A Comparison of Patient-Centered and Case-Mix Reimbursement for Nursing Home Care

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The trend in payment for nursing home services has been toward making finer distinctions among patients and the rates at which their care is reimbursed. The ultimate in differentiation is patient-centered reimbursement, wherein each patient's rate is individually determined. This paper introduces a model of overpayment and underpayment for comparing the potential performance of alternative reimbursement schemes. The model is used in comparing the patient-centered approach with case-mix reimbursement, which assigns a single rate to all patients in a nursing home on the basis of the facility's case mix. Roughly speaking, the case-mix approach is preferable whenever the differences between patient's needs are smaller than the errors in needs assessment. Since this condition appears to hold in practice today, case-mix reimbursement seems preferable for the short term.

THE design of a reimbursement policy for nursing home care has been an abiding problem. Simpler policies have been succeeded by more elaborate schemes designed to distinguish between allowed and disallowed costs and between patients requiring "heavy" and "light" care. Flat rates of payment have given way to payment differentiated by level of care (skilled or intermediate) and by the requirement that reimbursement be "reasonable cost related" [1,2]. Support is increasing for the ultimate in differentiation: tailoring reimbursement to each patient's condition [3]. Some people suggest that this individualized reimbursement serves as the starting point for incentive schemes based on patient outcomes [4,5].

The state of Illinois attracted a good deal of attention when it established a form of patient-centered reimbursement [6,7]. Nursing home reimbursement was divided into three components, and the fixed and add-on costs were reimbursed separately from the variable, or patient-related, costs. The latter were determined according to a formula arrived at by econometric analysis. The formula related a patient's level of care and level of debility to the rate of payment.

The rationale for patient-centered rates is that it is desirable to avoid both underpayment and overpayment for nursing home care [2,7]. Paying too much is obviously wasteful. Paying too little may mean that patients needing heavy care will be denied access to nursing homes or that, once admitted, they will receive substandard care. Thus it is argued that the three goals of lower cost, better access,

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and higher quality would all be facilitated by customizing reimbursement.

A generic issue in program design is the level of aggregation at which a program will function. Patient-centered reimbursement represents the extreme in disaggregation: it requires that the care of about one million nursing home patients be individually reimbursed. Given advances in large-scale information systems, given the fact that each patient supported by Medicaid is now reviewed by government workers at least once each year, and given the Illinois experience it is plausible that the logistical problems of patient-centered reimbursement could be overcome.

But do an attractive rationale and logistical plausibility justify a commitment to such an extreme level of disaggregation? Patient-centered reimbursement would add administrative costs and would rely heavily on fallible methods of assessing patient needs. In exploring this question, I will stay within the problem framework implicit in patient-centered rates: I will not challenge fundamental assumptions, such as the existence of an ideal rate for each patient, nor will I consider alternative reform strategies, such as government ownership of all facilities or nursing home ombudsmen. Rather, my analysis aims at determining whether patient-centered rates are desirable on their own terms. Patient-centered reimbursement is compared to a facility-centered alternative that uses some of the same information in a different way.

Patient-centered reimbursement rests on a sequence of three steps that must be taken for every patient:

1. Patient assessment—characteristics judged to be normatively and empirically related to the cost of care are ascertained, for example functional status or medical diagnosis;
2. Care planning—the description of the patient is translated into a prescription for services; and
3. Service costing—the costs of prescribed services are figured, and the total reimbursement rate is determined.

These three steps make up the process of needs assessment.

In case-mix reimbursement, the alternative to patient-centered reimbursement, needs assessments are performed on a simple random sample of patients in each facility (as a special case, the sample may be a census of all residents). The individual rates are averaged, and the average becomes the rate assigned to all patients in that facility. Thus the case-mix alternative also represents a move toward finer differentiation in rate-setting, although not as extreme a move.

Each of the alternatives has advantages. The patient-centered approach is more responsive to heterogeneous patient mix and avoids sampling error. The case-mix approach is cheaper, to the extent that it relies on a sample rather than a census, and, if the needs assessment process is unreliable, averaging several assessments will eliminate "noise."

