Effect of interhospital transfer on resource utilization and outcomes at a tertiary care referral center*

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Objective: **Mortality and length of stay are two outcome variables commonly used as benchmarks in rating the performance of medical centers. Acceptance of transfer patients has been shown to affect both outcomes and the costs of health care. Our objective was to compare observed and predicted lengths of stay, observed and predicted mortality, and resource consumption between patients directly admitted and those transferred to the intensive care unit (ICU) of a large academic medical center.**

Design: **Observational cohort study.**

Setting: **Mixed medical/surgical ICU of a university hospital.**

Patients: **A total of 4,569 consecutive patients admitted to a tertiary care ICU from April 1, 1997, to March 30, 2000.**

Interventions: **None.**

Measurements: **Acute Physiology and Chronic Health Evaluation (APACHE) III score, actual and predicted ICU and hospital lengths of stay, actual and predicted ICU and hospital mortality, and costs per admission.**

Main Results: **Crude comparison of directly admitted and transfer patients revealed that transfer patients had significantly higher APACHE III scores (mean, 60.5 vs. 49.7, $p < .001$), ICU mortality (14% vs. 8%, $p < .001$), and hospital mortality (22% vs. 14%, $p < .001$). Transfer patients also had longer ICU lengths of stay (mean, 6.0 vs. 3.8 days, $p < .001$) and hospital lengths of stay (mean, 20 vs. 15.9 days, $p < .001$). Stratified by disease severity using the APACHE III model, there was no difference in either ICU or hospital mortality between the two populations. However, in the transfer group with the lowest predicted mortality of 0–20%, ICU and hospital lengths of stay were significantly higher. In crude cost analysis, transfer patients' costs were $9,600 higher per ICU admission compared with nontransfer patients (95% confidence interval, $6,000–$13,400). Risk stratification revealed that the higher per-patient cost was entirely confined to the transfer patients with the lowest predicted mortality.**

Conclusions: **Patients transferred to a tertiary care ICU are generally more severely ill and consume more resources. However, they have similar adjusted mortality outcomes when compared with directly admitted patients. The difference in resource consumption is mainly attributable to the group of patients in the lowest predicted risk bracket. (Crit Care Med 2007; 35:1470–1476)**

Key Words: academic medical center; hospital costs; intensive care units; length of stay; mortality

The fundamental purpose of academic medical centers (AMCs) is to improve the health of their communities and society at large via the interrelated social missions of education for health professionals, biomedical research, and the provision of medical care. Service to the community is also provided in the form of rare and high-technology resources, continuous innovations in patient care, and care of the indigent, uninsured, and vulnerable populations (1). As part of this task, they commonly take on the responsibility for patients transferred to them from hospitals and health centers where their care would otherwise be compromised because of inadequate means or capabilities. In recent decades, the ability of AMCs to sustain these multiple missions has been hampered by changes in healthcare financing and regulation (2). When assessing performance, however, the same benchmarking systems are used to evaluate all hospitals. Such systems compare the performance of a hospital or healthcare center with a standard in an attempt to evaluate quality and efficiency of care (3). Benchmark variables range from simple measurements of mortality to relatively complex prognostic systems developed, most notably, with reference to intensive care unit (ICU) patients. Based on these comparisons, AMCs must compete financially with other hospitals that do not have the same stated missions.

A number of studies have demonstrated greater costs associated with hospitalization in AMCs (4–11). Their outcomes, on the other hand, have often been shown to be superior (5, 7, 11–14). Many factors contribute to the higher healthcare costs, most importantly, the cost of graduate medical education. However, patient-related factors also play a role. Among these, the added cost of caring for patients transferred from other medical facilities has been investigated in the past (15–20). Using prognostic scoring systems such as the Simplified Acute Physiology Score (SAPS) II, the Mortality Prediction Model (MPM) II and the Acute Physiology and Chronic Health Evaluation (APACHE) II (21–24), these studies have attempted to adjust for the confound-

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ing variable of disease severity. In general, higher resource consumption and poorer outcomes as judged by two commonly monitored variables, namely mortality and length of stay, have been demonstrated in transferred patients when compared with nontransfer patient samples.

