suppose that both procedures have the same cost and expected health outcomes, but that they differ in their variances. When an outcome turns out badly, under conventional risk adjustment the provider receives higher payment. This effect may bias decisions toward riskier procedures.

Our conceptual model suggests that this incentive problem can be fixed by a relatively straightforward modification of the conventional risk adjustment model. To highlight our focus on efforts that slow deterioration of health over time, we use the term *dynamic* risk adjustment. Providers should be paid the conventional risk adjusted amount as long as the disease progression observed is as good as expected. But when the progression of diseases is better (or worse) than expected, given the health status of a population group, then the incremental payment received for those who are healthier (or sicker) than expected should be higher (or lower) than the full cost differential expected for that group.

Since a certain amount of deterioration of low cost to high cost individuals is to be expected even with exemplary provider effort, we do not propose that a provider or region receive a reduced payment for all individuals whose health deteriorates. Only the difference between the actual and the expected rate of health transition should be used to reward or penalize a provider or region. Moreover, the payer may tailor the dynamic risk adjustment to local conditions or phase it in gradually. For example, the payer could choose to use rewards only, and never levy penalties.

Note that the prevention bonus should depend on the probability of provider actions translating into improved health; $x(m)$ is a probability. This is consistent with the Institute of Medicine's definition of quality health care as increasing the *likelihood* of desired health outcomes (IOM 2001).¹²

¹¹Adverse retention is "the tendency for people who stay put to magnify cost differentials between plans, as they will if they differ in age and costs are more than linear in age" (Altman, Cutler and Zeckhauser 1998). Although most of the risk adjustment literature focuses on adverse selection from "movers" (and provider risk selection activities), adverse retention from "stayers" is also an empirically important phenomenon. For example, Altman, Cutler and Zeckhauser (1998) found that adverse retention accounted for about 60 percent as large an effect on premium differences among insurers as adverse selection.

¹²The IOM defines quality as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (<http://www.iom.edu/CMS/8089.aspx>).

The magnitude of the reward (α) for health improvement should depend on the quality of the signals used, and the degree to which transition probabilities between health states can be influenced by health care. For many disease transitions, there is very little in the way of preventive actions that a provider or region can take in order to slow down disease progressions or foster recovery. In these cases, where progressions are random or reflect patient lifestyle choices that are not easily influenced by medical practice, conventional risk adjustment suffices. For other disease transitions, however, provider actions can play an important role. Ideally these transitions should be identified empirically and the conventional risk adjustment formula modified to provide a greater incentive for providers to invest in prevention. Specific preventive efforts do not need to be observable; only the outcomes (as measured by disease state transitions) must be. This focus on outcomes rather than process potentially makes dynamic risk adjustment easier to implement than a system that rewards observable efforts.¹³

In ongoing work we are using Canadian data to examine individual transition probabilities between health states and how they are affected by disease management. Our empirical strategy seeks to identify those disease transitions that are potentially improved by provider actions, and to estimate cost weights and thresholds for expected transition rates that could potentially be used for implementing dynamic risk adjustment.

In a more elaborate and accurate version, dynamic risk adjustment would be based on changes in risk over many years, not just two. One empirical challenge is to define such profiles, and the perhaps complicated correlation across time between baseline characteristics, interventions, and progression of diseases.

To help disentangle selection and prevention, a payer could use information from enrollee turnover. As noted earlier, dynamic risk adjustment involves inferring a provider's effort on prevention from the risk factor improvement for stayers. The formula would require a reasonable assumption about whether turnover was random. Countervailing forces apply: healthier individuals are more likely to have low switching costs, and higher risks are more likely to want or need to stay. To the extent that this true, providers suffer adverse retention. Yet the healthy movers go somewhere; some insurers may attract a disproportionate amount of healthy joiners, to offset less healthy stayers. If stayers show marked improvements over the expected health deterioration

¹³Of course, providers will still have incentives to game the system, particularly regarding initial budget allocations, just as UK primary care physicians increased hospital-based activity prior to becoming GP fundholders, thereby inflating their budgets (Croxon, Propper, and Perkins 2001). Also see Lu 1999.

rate, giving evidence of substantial investment in prevention, then dynamic risk adjustment allows the provider to benefit from favorable selection. Under this approach, insurer-providers with lower-than-average risk may receive payment as if they have average risk, because they have demonstrated prevention among stayers of sufficient magnitude to justify more generous payment. The extra payment could be justified entirely through projected cost savings from lower expenditures on chronic disease treatment and acute complications. More generally, a prevention bonus should be proportionate to the sum of cost savings and the value of enhanced quality of life, to reflect the social benefits of prevention.¹⁴

Although developed with healthcare as the central focus, our model may hold relevance for other policy arenas. For example, educational policy reforms encouraging choice between schools also challenge policymakers to design risk-adjusted vouchers to compensate schools for the expected costs of serving heterogeneous groups of students. Such risk adjustment should not only take account of current differences in educational costs and annual turnover, but also the pay-off over time from fostering new methods of addressing learning disparities and improving educational attainment over a lifetime of learning. Moreover, in some contexts failing to account for dynamic effects may also bias investments of schools and educators toward less robust programs, just as it may bias healthcare provider investments toward riskier procedures. Rewards for providers of healthcare or educational services need to take account of both the heterogeneity of the initial population served, and the difference that provider efforts make over time (such as in closing disparities).