I have made a quantitative comparison of these two approaches by means of a mathematical model of reimbursement error and have then identified the conditions under which each is preferable. These results supplement a larger simulation study of reimbursement alternatives, including the two considered here [8]. The major result is that, roughly speaking, the case-mix alternative should be used when the typical difference in cost between any two patients in a home is less than the error made in estimating that cost due to imperfections in the needs assessment process.

A Model of Reimbursement Error

The performance of either alternative must be measured in two ways: its ability to minimize over- and underpayment and its implementation costs. The mathematical models of performance derive from the conceptual model of reimbursement error presented in this section. Reimbursement error will always be present to some degree in both alternatives because the needs assessment process will be fallible and because patient condition will change between assessments.

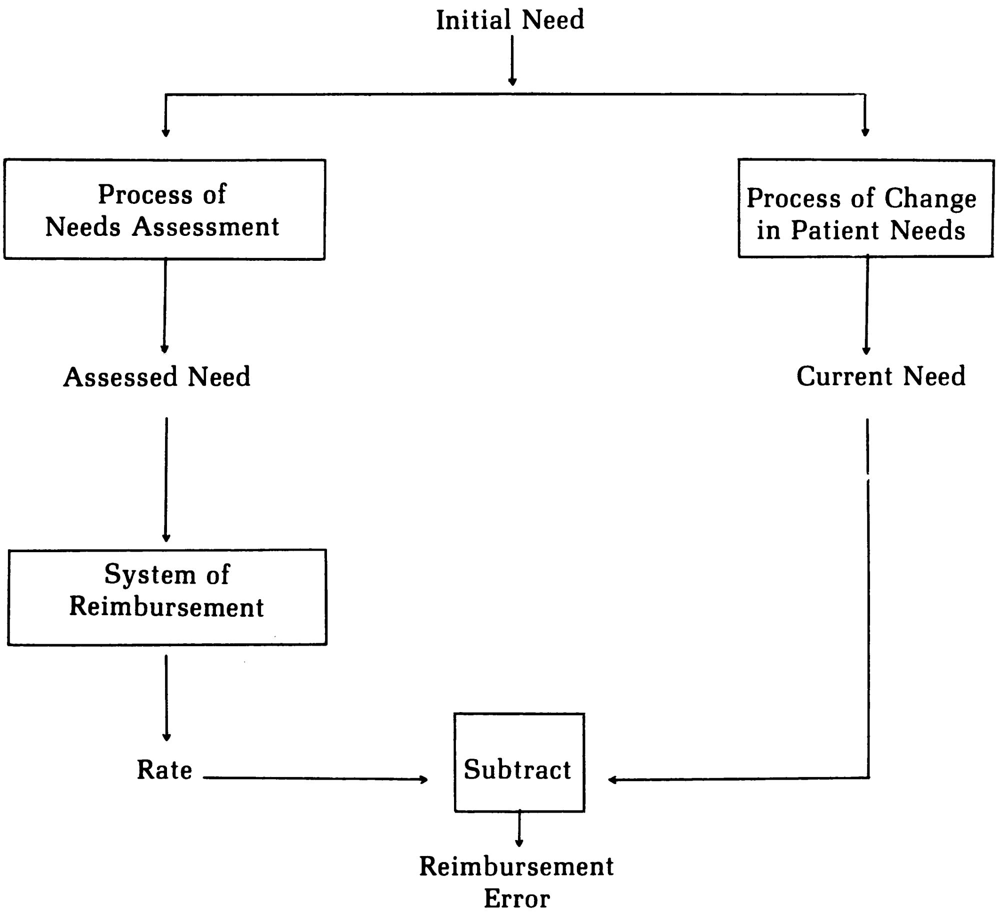
On the day a patient's status is first assessed, he will have some underlying, but imperfectly understood, level of need, which I will call "initial need." The underlying need fluctuates from day to day; and on any given day after the initial assessment, this need is the "current need." Both initial need and current need are expressed in dollars. A patient's current need is the cost of an optimal bundle of services. The processes of patient assessment, care planning, and service costing converts initial need into assessed need. If the assessment process works well, assessed need will approximate initial need. The reimbursement system then converts assessed need into a per diem rate. With patient-centered reimbursement, the assessed need is the rate; with case-mix reimbursement, the rate is the sample average. Since the initial need is only imperfectly translated into the assessed need, and thereby into the rate, there will always be some discrepancy between the actual and ideal per diem rates. The discrepancy between initial need and assessed need is called the "measurement error." To the extent that current need moves away from initial need over time, this discrepancy will grow, making it necessary to periodically reassess patient status. The difference between the rate and the current need on any given day is called the "reimbursement error." A positive reimbursement error signifies overpayment and vice versa. These relationships are summarized in Figure 1.

