AN INCENTIVE APPROACH TO PHYSICIAN IMPLEMENTATION OF MEDICAL PRACTICE GUIDELINES

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SUMMARY

We propose a probabilistically based incentive payment system for guideline implementation that provides rewards for physicians who follow practice guidelines and additional remuneration for physician leaders who engage in information sharing. All payments are based on observed outcomes of patient treatment. A fixed base payment forms the core of the system with probabilistic offsets calculated from the chance that a 'good' outcome occurs without optimal treatment or information. The system pays different physician types for different task sets. © 1997 by John Wiley & Sons, Ltd.

INTRODUCTION

Despite some evidence that medical practice guidelines have been 'oversold',[1] they remain the focus of intensive research and policy activity in the United States and elsewhere.[2,3] The Agency for Health Care Policy and Research (AHCPR) initially made guidelines development a central priority because guidelines allow improvement of both quality and cost effectiveness.[4] Other countries, including Canada, the United Kingdom and France, also are developing and implementing practice guidelines in a variety of clinical areas.[5–8] Two factors have contributed to growing interest in guidelines in the United States despite the movement of the AHCPR away from guideline development. First, research focusing on patient care outcomes offers extensive evidence of unexplained variation in the use of health care resources.[9,10] Several studies have found a high proportion of inappropriate use of health services.[11] These variations may result from uncertainty about how to optimally manage a given health condition.[12] Second, rapid increases in health care expenditures have led payers and providers to look for ways of ensuring more appropriate and cost-effective medical care. Proponents contend that use of guidelines will reduce unwanted variations in medical care, control health care costs and improve quality.[13–15] However, there is evidence that development and dissemination of guidelines rarely lead directly to changes in physician behaviour.[16,17] In the

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absence of medical malpractice tort reform, the threat of sanctions or the provision of economic incentives there is reason to doubt that physicians will implement guidelines.[17] However, social influence and opinion leaders may help change physician behaviour.[18,19]

Payers have an active interest in implementing guidelines that improve patient outcomes while containing medical care costs. Outcomes may include more easily measurable short-term results of care such as mortality and morbidity rates or less measurable longer term effects such as functional and health status, quality of life and patient satisfaction. Outcomes are most often measured over all patients in a hospital or medical group practice. However, it has been traditional to use a process based payment to pay providers of health care based on their treatment of patients without regard to outcome.[20,21] An intensive case by case control system, utilization management involves intervention in patient care activities for the purpose of reducing costs. However, there is evidence that long-term savings from utilization management is uneven, especially when the cost of the utilization management program is considered.[22,23] Further, utilization management disrupts the patient–physician relationship and places an administrative burden on the physician.[24,25]

One response to the problem of improving quality while containing costs would be to develop guidelines and pay directly for guideline adherence. Two problems arise, however. First, wooden adherence to guidelines may be contraindicated in specific cases. Medical practice is as much of an art as it is a science. Physician judgment is to be valued and physicians rewarded for practising the best medicine rather than penalized for it. As important, it would be difficult if not impossible to monitor each physician's adherence to guidelines. The second problem is referred to in the literature as the case of unobservable action by the agent.[26] In such cases, rather than mandate guideline adherence research suggests that it may be preferable to pay for overall outcomes, allowing providers freedom to deal with clinical care decisions for individual patients. In this way, if a treatment is inappropriate for a specific patient the physician can elect not to use it in that case, while overall adherence to the guidelines contributes to the most cost-effective production of health outcomes. The assessment of guidelines use is then based on both appropriateness and effectiveness of care, where appropriateness is the correct groups or individuals receiving care and effectiveness the goodness of outcome of care.[27]

Under current managed care networks and employer group purchasing, health care providers that have poor patient outcomes suffer economic loss. Accordingly, medical practice guidelines may advance a health plan's or health care provider's well being and improve chances for survival in a competitive era. However, while payers and administrators view guidelines as important, practitioners and patients may see their use as a threat to autonomy and a substitute for sound clinical judgment.[19] This perception makes guideline adoption difficult. Recognition of the importance of guideline implementation thus induces interest about incentives that encourage physicians to adopt and implement guidelines. Increased physician involvement is one component of improved guideline implementation.[28]