Dynamic risk adjustment combines two increasingly prevalent approaches to payment for healthcare services: risk adjustment and pay-for-performance. Our simple model illustrates how appropriately linking these two can both deter socially wasteful risk selection and reward innovations in prevention and disease management. Fruitful theoretical extensions might include incorporating strategic interactions among competing providers; modeling appropriate dynamic incentives for consumers to maintain their own health (e.g., decrease obesity, increase exercise, stop smoking); or incorporating a “business case for quality” and insurer ability to charge consumers more for proven

¹⁴Payers could supplement dynamic risk adjustment with other sources of information about selection. For example, payers could report separately the satisfaction rates for different providers among patients with multiple chronic diseases, or by major disease category (if sample size allows). To the extent that insurers or providers risk select through distortion of quality for specific services (Frank, Glazer and McGuire 2000; Eggleston and Bir 2006) and patients are able to respond to this distortion in quality (Chalkley and Malcomson 1998), patient dissatisfaction rates for unprofitable services can shed light on providers’ selection efforts.

ability to keep them healthier. Theoretical and empirical work refining risk adjustment can help society design incentives to improve the efficiency and equity of healthcare systems, and may also prove relevant for other areas of social policy.

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Figure 1a. The population risk mix, with prevention ($m > 0$)

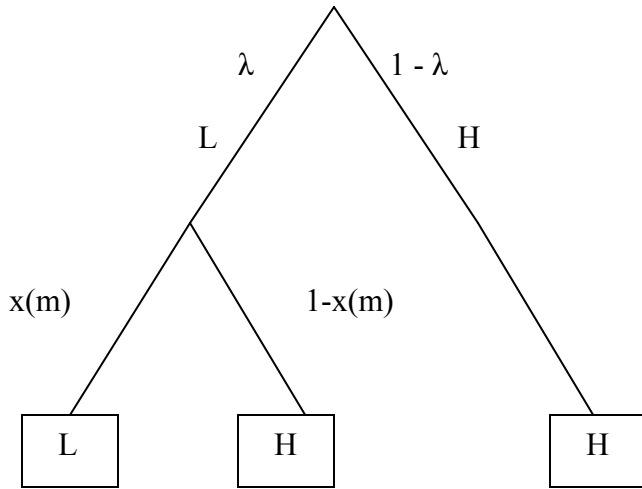
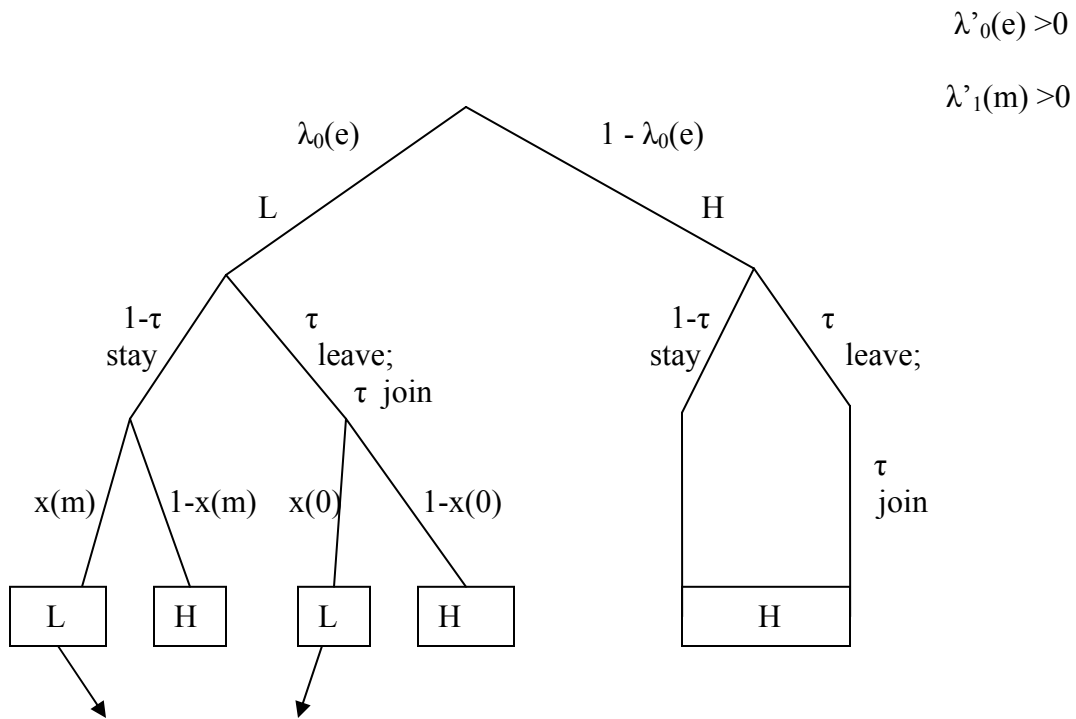


Figure 1b. A provider's risk mix, with prevention ($m > 0$) and selection ($e > 0$)
 (Assuming other providers choose $m = 0$)



$$\lambda_0(e) [(1-\tau) x(m) + \tau x(0)] = \lambda_1(e, m, \tau)$$