Reimbursement Error in Patient-Centered and Case-Mix Reimbursement

Each reimbursement method will lead to overpayment for some patients' care and underpayment for others'. In some cases these mistakes will be small; in other cases, large. Therefore a comparison of the two methods should focus on the entire distribution of reimbursement error. At the same time, it would be convenient to have a single-number summary of the distribution that reflects the seriousness of the error. The usual approach to this problem is to construct a loss function, which associates a loss, or seriousness, weighting with every possible value of reimbursement error, and then to use the average loss as the single-number summary.

The shape of the loss function will depend on whose values it represents. For example, providers may object relatively more to underpayment and less to overpayment than payers. Nevertheless, I would assert that, no matter what the details, every reasonable loss function will at least not decrease as the magnitude of the error increases. For any such loss function and for two distributions of reimbursement error that are symmetrical about zero error, the distribution with

Figure 1:
Conceptual Model of Reimbursement Error



the smaller variance has the smaller expected loss. This proposition is proven in Appendix A.

Appendix B contains details of the analysis of reimbursement error under each alternative. One major result is that the average reimbursement error is the same for both payment schemes. Given the results of Appendix A, this means that the superior scheme is the one with the smaller variance in reimbursement error. It is important to note that neither alternative is categorically superior. Expression (12) in Appendix B reveals that the case-mix alternative has smaller variance whenever the typical measurement error in needs assessment is about as large as or larger than the typical difference among initial needs of patients in the facility. That is, if the patients are so relatively homogeneous and the needs assessment process so imprecise that it is difficult to make meaningful distinctions among patients, the case-mix alternative gives a lower average loss. On the other hand, if a facility's patient mix is heterogeneous or the needs assessment process can support relatively fine distinctions, or both, then conditions favor patient-centered reimbursement.

Uncertainty in Needs Assessment

The analysis identified a central empirical question: how does the uncertainty in needs assessment compare with the variation in need among patients in a facility? Is the technology of needs assessment sufficiently refined to support patient-centered reimbursement? Needs assessment involves three sequential steps: patient assessment, care planning, and service costing. Uncertainties at each stage accumulate and affect the precision of the overall process.

Empirical evidence on this question, while not plentiful, does point to significant uncertainty in needs assessment. An indication of the uncertainty in the first stage—patient assessment—appears in the work of Walsh [7], who noted the extent of substate differences in assessed need and attributed the differences mainly to administrative variation in the assessment process. Evidence of uncertainty in the second stage—care planning—may be inferred from the work of Sager [9], who documented wide cost variations among home care plans drawn up by different professionals working from the same patient assessments.

Finally, multivariate regression analyses have been used in attempts to relate patient characteristics to nursing home expenditures. Bishop [10] reviewed econometric studies of the cost of nursing home services by Ruchlin and Levy [11], Deane and Skinner [12], Mennemeyer [13], Bishop [14], Birnbaum et al. [15] and Walsh [7]. She noted that only the latter two studies attempted to control for quality of care when estimating the relationship between patient characteristics and cost. Without controlling for quality, it is difficult to attribute differences in cost to differences in clientele rather than difference in the type of care provided. The studies by Birnbaum et al. and by Walsh revealed statistically significant positive relationships between patient characteristics and expenditures. However, for my purposes here, the standard error of estimate (SEE) of a regression analysis is at least as important as the regression coefficients, since the SEE is related to the measurement error in my analysis. Though Birnbaum et al. did not report the SEE for their analysis, Walsh did report the SEE for his. It is particularly interesting that Walsh's analyses formed the empirical basis for the Illinois system of patient-centered reimbursement.