Guidelines have also taken a central role in countries outside of the United States where managed care and competition are less prominent. In France, the National Agency for the Development of Medical Evaluation (ANDEM) has introduced National Medical Guidelines for a wide variety of medical diagnoses and treatments. This system includes overall incentive payments (fee increases and fines) to improve compliance.[5] The United Kingdom and Italy have also introduced practice guidelines into systems of national health reform.[6,7]

Recently, promotion of guidelines largely appears to have been taken over by evidence-based medicine advocates. Little attention has focused on the use of incentives to encourage guideline implementation. For a given clinical condition a health provider produces the lowest possible level of adverse outcomes at the lowest cost when physicians implement correctly developed guidelines. (There has also been insufficient attention given to the cost effectiveness of guidelines. This paper focuses implementation of guidelines that are cost effective. Other important research would consider the cost effectiveness issue.) In practice, providers have encountered obstacles in encouraging physicians to behave in this manner. Accordingly, we propose that health plans employ an incentive system for guideline implementation that rewards physicians who follow practice guidelines and who engage in guideline-related information sharing activity. This

paper advances such a system using principal–agent theory. The question of physician agency is a difficult one. Pauly and Redisch[29] conclude that the hospital is a physician cooperative: the hospital serves as an agent for the medical staff. However, contrary views exist.[30] Ellis and McGuire[31] developed a pioneering model of a physician as agent for two principals: the hospital and the patient. However, these views predate changes in health care financing that shift risk of loss from payers to providers while drastically reducing patient choice. In the evolving setting, the health plan, group practice or hospital has become a residual claimant: a principal (or substitute principal for the patient), economically responsible for the patient's medical care. The physician is often an agent for the hospital or for the group practice in which he or she is a partner or employee.[32]

INCENTIVES AND PHYSICIAN BEHAVIOUR

Recent research has demonstrated a link between economic incentives and physician behaviour.[33] Much of the payment research has focused on cost and utilization of hospital services.[34,35] Other work has attempted to identify incentives that lead physicians to engage in specific practice patterns.[36] Some payment studies ask how to design payment systems that lead to 'appropriate' amounts or types of care: whether payment systems can improve the quality of patient care[37,38] and the balance between professional ethics and financial incentives.[39,40] Hillman comments, 'whereas most physicians will act in the patient's best interest when the medical decision is clear-cut, the effect of financial incentives may be most important in cases where the correct decision is not obvious'.[39] In a later paper, Hillman[41] compares the alternative use of rules (including practice guidelines) and incentives in inducing appropriate behaviour under conditions involving medical uncertainty. Incentives provide indirect economic influences on clinical decisions. Hillman claims that managed care systems need to balance the use of rules and incentives.

However, rules and incentives are not an 'either or' proposition. Indeed, 'rules' implicitly include sanctions. Sanctions are nothing other than negative incentives, while rewards are positive incentives. Psychological research has emphasized that positive incentives are far more powerful than are negative ones (Ref. 42, p. 167). Our work carries forward Hillman's ideas by proposing that incentives can be used to provide economic influence that leads physicians to follow rules, but allows for physician autonomy in individual cases. Conceptually, incentives can induce physicians to implement guidelines. As Hillman observed, incentives thus serve as an important link between sound medical judgment and guideline implementation, particularly under conditions of uncertainty. We propose a probabilistically designed incentive system to encourage physician adherence to practice guidelines.

ASSUMPTIONS

A. We develop our model in the context of a provider's efforts to implement a guideline. The goal is to induce all physicians practising under the 'sponsorship' of the provider to adhere to the practice guideline. We assume that the provider either accounts for the wages of the physicians or, by granting the physician staff privileges, makes it possible for the physician to earn his or her income. We further assume that the guidelines are professionally developed: To the extent possible they incorporate practices that produce optimal outcomes in the most cost effective manner. Thus, they serve as a signal to physicians of the best process for accomplishing desired outcomes.