The APACHE prognostic system was developed in the United States to help clinicians predict outcomes for ICU patients. It was based on data collected in 42 ICUs involving >17,000 patients. The system gathers information on 27 variables, including age, chronic medical history, and physiologic data, which are then used to formulate an individual patient's predictive equations. Although developed in the 1980s, its methodology and predictive equations are periodically updated. The APACHE III version attempts to standardize mortality risk and length of stay according to a patient's admission source (25). To further assess this ability, we set out to compare mortality odds ratios and lengths of stay between transfer and nontransfer patients at a university hospital tertiary referral center, using an observational cohort design. We also sought to compare the costs of providing medical care between transfer and nontransfer patients. Finally, we studied the association between transfer status and cost, mortality, and length of stay according to categories of disease severity.

MATERIALS AND METHODS

The University of Wisconsin Hospital's Trauma and Life Support Center is a 24-bed ICU, admitting noncardiac medical and surgical patients. It is a level 1 trauma center, and supports one of the country's largest transplant programs. Admission sources include the emergency department, hospital wards, and clinics and transfers from surrounding community and rural health centers. An active MedFlight Program, staffed by emergency medicine and critical care attendings, transfers patients from throughout the upper Midwest.

A consecutive cohort of 4,569 patients admitted to the Trauma and Life Support Center between April 1, 1997, and March 30, 2000, were included in the study. The protocol was reviewed by the University of Wisconsin's institutional review board. Informed consent was waived by the institutional review board. There were no exclusion criteria. Data were collected prospectively using the hospital's electronic records, the patients' paper charts, and the University of Wisconsin Hospital's cost-accounting system. Basic demographic information was recorded at admission. Admission source and data required to calculate the APACHE III score were gathered on all patients within 24 hrs of admission to the University of Wisconsin Hospital's Trauma and Life Support Center, using APACHE III software (Cerner, Kansas City, MO). Each patient's encounter began at the time of initial ICU admission and ended at the point of hospital discharge or death. Patients who were readmitted to the ICU during the same hospitalization were considered a single encounter. Those admitted to the Trauma and Life Support Center from an outside hospital's ICU or general wards were considered as transfer patients, whereas those admitted from the emergency department of the University of Wisconsin Hospital, its general wards, or its clinics were considered nontransfers.

Measured dependent variables included ICU and hospital length of stay, ICU and hospital mortality, and costs per admission. APACHE III scores were used to calculate predicted ICU length of stay, ICU mortality, hospital length of stay, and hospital mortality. Cost data were derived using Transition Systems' (now known as Eclipsys, Atlanta, GA) Decision Support System. For each admission, actual total costs were used, not hospital charges. The total cost for each patient was the sum of all direct and indirect hospital costs, excluding physician professional fees. Comparison between transfer and nontransfer patients was also made after stratification according to categories of disease severity by subdividing each group into quintiles of predicted ICU and hospital mortality.

Statistical Analysis. Demographic comparisons of transfer and nontransfer patients were made using two-sample Student's *t*-tests for continuous outcomes and the Pearson chi-square test for dichotomous outcomes. Hospital and ICU mortality in the two groups were compared using logistic regression models that included APACHE III predicted mortality rates as an offset term. Offset terms are covariates with a known fixed coefficient. Comparisons of hospital and ICU lengths of stay were made using negative binomial regression models that included APACHE III predicted length of stay as an offset. Mean and median costs were compared using bootstrap methods (26); bootstrap methods do not rely on distributional assumptions of normality and hence obviate the need for transformation of skewed cost data. Analyses were replicated for subgroups based on APACHE III predicted mortality (0–20%, 21–40%, 41–60%, 61–80%, 81–100%). A two-sided p value of .05 was regarded as statistically significant. All analyses were performed using SAS version 8.2 (SAS Institute, Cary, NC).