Using 9 predictor variables, including a count of need points (assigned on the basis of the patient's debility), Walsh was able to account for about 60 percent of the variation in average operating cost per patient among 136 nursing homes in Illinois. The reported SEE was $2.75. This figure represents a rough lower bound on the error involved in estimating the average cost for an entire facility. The uncertainty in estimating the cost for an individual patient will be much greater. Unfortunately, Walsh's results cannot be used directly to estimate the magnitude of measurement error. The problem is that any regression analysis that gives equal weight to variables averaged over facilities of different sizes will report a biased estimate of the SEE [16]. While it is possible to adjust for differences in facility size by differentially weighting the data from each facility, this was not done for the Illinois data.

All one can do is argue that the uncertainty in needs assessment is relatively great at the individual level. If the SEE for facility averages is about \$2.75 and the typical facility has upwards of 50 beds, then the typical uncertainty in estimating the need of an individual patient would be on the order of \$20 ($\$2.75 \times \sqrt{50}$). This uncertainty is large compared to the Illinois methodology's difference of about \$10 in the per diem rates of patients requiring light and heavy care. This calculation is rough, and one might expect needs assessments technologies to improve. Nevertheless, at least in the near term, uncertainties in needs assessment appear to be sufficiently large to favor case-mix over patient-centered reimbursement.

Administrative Issues

Administrative issues of reimbursement are also important, and here, too, the case-mix approach has advantages.

One advantage is that case-mix reimbursement could facilitate a transition from the current reimbursement system to a patient-centered system, should that prove appropriate. Case-mix reimbursement resembles the status quo in that each facility receives a single rate; yet, since it uses the same information as patient-centered reimbursement, the case-mix approach can serve to "shake down" the needs assessment technology.

Other advantages would result from being able to use a sample of patients, rather than a census, as a basis for reimbursement. Sampling would lessen assessment costs, which Walsh estimated at \$4 million per year in Illinois [7]. Sampling would also permit greater time per assessment and thereby presumably reduce measurement error (the analysis in Appendix B ignored this difference). Sampling also reduces the risk of providers' misrepresenting patient status. Government officials worry that any reimbursement scheme closely tied to patient condition would tempt providers to increase their incomes by making their patients' condition appear to be worse than it really is. The sampling feature of case-mix reimbursement would help control this paper inflation of patient needs by making more time available for thorough assessments and by reducing the likelihood that any single act of deception would pay off. (Independent quality review and peer pressure would be essential under either reimbursement alternative to guard against providers' allowing the patients' actual condition to deteriorate.)

If sampling were less attractive than a complete census, either because providers objected to it or because the assessments might be used as an integral part of the care process, the administrative advantages associated with it would disappear. However, since the performance of case-mix reimbursement improves with sample size, lost administrative advantages would convert into reduced reimbursement error. Furthermore, while providers are often said to oppose sample surveys of their operations, I have begun to develop a new approach that would make sampling more attractive by permitting providers to nominate the patients to be included in the sample [17].

Summary and Conclusions

I have compared two schemes to relate payment of the operating costs of a nursing home to the condition of its patients. One is patient-centered reimbursement, an approach that is receiving increasing attention. The patient-centered option uses individual needs assessments to determine individualized reimbursement rates. The other scheme is case-mix reimbursement, which uses needs assessments from a sample of a facility's patients to determine a single facility-specific rate. Elaborating a model of reimbursement error, I have explored the conditions under which each alternative is superior in terms of over- and underpayment.