B. The provider cannot observe directly the treatment actions taken by physicians (direct observation is expensive and constitutes overly intrusive 'micro-management' of patient care). Physicians can observe, but cannot verify the actions of other physicians. Active teaching by physician leaders and their actions influence the behaviour of other physicians. The provider can observe (without error) outcomes over the set of the provider's patients. (While this is not true in every case, and may never be true for some more complicated medical practices, some outcomes can be measured and researchers are making progress in the area of outcomes measurement. See the section on practice implications for a further

discussion of issues surrounding outcomes measurement.) For example, the provider knows length of stay, ancillary service use, morbidity, mortality and hospital readmission rate. The provider also knows with certainty which physician treated each patient. The provider can adjust expectations for patient characteristics that might affect outcome. In other words, the provider knows the patient diagnosis, severity and demographic characteristics and can adjust outcome expectation accordingly.

C. The actions of the physicians are correlated, but not symmetrically so. If a physician 'leader' takes certain actions, other physicians will have an increased probability of also taking those actions.[43] If the leader actively disseminates information about her or his actions, the probability of other physicians taking similar actions becomes even higher. We assume that optimal outcomes result from active 'buy-in' and proselytizing of other physicians by leaders. If a physician who is not a leader exhibits actions or disseminates information, their conduct will not change the behaviour of other physicians. Leaders are those physicians who are generally considered 'opinion leaders' in the medical and quality improvement literature, typically physicians with good reputations, high-level academic training and charismatic personalities.[44] In the basic model, the leader type is known to both the health plan and the other physicians. Extensions of the model include the possibility of error in type identification.

D. The guidelines have been adopted in a cost effective manner and the cost of the incentive payment system does not exceed the benefit produced by guideline adherence.

DESIGNING THE INCENTIVES

The incentive system pays physicians based on observed patient outcomes. It pays (or sanctions) leaders an additional amount for making public their advocacy of adherence to the guidelines. The payment system has two components: the first is an outcome based payment that varies over patient outcome and physician 'type'. 'Type' is a multiplier of the outcome payment, with physicians of higher type receiving greater payment for the same outcomes. (Leaders are the highest type. Type is determined from seniority, referral practice, amount of specialty training and other similar factors. Payment based on type allows recruitment of better physicians and permits compensation for differences in risk among physician caseloads.) We omit the type multipliers from the model for clarity of notation. The second payment component is a cooperation-based payment to encourage the exchange of information. Because the provider cannot perfectly observe the exchange of information among physicians, it will pay based on outcomes and type. In addition to their treatment actions, the provider pays leaders for informing activity or teaching.

While we refer throughout to the 'provider' and the 'physician', this model generalizes to other settings (the principal could be a multi-specialty group practice). We selected this setting because providers financially at risk for care of a population of patients are more likely to implement the system than are others (others might include third party insurance payers or the government).

We define the utility of the provider in terms of money. Given a set of outcomes $O = \{O_1, O_2, O_3, ..., O_j\}$, we assume that there exists a function $\mathbf{f}$ that maps patient outcomes into money for the health plan such that $[O_2] > [O_1] \Rightarrow \mathbf{f}[O_2] > \mathbf{f}[O_1]$ where $[O_2] > [O_1]$ is the notation for production of better outcome. If a physician chooses action a, from a set of actions $A = \{a_1, a_2, a_3, ..., a_N\}$, outcome O_m will be produced with non-zero probability π_{nm} and with associated non-wage cost to the health plan of C_n [the cost is dependent only on the action, not the outcome]. Let $\omega[O_m]$ be the wage paid to the physician for outcome O_m. Then, let $x_{nm} = \omega[O_m]$. We then define a utility function $u[\mathbf{f}[O_m], x_{nm}, C_n]$. We assume that $u[\cdot]$ exhibits the characteristics of traditional utility functions (it is strictly increasing, continuous and twice differentiable). The expected utility gained by the health plan will then be

$$\sum_{n=1}^{N} \pi_{nm} u[\mathbf{f}[O_m], x_{nm}, C_n] \qquad (1)$$

This function represents utility gained for a probabilistic set of outcomes over the range of selected physician actions. Where u is concave, the

associated maximization problem will be a well behaved mathematical programming problem.