RESULTS

Study Population. A total of 4,951 admissions to the ICU were screened. Of these, 382 encounters (375 nontransfers and 7 transfers) represented a patient's readmission to the ICU during the same hospitalization, yielding a total of 4,006 nontransfer patients (88%) and 563 transfer patients (12%) for inclusion in the study. Table 1 shows the baseline demographic and clinical characteristics. There was no significant difference in age or sex distribution between the two groups. Transfer patients were more severely ill, as demonstrated by the higher mean APACHE III scores (60.5 vs. 49.7, $p < .001$). Comparison by the body system primarily impaired revealed that a greater proportion of transfer patients had gastrointestinal abnormalities, whereas trauma and neurologic abnormalities were more often encountered among nontransfer patients. Of the ten most frequent admission diagnoses, a smaller proportion of patients with sepsis were nontransfers, whereas the same group had a greater proportion of head trauma, aortic aneurysm, neurosurgical diagnoses, and postsurgical multiple trauma patients. These differences reflect variations in patterns of referral to the institution. There was no statistically significant difference in the proportion of patients with nonsurgical multiple trauma, pneumonia, gastrointestinal bleeds, other respiratory diseases, or drug overdoses.

ICU and Hospital Mortality. Table 2 outlines data for actual and predicted crude ICU mortality rates. Actual ICU mortality was greater among transfer patients (14% vs. 8%, $p < .001$). Predicted ICU mortality, based on the APACHE III model was also greater in the transfer group (19% vs. 11%, $p < .001$). Likewise, actual hospital mortality was greater among transfer patients (22% vs. 14%, $p < .001$), as was predicted hospital mortality (27% vs. 24%, $p < .001$). Table 3 displays mortality data adjusted for case-mix severity, using APACHE III. Stratification by predicted ICU mortality shows that a significantly lower proportion of transfer patients fell into the lowest risk categories. For example, in the nontransfer group, 3,295 patients (82%) had a predicted ICU mortality of 0–20%, whereas in the transfer group, there were 384 patients (68%) in the same risk category ($p < .001$). Conversely, there were 85 nontransfer patients (2%) in the highest quintile of predicted mortality of 81–100% compared with 23 patients (4%) in the transfer group. The same trend is evident when examining quintiles of predicted hospital mortality.

The actual odds of death were significantly lower than the predicted odds of

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Table 1. Baseline characteristics of study patients by source of admission to the intensive care unit (ICU)

Characteristic	Admission Source: Nontransfer (n = 4006)	Admission Source: Transfer (n = 563)	p Value
Mean yrs of age (SD)	56 (18)	55 (17)	.65
Male sex, n (%)	2323 (58)	332 (59)	.71
Mean APACHE III score (SD)	49.7 (29)	60.5 (31)	<.001
Primary impaired system in the ICU, n (%)			
Cardiovascular	1143 (28.5)	170 (30.2)	.41
Neurologic	789 (19.7)	85 (15.1)	.009
Respiratory	625 (15.6)	100 (17.8)	.19
Gastrointestinal	585 (14.6)	135 (24)	<.001
Trauma	616 (15.4)	39 (6.9)	<.001
Genitourinary	124 (3.1)	18 (3.2)	.90
Metabolic	58 (1.4)	4 (0.7)	.16
Musculoskeletal	36 (0.9)	6 (1.1)	.70
Hematologic	23 (0.6)	6 (1.1)	.17
Transplant	7 (0.2)	0 (0.0)	.32
ICU admission diagnostic category, n (%)[a]			
Sepsis	197 (4.9)	61 (10.8)	<.001
Multiple trauma	192 (4.8)	20 (3.6)	.19
Head trauma	194 (4.8)	10 (1.8)	.001
Aortic aneurysm	195 (4.9)	5 (0.9)	<.001
Pneumonia	155 (3.9)	30 (5.3)	.10
Neurosurgical	163 (4.1)	1 (0.2)	<.001
Postsurgical multiple trauma	150 (3.7)	8 (1.4)	.005
GI bleed	135 (3.4)	19 (3.4)	1.00
Other respiratory[b]	112 (2.8)	22 (3.9)	.14
Drug overdose	121 (3.0)	10 (1.8)	.10

APACHE, Acute Physiology and Chronic Health Evaluation; GI, gastrointestinal.

[a]Ten most frequent diagnostic categories included; [b]includes miscellaneous respiratory diagnoses, including pleural diseases, lung collapse, pulmonary hypertension, and smoke inhalation.

