Referral Selection Bias in the Medicare Hospital Mortality Prediction Model: Are Centers of Referral for Medicare Beneficiaries Necessarily Centers of Excellence?

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Objective. Although the Health Care Financing Administration (HCFA) uses Medicare hospital mortality data as a measure of hospital quality of care, concerns have been raised regarding the validity of this concept. A problem that has not been fully evaluated in these data is the potential confounding effect of illness severity factors associated with referral selection and hospital mortality on comparisons of risk-adjusted hospital mortality. We address this issue.

Data Sources and Study Setting. We analyzed the 1988 Medicare hospitalization data file (MEDPAR). We selected data on patients treated at the two Mayo Clinic-associated hospitals in Rochester, Minnesota, and a group of seven other hospitals that treat many patients from large geographic areas. These hospitals have had observed mortality rates substantially lower than those predicted by the HCFA model for the period 1987-1990.

Study Design. Using the multiple logistic regression model applied by HCFA to the 1988 data, we evaluated the relationship between distance from patient residence to the admitting hospital and risk-adjusted hospital mortality.

Principal Findings. Among patients admitted to Mayo Rochester-affiliated hospitals, residence outside Olmsted County, Minnesota was independently associated with a 33 percent lower 30-day mortality rate ($p < .001$) than that associated with residence in Olmsted County. When patients at Mayo hospitals were stratified by residence (Olmsted County versus non-Olmsted County), the observed mortality was similar to that predicted for community patients (9.6 percent versus 10.2 percent, $p = .26$), whereas hospital mortality for referral patients was substantially lower than predicted (5.0 percent versus 7.5 percent, $p = < .001$). After incorporation of the HCFA risk adjustment methods, distance from patient residence to the hospitals was also independently associated with mortality among the Mayo Rochester-affiliated hospitals and seven other referral center hospitals.

Conclusions. The HCFA Medicare hospital mortality model should be used with extreme caution to evaluate hospital quality of care for national referral centers because of residual confounding due to severity of illness factors associated with geographic referral that are inadequately captured in the extant prediction model.

Keywords. Hospital mortality, selection bias, confounding

The Health Care Financing Administration (HCFA) has been publishing observed and risk-adjusted estimates of hospital mortality rates for Medicare beneficiaries each year since 1986 based on the concept that these rates can be used to compare quality of care across hospitals. This approach has engendered substantial discussion in the lay press and in the scientific community. There has been considerable controversy concerning the validity of these comparisons across hospitals (Blumberg 1987; Hartz, Krakauer, Kuhn, et al. 1989; DuBois, Rogers, Moxley, et al. 1987; Green et al. 1990; Berwick and Wald 1990; DuBois 1989; Fink, Yano, and Brook 1989; Wennberg et al. 1989; Green, Passman, and Wintfeld 1991). Nevertheless, because some institutions that are viewed in the lay and medical community as being "centers of excellence" have mortality rates that are substantially lower than their predicted values, the HCFA prediction model has acquired a certain degree of face validity. For example, the two Mayo Clinic Rochester-affiliated hospitals have had statistically unusual 30-day

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mortality experiences as reported by HCFA for the years 1986–1990 (Health Care Financing Administration 1989, 1990, 1991).

Analyses by Green et al. (1990; 1991), Smith, Pine, Bailey, et al. (1991), and Iezzoni et al. (1992) suggest that the HCFA prediction model does not adequately account for patient severity of illness. Severity of illness is typically lower for geographically referred Medicare beneficiaries than for community patients at the Mayo Clinic (Warner, Hosking, Lobdell, et al. 1990). Consequently, we hypothesized that the statistically unusual Medicare hospital mortality performance of national referral centers such as Mayo may be attributable to severity factors associated with referral selection that are not fully captured in the extant Medicare hospital mortality prediction model of HCFA. Therefore, we evaluated the effect of referral selection on comparisons of observed mortality with mortality predicted by HCFA's statistical models.

METHODS

STUDY POPULATION

To conduct this study, we used the MEDPAR file of all patient discharge abstracts from HCFA for 1988 (Health Care Financing Administration 1989). This file includes all hospitalizations in the United States among Medicare beneficiaries in 1988. To evaluate the generalizability of the analysis for Mayo Rochester-affiliated hospitals, we also examined the mortality experience of seven other national referral centers that have been characterized as "centers of excellence" on the basis of their Medicare hospital mortality experience (Shaller et al. 1992).