Since the two approaches give the same average reimbursement error, discrimination between them hinges on the variance of the reimbursement error. Which method minimizes payment error for a facility depends mainly on the heterogeneity of the facility's patients with regard to their ideal reimbursement rates and on the typical error made in assessing that ideal rate. Factors of less importance are the size of the facility and the size of the sample of patients used in the case-mix option. As a rule of thumb, the case-mix method is preferable whenever the differences between patients' needs are smaller than the errors in needs assessment.

Pertinent empirical literature is rather sparse but does suggest that the case-mix alternative would be superior in practice. In reaching this conclusion, I relied heavily on Walsh's analysis of patient-centered reimbursement as implemented in Illinois.

Comparison of the two alternatives also involves administrative issues. Case-mix reimbursement can ease the transition from the status quo to patient-centered rates, should that become advisable. In addition, implementing case-mix reimbursement on a sampling basis offers several advantages. Among these are reduced assessment costs, more thorough assessments, and weakened incentives for providers to misrepresent patient status.

This analysis should add perspective to the debate about reform of long-term care reimbursement. It is true that the present system has drawbacks, relying as it does on two broad and ill-defined levels of care and focusing heavily on skilled nursing services. In contrast, an individualized approach based on thorough patient assessments seems quite attractive, especially since patient-centered reimbursement appears to be logistically feasible. However, theoretically attractive policies may be harmful if they cannot be implemented successfully. The case-mix alternative to patient-centered reimbursement uses the same type of information in a more modest way, and I have established that its performance can be superior. Judging from the pertinent empirical literature, I find that the state of the art of needs assessment argues against patient-centered reimbursement as a response to the problems of overpayment and underpayment. Should the state of the art improve, my analysis provides a way to recognize when this conclusion should be reversed.

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APPENDIX A

The case of zero mean error. First I establish that, for any two unimodal distributions of reimbursement error symmetrical about zero and for any monotonic, nondecreasing loss function for reimbursement error, the error distribution with the greater variance has the greater expected loss. Let

$L(\cdot)$ = a monotonic, nondecreasing loss function for reimbursement error;
$f(\cdot)$ = a symmetrical, unimodal probability density for reimbursement error with mean $\mu = 0$ and variance σ_f^2;
$F(\cdot)$ = the cumulative distribution corresponding to $f(\cdot)$;
$g(\cdot)$ = another symmetrical, unimodal error density with mean 0 and variance $\sigma_g^2 > \sigma_f^2$;
$G(\cdot)$ = the cumulative distribution corresponding to $g(\cdot)$;
x_1 = the value of reimbursement error for which $x_1 < 0$ and $f(x_1) = g(x_1)$; and
x_2 = the value of reimbursement error for which $x_2 > 0$ and $f(x_2) = g(x_2)$.

I wish to prove that the expected loss increases with the variance of the error distribution; that is,

$$\int_{-\infty}^{\infty} L(x)g(x)dx \geqslant \int_{-\infty}^{\infty} L(x)f(x)dx. \tag{1}$$

Since the problem is symmetric, this reduces to establishing that

$$\int_0^{\infty} L(x)\{g(x) - f(x)\}dx \geqslant 0. \tag{2}$$

This is, in turn, equivalent to

$$\int_{x_2}^{\infty} L(x)\{g(x) - f(x)\}dx \geqslant \int_0^{x_2} L(x)\{f(x) - g(x)\}dx. \tag{3}$$

Now, because $L(\cdot)$ is monotonic nondecreasing

$$\int_{x_2}^{\infty} L(x)\{g(x) - f(x)\}dx \geqslant L(x_2)\int_{x_2}^{\infty}\{g(x) - f(x)\}dx \tag{4}$$

and

$$\int_0^{x_2} L(x)\{f(x) - g(x)\}dx \leqslant L(x_2)\int_0^{x_2}\{f(x) - g(x)\}dx, \tag{5}$$

inequality (3) is true if

$$L(x_2)\int_{x_2}^{\infty}\{g(x) - f(x)\}dx \geqslant L(x_2)\int_0^{x_2}\{f(x) - g(x)\}dx \tag{6}$$

or

$$F(x_2) - G(x_2) \geqslant F(x_2) - G(x_2) - \{F(0) - G(0)\}. \tag{7}$$

Now, since $F(0) = G(0) = 0.5$, inequality (7) holds, and it follows that inequality (1) has been established.