Table 2. Crude actual and predicted values for mortality and length of stay by admission source

Outcome	Admission Source: Nontransfer	Admission Source: Transfer	p Value
Actual ICU mortality, n (%)	309 (8)	76 (14)	<.001
Predicted ICU mortality, %[a]			
Mean (SD)	11 (2)	19 (24)	<.001
Median (interquartile range)	3 (1–11)	9 (2–28)	
Actual hospital mortality, n (%)	550 (14)	126 (22)	<.001
Predicted hospital mortality, %[a]			
Mean (SD)	18 (24)	27 (27)	<.001
Median (interquartile range)	6 (2–23)	17 (5–42)	
Actual ICU LOS, days			
Mean (SD)	3.8 (5.5)	6.0 (7.6)	<.001
Median (interquartile range)	2 (1–4)	3 (2–7)	
Predicted ICU LOS, days[a]			
Mean (SD)	4.7 (2)	5.9 (2)	<.001
Median (interquartile range)	4.3 (3.1–6)	5.8 (4.4–7.3)	
Actual hospital LOS, days			
Mean (SD)	15.9 (18.8)	20 (23.1)	<.001
Median (interquartile range)	10 (15–18)	13 (7–25)	
Predicted hospital LOS, days[a]			
Mean (SD)	13 (5)	13.9 (4.3)	<.001
Median (interquartile range)	12.7 (9.5–16.3)	14.2 (11.0–17.0)	

ICU, intensive care unit; LOS, length of stay.

[a]Predicted values calculated using the Acute Physiology and Chronic Health Evaluation III model.

death in both the transfer (odds ratio, 0.52; 95% confidence interval [CI], 0.38–0.69) and nontransfer patient groups (odds ratio, 0.51; 95% CI, 0.44–0.50), as shown in Table 3. There was, however, no difference between the comparison groups in the mortality odds ratios when adjusted for disease severity (odds ratio, 1.01; 95% CI, 0.73–1.41; $p = .94$). Stratification by quintiles based on APACHE III predicted mortality revealed no significant difference in the mortality odds ratio in any of the risk categories. The odds ratio approached statistical significance for hospital mortality in the lowest risk category of 1–20% predicted mortality, with a higher odds of death among transfer patients (odds ratio, 1.59; 95% CI, 0.96–2.61; $p = .07$).

ICU and Hospital Length of Stay. For the study population as a whole, ICU length of stay was, on average, 27% longer in transfer patients (95% CI, 18–37%), as shown in Table 4. Stratification by disease severity, however, revealed this difference to be significant only in patients in the lowest quintile of disease severity, who demonstrated a 23% longer length of stay (95% CI, 12–33%). No difference in length of stay was observed in any of the other quintiles. Similarly, hospital length of stay was 23% longer for the transfer group when compared with nontransfer patients (95% CI, 14–33%). Analysis of stratified data demonstrated, again, that the difference was only significant for patients in the lowest category of disease severity, with no significant difference in lengths of stay between the other quintiles.

Total Costs per Admission. Mean per-patient hospital costs were $9,600 greater in the transfer group compared with the nontransfer group (95% CI, $6,000–$13,400; $p < .001$). The unadjusted incremental cost for the study period attributable to the 563 transfer patients was $5,404,800. Table 5 displays cost data stratified by quintiles of disease severity. The lowest quintile of 0–20% predicted hospital mortality was the only category with a statistically significant difference in total costs; here, the transfer group had a mean excess cost of $7,700 per patient per admission (95% CI, $3,800–$12,100; $p < .001$). There were no significant differences in costs between the comparison groups for those with predicted hospital mortality of >20%.

DISCUSSION

Summary of Study Findings. Transferred patients were more severely ill, had longer ICU and hospital lengths of stay, and incurred more hospital costs than did directly admitted patients. After adjustment for case-mix severity using the APACHE III model, we found no differ-

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Table 3. Intensive care unit (ICU) and hospital mortality: Comparison between transfer and nontransfer patients, stratified by disease severity