The utility function for physicians depends on their wages and on the disutility of action. Let any treatment action taken by a non-leader physician be represented by a_i and any treatment action taken by a leader represented as a_L both chosen from $\{a_1, ..., a_N\}$. The level of effort used by leaders for informing is represented as k, chosen from $\{k_1, ..., k_N\}$. The action taken by a leader is independent of actions taken by other physicians, while the action taken by non-leaders is dependent on k. The wage of a non-leader is dependent only on outcome and type. The wage of a leader also depends on the outcomes of all other physicians in the health plan. The total wages paid to physicians by the health plan will be $\omega = \omega_i + \omega_L$. (The payment is more specifically $\omega = \omega_i[\pi_{im}[a_i[k]]] + \omega_L[\pi_{Lm}[a_L]; \pi_{im}[a_i[k]]]$. The payment to the non-leader physician depends only on their adherence to the guidelines while payment to the leaders depends *both* on adherence to guidelines and the adherence by other physicians which is a function of the leaders' informing actions.)

The utility function for a non-leader physician will be

$$u[p_i] = \omega_i - d[a_i[k]] \tag{2}$$

where $d[a_i[k]]$ is the disutility of adhering to the guideline. The utility for a leader is

$$u[p_L] = \omega_L - d[a_L] - \delta[k] \tag{3}$$

where $\delta[k]$ is the disutility of informing. There are two constraints for each physician type. The first is the participation constraint, also known as the individual rationality constraint [*IR*]. The second is the incentive compatibility constraint [IC]. Setting reservation utilities to zero, the linear constraints for the non-leaders are (summing over all possible actions):

$$[IR, p_i] \sum_{i=1}^{N} \omega_i[\pi_{im}; a^*_i[k]] - d[a^*_i[k]] \geq 0 \tag{4}$$

$$[IC, p_i] \sum_{i=1}^{N} \omega_i[\pi_{im}; a^*_i[k]] - d[a^*_i[k]] \geq$$

$$\sum_{i=1}^{N} \omega_i[\pi_{im}; a_i[k]] - d[a_i[k]] \tag{5}$$

where a^* is adhering perfectly to the guideline and a is any other action.

The constraints for the leaders are:

$$[IR, pL] \sum_{L=1}^{N} \omega_L[\pi_{im}[a^*_L]; \pi_{im}; a_i^*[k]] -$$
$$d[a^*_L] - \delta[k^*] \geq 0 \tag{6}$$

$$[IC, pL] \sum_{L=1}^{N} \omega_L[\pi_{Lm}[a^*_i]; \pi_{im}; a_i[k^*]] -$$
$$d[a^*_L] - \delta[k^*] \geq \sum_{L=1}^{N} \omega_L[\pi_{Lm}[a^*_L]; \pi_{im};$$
$$a_i[k]] - d[a^*_L] - \delta[k] \geq \sum_{L=1}^{N} \omega_L[\pi_{Lm}[a_i]; \pi_{im};$$
$$a_i[k]] - d[a_L] - \delta[k] \geq \sum_{L=1}^{N} \omega_L[\pi_{Lm}[a_i]; \pi_{im};$$
$$a_i[k^*]] - d[a_L] - \delta[k^*] \tag{7}$$