The case of nonzero mean error. When the error distributions are not centered on zero, the situation is more complicated. In fact, it is possible to create a monotonic, nondecreasing loss function that favors greater variance: when

$$x_1 < \mu < x_2 < 0,$$

such a loss function would be a positive constant for all values of reimbursement error less than x_2 and zero everywhere else. Such a function is pathological, however, and could not be justified as representing any party's concerns for payment error. While I have not been able to prove the general proposition that, with nonzero mean error, the greater variance gives the greater mean loss, my colleagues and I have elsewhere established the truth of the proposition for linear loss functions [8].

Leaving loss functions aside for the moment, one certainly can say that, of two error distributions with the same mean but unequal variances, the distribution with the greater variance will be more likely to produce overpayments and underpayments of large size. Thus it still seems reasonable to treat the variance of reimbursement error as the basis for evaluating the relative performance of patient-centered and case-mix reimbursement.

APPENDIX B

Analysis of patient-centered reimbursement. We seek the mean and variance of the reimbursement error. For any patient let

E = reimbursement error at any time after the previous needs assessment, having mean m_e and variance v_e;
N = initial need, having mean m_n and variance v_n ;
C = change in need since the previous needs assessment, having mean m_c and variance v_c;
M = measurement error in needs assessment process, having mean m_m and variance v_m; and
A = assessed need, being the sum of initial need and measurement error.

Now, since reimbursement error is the difference between assessed need and current need, and current need is initial need plus change in need,

$$E = A - (N + C). \quad (1)$$

Furthermore, since assessed need is initial need plus measurement error,

$$E = M - C. \quad (2)$$

It follows from expression (2) that the mean reimbursement error is

$$m_e = m_m - m_c \quad (3)$$

and the variance of the reimbursement error is

$$v_e = v_m + v_c - 2cov(M,C). \quad (4)$$

Note that the performance of the patient-centered approach does not depend explicitly on the distribution of initial need in the facility. Further, to the extent that the distributions of measurement error and change in need are roughly symmetric, the distribution of reimbursement error defined in expression (2) will be even more symmetric, by the central limit theorem.

The covariance term in expression (4) deserves mention. It is possible to imagine ways in which measurement error and change in need would be associated. For instance, if initial need were almost zero, then both variables would probably be positive, since neither assessed need nor current need can be a negative number. However, nursing home patients are unlikely to have almost no need for services. In another instance, if assessed need were different from initial need, the patient's treatment plan might be appropriate and thereby impede improvement; however, it does not seem possible to foretell even the sign of the covariance in such a case. The correlation between measurement error and change in need seems likely to be weak in any case. Lacking empirical support for any alternative assumption, I regard measurement error and change in need as uncorrelated, but not necessarily independent, random variables. In this case,

$$v_e = v_m + v_c. \tag{5}$$

Analysis of case-mix reimbursement. The analysis of the case-mix alternative is more difficult because the variance of reimbursement error for an individual patient depends on whether or not that individual is included in the sample of patients whose needs are assessed. Let

P = number of patients in the facility
S = size of the sample $(2 \leqslant S \leqslant P)$.

Furthermore, let subscript i denote the patient in question and subscript j denote any patient in the sample.