THE HCFA MEDICARE HOSPITAL MORTALITY PREDICTION MODEL

We implemented the approach undertaken by HCFA in reporting data for patients discharged during 1988 (Health Care Financing Administration 1989). We report analyses based on sampling last hospitalizations for the calendar year 1988; the results of these analyses were similar to the findings from analyses based on sampling randomly among all hospitalizations for the fiscal year 1988 (Health Care Financing Administration 1990).

We used the patient groups, predicted regression models, and mortality rates described by HCFA in 1989 (Health Care Financing

Administration 1989). HCFA used 17 analytical diagnostic categories through grouping ICD-9-CM diagnosis codes with similar raw mortality rates and clinical definitions. Within each category, the following explanatory variables were used in a logistic regression model for the 1989 Medicare hospital mortality release: demographic variables (age and sex); comorbidities (cancer, chronic cardiovascular disease, chronic liver disease, and chronic renal disease); hospital admission sources (physician, skilled nursing facility); types of hospitalizations (elective procedure, emergency); and previous hospitalization categorized by risk level.

We included two additional variables separately in two logistic regression models. (1) To evaluate the magnitude of the independent association of patient residence and mortality for Mayo Clinic patients, a variable for patient residence (0 = Olmsted County, 1 = non-Olmsted County) was added to our model. (2) To assess the independent relationship between referral distance and mortality for Mayo patients from outside the community, referral distance from patient residence to the Mayo Clinic was added to another model.

COMMUNITY VERSUS GEOGRAPHICALLY DISTANT PATIENTS

We defined Olmsted County residence using the patient's zip code in the MEDPAR file. For the non-Olmsted County residents in the Mayo data and for the other seven national referral centers, we used a software program developed by the Fred Hutchinson Cancer Center (Polissar et al. 1984) to estimate the distance in miles between the zip code of each patient's residence and the zip code of the national referral center where the patient was hospitalized.

RESULTS

MORTALITY RATES STRATIFIED BY PATIENT RESIDENCE

The predicted mortality rates, stratified by patient residence, are indicated in Table 1. The observed 30-day mortality for Olmsted County residents was not statistically different than predicted (9.6 percent versus 10.2 percent, $p = 0.26$). In contrast, the 30-day mortality for the non-Olmsted County Medicare enrollees admitted to these Mayo hospitals was substantially lower than predicted (5.0 percent versus 7.5 percent, $p < .001$).

Table 1: Observed and Predicted 30-Day Case-Fatality Rates among Medicare Beneficiaries Hospitalized in 1988 at Mayo Rochester-Affiliated Hospitals, Stratified by Patient Residence

Patient Residence	*No. of Patients*	*Observed Mortality Rate (%)*	*Predicted Mortality Rate (%)*	*Predicted ± 2 s.d. (%)*	p-*Value*
Olmsted County	2,408	9.6	10.2	9.1-11.3	.26
Non-Olmsted County	11,188	5.0	7.5	7.1- 8.0	<.001
Total	13,596	5.8	8.0	7.6- 8.4	<.001

LOGISTIC REGRESSION ANALYSIS

After incorporation of HCFA risk adjustment methods, patients from outside Olmsted County had a 33 percent lower mortality rate than residents of Olmsted County (odds ratio = .67, 95 percent confidence interval = .56 to .81, $p < .001$) (Table 2).

MAGNITUDE OF REFERRAL BIAS AS A FUNCTION OF REFERRAL DISTANCE FROM RESIDENCE

For the Mayo Rochester-affiliated hospitals, the mortality ratio (observed/predicted) rates decreased consistently as referral distance increased (Figure 1A). Consistent with the concept that the HCFA Medicare mortality prediction model does not fully capture all of the factors associated with geographic referral and with lower 30-day mor-

Table 2: Relative Risk of Death within 30 Days of Hospitalization in 1988 Associated with Referral Status among Medicare Beneficiaries at Mayo Rochester-Affiliated Hospitals and Seven National Referral Centers