where k^* is optimum use of informing to convert other physicians to the action of the leader and k is any other amount of informing. (Because informing by leaders produces more of the type of activity in which the leaders are engaged, optimal informing by physicians who are not adhering to guidelines results in worse outcomes than non-optimal informing. Maximum utility occurs when leaders adhering to guidelines inform optimally, followed by the situation where leaders adhere to the guidelines and inform suboptimally, then the case where leaders do not adhere to the guidelines but inform suboptimally. The least utility occurs where the leaders do not adhere to the guidelines but inform about this action.) The leader's *IC* constraint states that the wages received will conform to the hierarchy: (1) wages received by adhering perfectly to the guidelines and expending optimal energy informing will exceed (2) wages received when adhering perfectly to the guideline but expending any other effort in informing will exceed (3) wages received for taking non-guideline actions and less than optimal informing and will exceed (4) wages received for taking less than optimal actions and informing about these actions. One must exceed two which must exceed three which must exceed four. The leaders' wages are jointly dependent on two actions: adhering to the guidelines and informing.

We want to maximize expected income to the health plan, $\sum \pi_{n^*m} u[\mathbf{f}[O_m], x_{n^*m}, C_n]$ (where $\sum$ is summed over n) subject to the constraints above (n^* is optimal adherence to the guideline and

optimal informing action on the part of all physicians in the health plan). Because we are maximizing a concave utility function in money, subject to linear inequality constraint functions, we invoke the Kuhn–Tucker conditions. These conditions will be necessary and sufficient for a local maximization of the objective function, given that the objective function is concave and the constraint functions are convex.[45]

Before proceeding, we rewrite the objective function and constraints substituting x for the wage and for probability multipliers. The health plan objective function then becomes

$$\sum_{n=1}^{N} \pi_{kn^*m} u[\mathbf{f}[O_m], x_{nm}, C_n] \tag{8}$$

where π_{knm} are the probabilities of overall health plan outcomes m that result from the actions n of all physicians in the presence of the information disseminated by the leaders k (π_{kn^*m} is the probability of non-leader physicians adhering to the guideline in the presence of whatever amount of information dissemination is performed by the leaders). While the actions of the non-leaders are dependent on k, the actions of the leaders are not dependent on the actions of the non-leaders. It may also occur with non-zero probability that non-leaders adhere to the guidelines without information from leaders. This probability is always less than the probability of action a^*_i in the presence of information. The constraints may be similarly rewritten:

$$[IR, p_l]\ \sum_{n=1}^{N} \pi k_{n^*m}[x_{kn^*m}] - d[a^*_n[k]] \geq 0 \tag{9}$$

$$[IC, p_l]\ \sum_{n=1}^{N} \pi_{kn^*m}[x_{kn^*m}] - d[a_{n^*}] -$$
$$(\sum_{n=1}^{N} \pi_{knm}[x_{knm}] - d[a_n]) \geq 0 \tag{10}$$

The constraints for the leaders are

$$[IR, p_l]\ \sum_{n=1}^{N} [\pi_{k^*nm}\pi_{kn^*m}]x_{kn^*m} - d[a^*_L] -$$
$$\delta[k^*] \geq 0 \tag{11}$$

$$[IC, p_l]\ \sum_{n=1}^{N} [\pi_{k^*nm}\pi_{kn^*m}]x_{kn^*m} - d[a^*_L] -$$
$$\delta[k^*] \geq \sum_{n=1}^{N} [\pi_{knm}\pi_{kn^*m}]x_{kn^*m} - d[a^*_L] -$$
$$\delta[k] \geq \sum_{n=1}^{N} [\pi_{knm}\pi_{knm}]x_{knm} - d[a_L] -$$
$$\delta[k] \geq \sum_{n=1}^{N} [\pi_{k^*nm}\pi_{knm}]x_{knm} - d[a_L] -$$
$$\delta[k^*] \tag{12}$$

For a unique solution, all constraints must bind. The final payment scheme should be separable: it should consist of payments to non-leaders and to leaders. Different agents of different types will receive payment for different task sets. The provider pays non-leader types for their treatment actions after measuring outcomes. The provider pays leaders for both their treatment actions and their leadership actions. The provider infers both from outcomes. The Lagrangian after application of Kuhn–Tucker is set forth in the Appendix. This equation may be simplified to the final payment scheme expression (omitting the symbol for the summation of each right-hand term from $n = 1$ to N):

$$u'[\cdot] = [\lambda_1 + \lambda_2] - \lambda_2[\pi_{knm}/\pi_{kn^*m}] + [\lambda_3 + \lambda_4]\pi_{k^*nm} - \lambda_5\pi_{knm} - \lambda_6[\pi_{knm}\pi_{knm}] / [\pi_{kn^*m}]$$
$$- \lambda_7[\pi_{kn^*m}\pi_{knm}] / [\pi_{kn^*m}] \tag{13}$$