The reimbursement error for the ith patient is given in a way analogous to expression (1):

$$E_i = \left(\frac{1}{S}\sum_{j=1}^{S} A_j\right) - \left(N_i + C_i\right). \tag{6}$$

Again noting that assessed need equals initial need plus measurement error, one can rewrite expression (6) to provide an illuminating contrast with patient-centered reimbursement:

$$E_i = \left\{\left(\frac{1}{S}\sum_{j=1}^{S} M_j\right) - C_i\right\} + \left\{\left(\frac{1}{S}\sum_{j=1}^{S} N_j\right) - N_i\right\}. \tag{7}$$

The first term in brackets is similar to expression (2) for patient-centered reimbursement, but it is more attractive because it substitutes an average of random measurement error terms for a single value. However, the second term in brackets is an additional error component not found with patient-centered reimbursement. This additional term represents the difference between the average initial need in the sample and the initial need of an individual patient. The more heterogeneous a facility's case mix, the more this term will contribute to total reimbursement error, rendering the case-mix alternative less attractive. The relative success of case-mix reimbursement depends on whether the advantages provided by the first bracketed term are offset by the disadvantages of the second.

It is important to note that despite the differences between expressions (2) and (7), both reimbursement schemes have the same mean reimbursement error.

Because the averages in expression (7) are unbiased estimates in simple random samples, expression (3) for the mean error with patient-centered reimbursement also applies to case-mix reimbursement.

I have already assumed that measurement error and change in need are uncorrelated. To obtain further results, one must also assume that both of these variables are uncorrelated with, but not necessarily independent of, initial need. Although the analysis would support alternative assumptions, I know of no empirical findings to document specific alternatives.

Having made these assumptions, one can use expression (7) to determine the variance of reimbursement error in the case-mix scheme:

$$v_e = \left(\frac{1}{S}\right) v_m + v_c + \left\{\left(\frac{P-S}{P-1}\right)\left(\frac{1}{S}\right) + 1\right\} v_n - 2cov\left(\frac{1}{S}\sum_{j=1}^{S} N_j, N_i\right). \quad (8)$$

The value of the covariance term depends on whether the ith patient was included in the sample

$$cov\left(\frac{1}{S}\sum_{j=1}^{S} N_j, N_i\right) = \frac{v_n}{S} \quad (9)$$

if the ith patient was included in sample; it equals zero if the ith patient was not included.

The distribution of reimbursement error in the case-mix alternative is, therefore, a mixture of two distributions: one for those patients included in the sample and one for the others. Since the probability that the ith patient is included in the sample is S/P, the variance of the resulting mixture is

$$v_e = \left(\frac{1}{S}\right) v_m + v_c + \left\{\left(\frac{P-S}{P-1}\right)\left(\frac{1}{S}\right) + 1 - \frac{2}{P}\right\} v_n. \quad (10)$$

As a final point, note that the form of expression (7), which involves sums or differences of four terms, two of which are themselves sums, augers well for assuming that the distribution of reimbursement error is very nearly symmetric, whatever the distributions of M, N, and C.

Comparison of patient-centered and case-mix reimbursement. I have now shown that the reimbursement error has the same mean but different variances under the two alternatives. The results of Appendix A show that the preferable alternative from the perspective of minimizing reimbursement error is the one with the smaller variance. Thus the comparison is reduced to the differences between expressions (5) and (10).

The condition under which the case-mix approach would be superior, therefore, is

$$\left(\frac{1}{S}\right) v_m + v_c + \left\{\left(\frac{P-S}{P-1}\right)\left(\frac{1}{S}\right) + 1 - \frac{2}{P}\right\} v_n < v_m + v_c. \quad (11)$$

Rearranging, one has

$$\frac{v_m}{v_n} > \frac{S(1-2/P) + (P-S)/(P-1)}{S-1}. \tag{12}$$

Expression (12) means that case-mix reimbursement is preferable whenever the typical error in needs assessment, $\sqrt{v_m}$, is sufficiently large compared to the typical difference in need among patients, $\sqrt{v_n}$. The meaning of "sufficiently large" depends on both the number of patients in the facility and the size of the sample. For most reasonable values of sample size and facility size, the value of the right hand side of expression (12) is nearly unity. In the extreme case, when the sample is a complete census, the condition becomes

$$\frac{v_m}{v_n} > \frac{P-2}{P-1}. \tag{13}$$

Case-mix reimbursement is least desirable when it is based on a small sample from a large facility. When the inequality in expression (12) is not satisfied, the patient-centered approach is superior in terms of the distribution of reimbursement error.

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