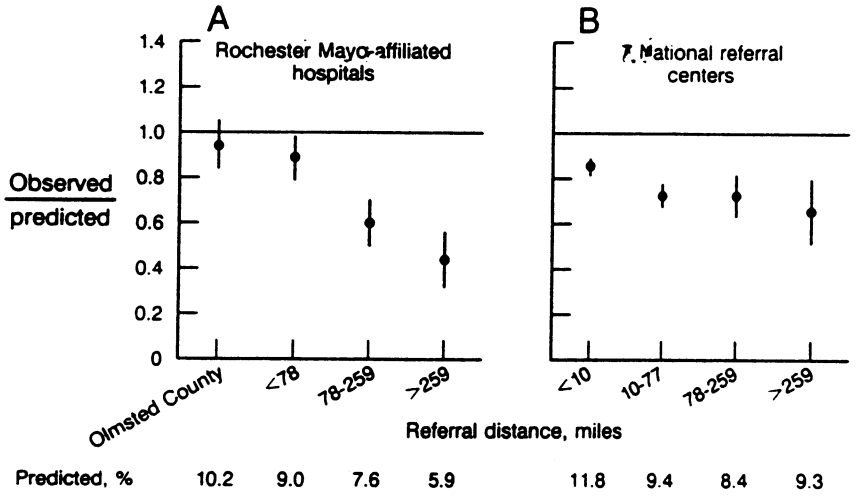
Hospital	*Contrast*	*Odds Ratio**	*(95% CI)†*	p-*Value*
Mayo Rochester-affiliated hospitals	0 = Olmsted County; 1 = non-Olmsted County	.67	.56-.81	<.001
Seven national referral centers	0 = <10 miles; 1 = ≥10 miles‡	.80	.73-.87	<.001

*The risk of death for geographically referred patients relative to community patients is estimated by the odds ratio derived from the multiple logistic regression model, including the Medicare hospital mortality prediction model variables and a dichotomous variable to classify patient residence.

†CI = confidence intervals.

‡Distance in miles from patient residence to the admitting hospital.

Figure 1: Observed versus Predicted Mortality within 30 Days of Hospital Admission with Associated 95 percent Confidence Intervals, by Patient Residence, Based on Sampling the Last Hospital Admissions in 1988 for Medicare Beneficiaries for Mayo Rochester-Affiliated Hospitals (A) and Seven National Referral Centers (B)



tality, the predicted mortality declined as a function of referral distance, but less so than the observed mortality (Figure 1A). According to these data, the Mayo Rochester-affiliated hospitals would be labeled as "low-mortality outliers" for distantly referred patients. In contrast, the mortality experience of Olmsted County residents treated at these institutions was statistically unremarkable.

GENERALIZABILITY OF REFERRAL SELECTION BIAS

For seven other national referral centers, patient residence at least ten miles from the referral hospital, in contrast to residence within ten miles, was independently associated with a 20 percent decrease in 30-day mortality (Table 2). Similar findings for mortality as a function of distance from patient residence were observed for the seven national referral centers (Figure 1B); the mortality ratio diminished as a function of increasing referral distance ($p < .001$) for the coefficient of referral distance as a dichotomous variable (< 10 miles, ≥ 10 miles) or as a continuous variable in multiple logistic regression models). For the

patients residing within ten miles of these referral centers, the observed mortality was significantly less than the value predicted by the HCFA model (95 percent confidence interval for the observed/predicted mortality = .80 to .88).

DISCUSSION

This analysis of the 1988 HCFA Medicare hospital mortality data reveals a strong association between distance from patient residence to the admitting hospital and 30-day mortality after hospital admission for several national medical care referral centers in the United States. That is, there is substantial referral bias in the mortality statistics of these hospitals. Among patients from Olmsted County at the Mayo Rochester-affiliated hospitals, the observed 30-day mortality rate was clinically and statistically indistinguishable from the predicted rate. In contrast, non-community patients at this national medical care referral center had an observed mortality rate that was substantially lower than predicted. Several scientific and health policy questions emerge from our study findings.

Although the independent effect of referral selection in our analyses cannot be explained by chance and does not appear to be resolved with refinements in the HCFA analytic approach to hospital mortality prediction in Medicare beneficiaries, several other issues must be considered. Our study findings could possibly be explained by true differences in the quality of care (Iezzoni 1993). However, we cannot identify factors relating to quality of care that might vary systematically as a function of referral distance. Specifically, no one has identified process-of-care elements for surgical patients at Mayo Rochester-affiliated hospitals that vary systematically with increasing referral distance. In general, internal medicine patients from the region surrounding Rochester are admitted to hospital services staffed by general internists, whereas distantly referred internal medicine patients are primarily admitted to subspecialty services. However, there is considerable overlap across hospital services at Mayo Rochester in the care of Medicare beneficiaries.

Because the MEDPAR file cannot be linked with intra-institutional files that identify the primary hospital medical service, we were unable to determine whether or not the effect of referral distance was present in the hospital care stratum of subspecialty primary service. Thus, although we cannot completely rule out the possibility that our findings are truly due to differences in quality of care associated

with referral distance for Medicare patients at these hospitals, such an explanation is implausible.