There is only a single payment based on outcomes, a portion of which is paid to the non-leader physicians and another portion of which paid to the leaders. The payment is calculated based on probabilities of outcomes occurring given certain actions (guideline adherence). The portion paid to non-leaders is a fixed sum $[\lambda_1 + \lambda_2]$. This amount is adjusted to account for the probability that the desired outcome may have occurred 'spontaneously' without adherence to guidelines, $\lambda_2[\pi_{knm}/\pi_{kn^*m}]$. This adjustment assumes that these results occur either in patients for whom treatment was not necessary or through treatment plans that were less efficient in producing desired outcomes than the plan recommended by the guideline. Payment to leader physicians consists of a base amount based on outcomes premised on the probability that the outcome occurred as a result of activity by the leaders, $[[\lambda_3 + \lambda_4]\pi_{k^*nm}]$. The provider adjusts the base pay-

ment amount downward for three 'spontaneous' occurrences: (i) the probability that a good outcome occurred when the leader followed the guideline but failed to expend optimal energy in informing other physicians, $\lambda_5 \pi_{knm}$; (ii) a good outcome, but the leader physicians neither followed the guideline nor informed other physicians, $\lambda_6 [\pi_{knm} \pi_{knm}]/[\pi_{kn*m}]$; and (iii) good outcomes occurred while the leader was *not* following the guideline but was informing the other physicians, $\lambda_7 [\pi_{kn*m} \ \pi_{knm}]/[\pi_{kn*m}]$. The probability of a good outcome under each successive undesirable occurrence is successively smaller as are the offsets for λ_5, λ_6 and λ_7.

SOME PRACTICAL IMPLICATIONS

Application of principal agent theory in the context of incentives for guideline implementation suggests that optimal guideline adherence will result from an incentive system based on outcomes. Applying the theory in clinical practice requires careful consideration of a number of practical issues.

First, because the actions of the agent (the physician) cannot be observed, principal agent theory suggests a way to obtain an optimal (best possible) outcome rather than a perfect one. A perfect solution would require perfect observability for the agent.

Second, the model assumes that the cost of action (c_n) is observable. In practice, costs might not be fully observable. The model deals with this difficulty. The costs of complying with guidelines accrue to the physicians. They include both measurable costs (time, technology risk and so forth) and non-measurable costs (satisfaction). While these costs are not known to others they are known to the physician. The incentive system optimizes physician adherence to the guidelines and physician leader informing based on their perception of their own costs. The system also provides an incentive for the physician to learn as much as possible about the cost of action, perhaps an improvement over current practice. Thus, while costs might not be fully or perfectly observable, the payment system should still produce an optimal (albeit not perfect) result.

Third, social theory suggest that individuals may actually devalue some activity for which there is payment. Thus, volunteers who receive no

payment for their efforts may place more value on their activities than if they were paid.[46] There is the danger that payment to physician leaders for guideline adherence may diminish their status as leaders. Still, in US hospitals there is a tradition of payment for physician leaders (chiefs of staff, department heads and others). There is little evidence that the payment system diminishes their stature as leaders, although there are probably situations where paid physician leaders are perceived to have been coopted by management.[47] Alternatively, payment to physician leaders for guideline adherence may serve as an additional signal by the payer of the importance of guideline use.