	Admission Source									
	Nontransfer				Transfer				Transfer vs. Nontransfer	
	n (%)	Predicted Deaths, n	Actual Deaths, n	OR (95% CI)[a]	n (%)	Predicted Deaths, n	Actual Deaths, n	OR (95% CI)[a]	OR (95% CI)[b]	*p* Value
ICU Mortality										
All patients	4006 (100)	456	309	0.51 (0.44–0.59)	563 (100)	109	76	0.52 (0.38–0.69)	1.01 (0.73–1.41)	.94
Predicted mortality, %										
0–20	3295 (82)	118	56	0.45 (0.34–0.59)	384 (68)	23	15	0.64 (0.38–1.08)	1.43 (0.79–2.57)	.24
21–40	332 (8)	94	59	0.54 (0.41–0.72)	81 (14)	23	11	0.39 (0.20–0.73)	0.71 (0.35–1.43)	.34
41–60	170 (4)	83	61	0.59 (0.43–0.81)	46 (8)	23	17	0.60 (0.33–1.10)	1.03 (0.52–2.03)	.94
62–80	124 (3)	86	73	0.62 (0.43–0.89)	29 (5)	20	15	0.46 (0.22–0.97)	0.74 (0.33–1.69)	.48
81–100	85 (2)	75	60	0.31 (0.19–0.51)	23 (4)	20	18	0.44 (0.16–1.22)	1.40 (0.45–4.33)	.56
Hospital Mortality										
All patients	4006 (100)	702	550	0.63 (0.56–0.70)	563 (100)	153	126	0.68 (0.53–0.86)	1.08 (0.82–1.41)	.58
Predicted mortality, %										
0–20	2906 (73)	151	93	0.48 (0.34–0.73)	300 (53)	22	21	0.94 (0.59–1.47)	1.59 (0.96–2.61)	.07
21–40	479 (12)	137	108	0.72 (0.58–0.90)	117 (21)	34	21	0.54 (0.33–0.86)	0.74 (0.44–1.25)	.26
41–60	255 (6)	126	92	0.57 (0.44–0.74)	57 (10)	28	22	0.66 (0.38–1.12)	1.15 (0.63–2.08)	.65
62–80	202 (5)	142	131	0.78 (0.58–1.05)	54 (10)	38	34	0.74 (0.43–1.29)	0.95 (0.51–1.78)	.87
81–100	164 (4)	146	126	0.40 (0.27–0.58)	35 (6)	31	28	0.45 (0.19–1.07)	1.14 (0.45–2.92)	.78

OR, odds ratio; CI, confidence interval.

[a]Represents ratio of the actual mortality odds for a given subject relative to the odds of mortality predicted from the Acute Physiology and Chronic Health Evaluation III; [b]represents the ratio of the actual odds of mortality among transfer patients to the actual odds of mortality among nontransfer patients.

Table 4. Mean intensive care unit (ICU) and hospital length of stay (LOS): Comparison between transfer and nontransfer patients, stratified by disease severity

	Admission Source									
	Nontransfer				Transfer				Transfer vs. Nontransfer	
	n	Predicted, Days	Actual, Days	LOS Ratio (95% CI)[a]	n	Predicted, Days	Actual, Days	LOS Ratio (95% CI)[a]	Ratio (95% CI)[b]	*p* Value
ICU LOS										
All patients	4006	4.7	3.8	0.79 (0.77–0.81)	563	5.9	6.0	1.01 (0.94–1.08)	1.27 (1.18–1.37)	<.001
Predicted mortality, %[c]										
0–20	3295	4.2	3.1	0.74 (0.72–0.76)	384	5.2	4.8	0.90 (0.83–0.98)	1.23 (1.12–1.33)	<.001
21–40	332	7.3	6.9	0.97 (0.88–1.07)	81	7.6	8.6	1.09 (0.90–1.32)	1.12 (0.91–1.39)	.28
41–60	170	7.6	7.7	1.03 (0.89–1.19)	46	7.7	9.6	1.24 (0.94–1.64)	1.20 (0.88–1.64)	.24
62–80	124	6.7	6.2	0.93 (0.78–1.10)	29	7.4	9.0	1.19 (0.84–1.68)	1.28 (0.87–1.89)	.21
81–100	85	5.1	5.7	1.28 (0.99–1.65)	23	5.4	7.1	1.79 (1.10–2.90)	1.40 (0.81–2.42)	.22
Hospital LOS										
All patients	4006	13.0	15.9	1.23 (1.20–1.27)	563	13.9	20.0	1.52 (1.42–1.63)	1.23 (1.14–1.33)	<.001
Predicted mortality, %[d]										
0–20	2906	11.8	13.3	1.13 (1.10–1.17)	300	12.7	17.3	1.39 (1.28–1.52)	1.23 (1.12–1.35)	<.001
21–40	479	17.1	22.9	1.36 (1.26–1.46)	117	16.3	23.3	1.45 (1.25–1.68)	1.07 (0.90–1.26)	.45
41–60	255	17.8	24.6	1.40 (1.25–1.56)	57	17.0	25.8	1.57 (1.24–1.98)	1.12 (0.87–1.45)	.38
62–80	202	16.0	22.7	1.47 (1.27–1.70)	54	14.7	24.7	1.81 (1.36–2.40)	1.23 (0.90–1.69)	.20
81–100	164	11.6	20.0	2.30 (1.85–2.87)	35	10.5	15.2	2.93 (1.83–4.67)	1.27 (0.76–2.13)	.36