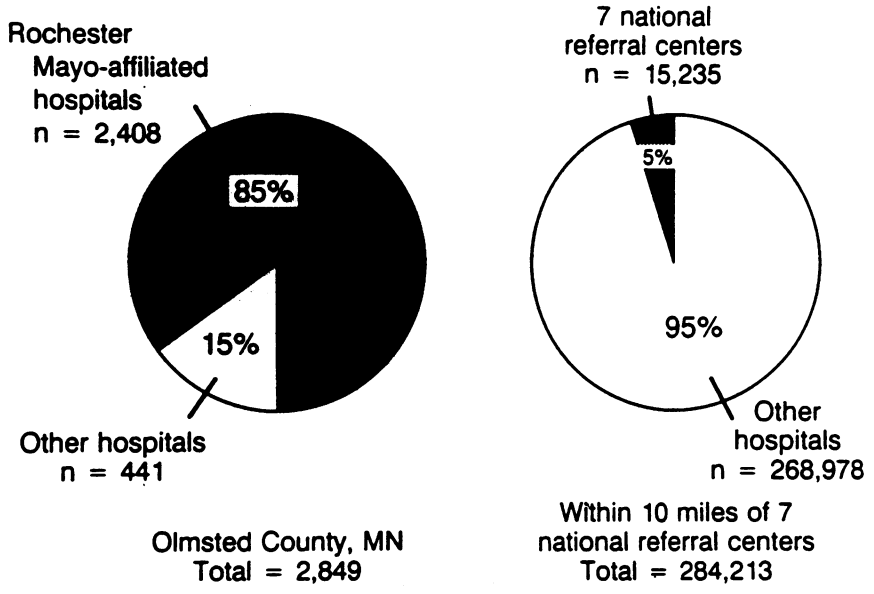
The other national referral centers, also do not have systems of care that vary systematically as a function of referral distance. Analysis of their hospital mortality experience further supports the conclusion that our findings are not fully attributable to differences in quality of care.

Random allocation of Medicare beneficiaries to general medicine versus special service hospital care at Mayo Rochester-affiliated hospitals and at these other seven centers would be necessary to resolve any residual scientific uncertainty regarding an association between referral distance and type of medical service as an explanation for our findings.

It is important to emphasize that the full complexity of the medical care referral process is inadequately captured by a simple measure such as referral distance. The Mayo Rochester-affiliated hospitals account for 85 percent of all Medicare hospital admissions for residents of Olmsted County, Minnesota (Figure 2). In contrast, the other seven national referral centers encompass only 5 percent of all hospitalizations among Medicare beneficiaries who reside within 10 miles of these centers (Figure 2). Given the low sampling fraction of all Medicare admissions among community residents for these other seven national referral centers, considerable hospital referral selection within the communities (i.e., within a restricted referral distance) encompassed by these other seven national referral centers that is not fully captured in the extant HCFA model may account for the statistically unusual mortality experience of these centers for Medicare beneficiaries who reside within 10 miles of these referral centers. Therefore, while referral distance may be a useful proxy for patient severity selection bias in the Mayo Rochester setting based on these data and other studies conducted in this setting (Melton 1985), other measures of patient severity are necessary to capture selection bias in metropolitan hospital settings (Shapiro et al. 1993). Thus, the central problem is not that HCFA has failed specifically to account for referral selection bias; the fundamental concern with the data used by HCFA to develop mortality ratios is that severity of illness is inadequately measured (Iezzoni et al. 1992).

We conclude that the HCFA mortality prediction model does not adequately incorporate patient information that relates to the referral process and to mortality. Previous comparisons of the outcome of patients at Mayo Rochester-affiliated hospitals stratified by patient residence suggest that this is a reasonable explanation for our study findings (Melton 1985). For example, a study conducted by Warner,

Figure 2: Distribution of Hospitalizations among Medicare Beneficiaries Residing in Olmsted County, Minnesota, and within 10 Miles of Seven National Referral Centers, Based on Sampling the Last Hospitalization in 1988



Hosking, Lobdell, et al. (1990) indicated that Mayo Rochester-affiliated hospital patients from Olmsted County who were at least 90 years of age had substantially higher comorbidity levels than non-Olmsted County residents and, consequently, had higher 30-day perioperative mortality rates. After adjustment for these potential confounding factors in the analysis of surgical outcomes, no independent association between patient residence and mortality was found. This suggests that if the additional potential confounders could be included in the HCFA mortality model, the magnitude of the residual confounding due to referral selection might be diminished.