Fourth, the model presumes that outcomes can be defined, observed and measured. This poses perhaps the greatest practical implementation difficulty. While the difficulty in correctly measuring outcomes has been discussed, many physicians and researchers are committed to outcomes based guideline development and implementation.[27,48,49] Philosophically, the medical care system presumes that medical intervention is effective and that it will therefore produce a beneficial outcome. Increased cost consciousness has produced renewed effort toward evaluating the effectiveness of medical interventions.[1] On one level, if an intervention cannot produce an observable beneficial outcome, the system should not pay for it (or should reduce the amounts paid based on uncertainty). Moreover, there is extensive research by government and industry regarding outcome definition and measurement. The Agency for Health Care Policy and Research has funded several large pilot outcome research projects addressing these issues.[50] Employers and employer funded groups have begun to measure employee health status and to track the effectiveness of managed care organizations over time in maintaining and improving health.[51] Our model assumes that outcomes can be defined, observed and measured. It is important to note that our model may only be applicable to certain guidelines initially. One example might be an initial evaluation of guidelines for antibiotics used based on short term clinical and financial outcomes including rates of adverse drug events, patterns of antimicrobial resistance, mortality, length of hospital stay, yearly expenditures for antibiotics and daily doses per 100 occupied bed days.[52] Future guidelines and incentive systems might incorporate broader outcomes including patient quality

of life and satisfaction in the longer term.[53] During the period that outcomes measurement is being refined and improved, it is important to note that our model may be of use only in situations where appropriate intermediate outcomes can be measured. In certain clinical situations, it may not be possible to use outcome based incentives. This would be the case where outcomes are too difficult or expensive to measure or in cases, such as therapy for HIV/AIDS or some types of cancer, where technology is changing so rapidly that long term outcomes have no relevance to actual clinical practice by the time those outcomes can be measured and made available. However, we do believe that guideline development should be outcome based[27] and that guideline implementation will be aided by the measurement of outcomes and incentives for producing desirable outcomes. We anticipate the expansion of measurable outcomes from such short-term measures as mortality, readmission rate and length of stay to more complete outcomes including health and functional status, quality of life and patient satisfaction. This has not yet come about and we do not intend to give short shrift to a more ambitious task than ours, only to note that if outcome measures become available the current model suggests one way to induce optimal physician effort.

Fifth, the model does not comment on the manner of guideline development. Payment to physicians and leaders suggests, perhaps, that they be excluded from guideline development (on conflict of interest grounds) lest they 'water down' guidelines to the point that the bonuses are easily achieved without any real effort. However, physicians currently make decisions concerning medical necessity for treatment and receive payment for these decisions. Moreover, participation of physicians and leaders in guideline development will enhance their acceptance.[54] The real test of guideline effectiveness may be improved outcomes. Accordingly, conflicts can be reduced if outcomes are defined and tracked by a group that does not include the treating physicians or physician leaders.

Sixth, the model results suggest merely that optimal action will be induced by payment based on outcomes. The model does not specify how outcomes will be defined and measured. There are a host of practical considerations that must be addressed if the payment systems is to be effective. For example, to minimize the possibility of physicians gaming the system, outcomes on which payments are based will need to be adjusted for individual physicians' patient case mix. If either case mix adjustment or initial outcomes measurement lead to incorrect assessment of outcomes, physicians could gain by treating only those patients who are likely to respond regardless of treatment (assuming that the physician can select patients) or may be incented by the incorrectly measured outcomes to provided inappropriate treatment. The model does deal with the potential for 'spontaneous' improvements. Good guidelines presuppose that their application will produce something more than spontaneous improvement. Second, the model provides an offset for the probability that a good outcome occurs in settings where there is less than optimal effort by either the non-leader or the leader physicians including those efforts that may be optimal in the sense of providing desired health outcomes, but less than ideal when cost-effectiveness is considered.

Finally, there is an overall practical constraint or qualification that is not formalized in the model. The payment to the physician for the outcome cannot exceed the net benefit produced by the outcome, including the costs of measuring the outcomes. While this is, perhaps, obvious in a market-based system of health care, in a regulated environment or a managed care arena this premise might be lost.

CONCLUSIONS AND DISCUSSION

If medical practice guidelines are to play a role in improving outcomes and reducing costs, physicians must implement them. Physicians' intrinsic rewards for implementing guidelines may not be effective in altering behaviour. Moreover, it will not be practical to adopt extensive monitoring to ensure that they are adhering to them and good implementation should encourage discretion to deviate from the guidelines in special circumstances (where deviation will enhance outcomes). Weingarten and Ellrodt[55] showed that concurrent teaching by physicians who are respected by their peers and who are comfortable offering unsolicited advice encourages guideline adoption. Our model underscores these findings and suggests that an economic incentive scheme that encourages physician leaders to offer opinions and to

deviate from guideline adherence where this produces a more optimal result.

This paper shows that it is possible to design an incentive system that encourages individual adherence to guidelines by all physicians as well as teaching on the part of opinion leaders. However, there are issues that remain to be addressed before implementing such a system will be fully practical. Current research includes the careful study of the linkages between guidelines and outcomes.[56] Additional understanding will allow better assignment of probabilities to outcomes. Further, it may not be possible to recognize physician type accurately. Further work might profitably extend this model to include errors over identification of type.

We have used a principal–agent mechanism with the provider acting as principal to protect its own financial interests. It may be appropriate to modify the model for a single payer to deal with the eventuality of a single payer system for health care payment. This would require the ability to monitor outcomes and understand the spread of information through a more complex network of physician relationships. While more challenging, such a model should prove tractable. As interest in implementing guidelines continues to increase, mechanism design approaches may prove useful in conjunction with efforts to change reimbursement, encourage education and remove organizational disincentives.

APPENDIX. SOLUTION FOR OBJECTIVE FUNCTION AND CONSTRAINTS

The Lagrangian after imposing Kuhn Tucker conditions is:

$$\Lambda = \sum_{n=1}^{N} [\pi k_{n^*m} u[x_{nm}, \mathbf{f}[O_m], C_n] + \lambda_1[0 -$$

$$\sum_{n=1}^{N} \pi_{kn^*m}[x_{kn^*m}] - d[a^*_n[k]]] + \lambda_2[0 -$$

$$\{\sum_{n=1}^{N} \pi_{kn^*m}[x_{kn^*m}] - d[a^*_n] - \Sigma\pi_{knm}[x_{knm}] -$$

$$d[a_n]\}] + \lambda_3[0 - \{\sum_{n=1}^{N} [\pi_{k^*nm}\pi_{knm}]x_{n^*m} -$$

$$d[a_L] - \delta[k]\} + \lambda_4[0 -$$

$$\{\sum_{n=1}^{N} [\pi_{k^*nm}\pi k_{n^*m}]x_{kn^*m} - d[a^*_L] - \delta[k^*]\} +$$

$$\lambda_5[0 - \{\sum_{n=1}^{N} [\pi_{knm}\pi k_{n^*m}]x_{kn^*m} - d[a^*_L] -$$

$$\delta[k]\} + \lambda_6[0 - \{\sum_{n=1}^{N} [\pi_{knm}\pi_{knm}]x_{knm} - d[a^*_L]$$

$$- \delta[k]\} + \lambda_7[0 - \{\sum_{n=1}^{N} [\pi_{k^*nm}\pi_{knm}]x_{knm} -$$

$$d[a_L] - \delta[k^*]\} \tag{A1}$$

Taking the derivative with respect to payment, leaving out the summation signs for convenience and setting the expression to zero to obtain the maximum gives

$$\frac{\partial L}{\partial x} = \pi_{kn^*m}u'[\cdot] - \lambda_1\pi_{kn^*m} - \lambda_2\pi_{kn^*m} +$$

$$\lambda_2\pi_{knm} - \lambda_3\pi_{k^*nm}\pi_{kn^*m} - \lambda_4\pi_{k^*nm}\pi_{kn^*m} +$$

$$\lambda_5\pi_{knm}\pi_{kn^*m} + \lambda_6\pi_{knm}\pi_{knm} +$$

$$\lambda_7\pi_{k^*nm}\pi_{knm} = 0 \tag{A2}$$

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