While we have addressed the issue of referral selection bias in an aggregate analysis encompassing all Medicare admissions, previous research based on this methodologic concept in the Rochester Mayo setting indicates that the magnitude and direction of referral selection bias is condition-specific for patients receiving care at Rochester Mayo (Melton 1985; Ballard and Duncan 1994). For example, at Rochester Mayo, community patients undergoing elective abdominal aortic

aneurysm surgery have a higher mortality rate within 30 days of surgery and worse long-term survival than referral patients (Roger, Ballard, Hallett, et al. 1989; Hollier, Reigel, Kazmier, et al. 1986; Ballard, Etchason, Hilborne, et al. 1992), while community patients with idiopathic dilated cardiomyopathy have a substantially better prognosis than Mayo referral patients with this condition (Fuster, Gersh, Giuliani, et al. 1981; Sugrue, Rodeheffer, Codd, et al. 1992). Depending on the availability of specialized clinical services in a given referral center and other factors, we hypothesize that the magnitude and direction of referral selection bias is referral center-specific, in addition to being condition-specific.

Several comments are germane with respect to refinements in the HCFA mortality prediction model. The Uniform Clinical Data Set (Hopkins 1991; Jencks and Wilensky 1992) has been described as a major advance in the ability to use risk-adjusted mortality as a measure of hospital quality of care. Even if resources could be committed to national implementation of the UCDS, it is uncertain whether these extensive clinical attributes could be collected with a sufficiently low misclassification percentage to capture adequately the lower severity of illness of Medicare beneficiaries who travel to national referral centers. Furthermore, even if the Uniform Clinical Data Set effort can reliably classify clinical information, these data may not deal adequately with the residual confounding effect of the judgments made by Medicare beneficiaries and their physicians to travel extensive distances for medical care that results in hospital admission at national referral centers, or to seek care at highly specialized centers even within a given metropolitan area. That is, the prognostic significance of the decision and ability to gain access to care at a national referral center may not be captured sufficiently through the Uniform Clinical Data Set. Nevertheless, the clinical information that will be collected through the Uniform Clinical Data Set and condition-specific evaluations such as the Cooperative Cardiovascular Project (Jencks and Wilensky 1992) has the potential to support much more valid and clinically meaningful hospital-level analyses.

Our study findings raise several questions about health care policy. Should the HCFA MEDPAR data and the associated method for risk adjustment, in present form or based on current refinements, be used to identify "centers of excellence" for hospital care of Medicare beneficiaries in the United States? For example, with respect to targeting institutions for the performance of nonemergency surgical procedures in the Medicare population (such as coronary artery bypass graft surgery), what are the implications of these study findings? Our data

suggest that, until better prediction models based on more sophisticated severity measurement approaches can be developed and feasibly applied across all hospitals in the United States (Iezzoni et al. 1992; Iezzoni 1993), it would be extremely unwise to base the designation "centers of excellence" solely on the use of MEDPAR-type administrative data for quality measurement.

What are the implications of these data quality concerns with respect to generic hospital quality of care monitoring efforts? In this regard, as part of its Health Care Quality Improvement Initiative (HCQII) (Jencks and Wilensky 1992; Nash 1992; Hayes, Lundberg, and Ballard 1994), HCFA launched a Medicare hospital mortality pattern analysis project, designated the Medicare Hospital Information Project (MHIP). Through the MHIP, the Connecticut and Wisconsin peer review organizations (PROs) used MEDPAR data and associated hospital mortality prediction models to develop pattern analysis strategic and educational materials for other PROs. Pattern analysis making use of the insights derived from the MHIP will be included in HCQII's Fourth Scope of Work encompassing quality of care evaluation and improvement activities by PROs. Our observations with respect to referral selection bias, in addition to other severity measurement concerns with the MEDPAR data (Green et al. 1990; Green, Passman, and Wintfeld 1991; Smith, Pine, Bailey, et al. 1991; Iezzoni et al. 1992), indicate that more refined clinical information will be necessary to support the useful application of pattern analysis techniques by PROs in evaluating hospital quality of care.

Furthermore, an ongoing issue of debate is whether even the best data on severity of illness can adjust hospital mortality data well enough for PROs to identify quality problems with acceptable accuracy in institutions with aberrantly high adjusted mortality rates (Park, Brook, Kosecoff, et al. 1990; Park, Brook, Kosecoff, et al. 1991; Thomas, Holloway, and Guire 1993). Krakauer, Bailey, Skellan, et al. (1992) conclude that the 1986 MEDPAR data and HCFA mortality prediction model can be used satisfactorily "to characterize variations in mortality rates associated with hospitalization," but that HCFA's approach "does not positively identify outlier hospitals as providers of problematic care" (p. 318). To extend the argument of Krakauer et al., our analysis indicates that the procedures employed by HCFA do not identify low-mortality outlier hospitals as providers of superior care.

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