CI, confidence interval.

[a]Represents ratio of the expected LOS for a given subject relative to the LOS predicted from Acute Physiology and Chronic Health Evaluation III (estimates obtained from a negative binomial model for LOS); [b]ratio of actual LOS for transfer vs. nontransfer patients; [c]disease severity stratification based on Acute Physiology and Chronic Health Evaluation III predicted ICU mortality; [d]disease severity stratification based on Acute Physiology and Chronic Health Evaluation III-predicted hospital mortality.

ence in either ICU or hospital mortality between transfer and nontransfer patients. Stratified analysis revealed adjusted length of stay to be significantly longer only in the transferred group of patients in the lowest quintile of disease severity, a finding that was somewhat unexpected. We also found greater hospital expenditure associated with the care of transfer patients. This was likewise seen to be attributable to patients with the lowest level of disease severity.

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Table 5. Total hospital costs per admission in thousands of dollars, crude and stratified by disease severity

	Admission Source						Transfer vs. Nontransfer		
	Nontransfer			Transfer					
	n	Mean (SD)	Median (IQR)	n	Mean (SD)	Median (IQR)	Mean (95% CI)[a]	Median (95% CI)	p Value[b]
All patients	4006	27.6 (34.8)	16.1 (9.3–31.5)	563	37.2 (43.4)	20.6 (10.9–45.9)	9.6 (6.0 to 13.4)	4.5 (2.1 to 6.7)	<.001
Predicted mortality, %[c]									
0–20	2906	21.7 (24.2)	14.5 (8.5–24.9)	300	29.4 (35.5)	17.1 (10.2–34.7)	7.7 (3.8 to 12.1)	2.6 (1.0 to 6.1)	<.001
21–40	479	39.3 (45.7)	24.0 (13.2–48.8)	117	41.3 (42.2)	25.2 (15.5–54.5)	2.0 (−6.3 to 10.9)	1.2 (−4.8 to 11.2)	.48
41–60	255	45.9 (52.4)	30.0 (15.1–58.7)	57	52.4 (60.3)	29.3 (11.0–72.2)	6.5 (−9.6 to 23.9)	−0.8 (−15.0 to 20.9)	.95
62–80	202	48.1 (51.1)	28.9 (12.5–67.2)	54	53.3 (50.2)	27.7 (14.6–78.7)	5.1 (−9.7 to 21.0)	−1.2 (−10.3 to 28.1)	.48
81–100	164	42.8 (57.4)	20.7 (6.7–58.8)	35	39.9 (51.9)	17.5 (8.4–44.3)	−3.0 (−20.0 to 17.4)	−3.2 (−14.9 to 12.7)	.77

IQR, interquartile range; CI, confidence interval.

[a]Represents the difference in mean or median total hospital costs per admission between transfer and nontransfer patient groups; [b]p value is for the difference in mean total hospital costs per admission; [c]disease severity stratification based on Acute Physiology and Chronic Health Evaluation III-predicted hospital mortality.

Explanation and Relation to Previous Work. A number of factors may have contributed to the lower mortality odds observed in our patient population as compared with that predicted by the APACHE III model. Selection effect may have resulted from differences in the patient mix presenting to our institution compared with the sample of patients used to derive the model's predictive equations. Systematic differences in data collection could have played a role. It is also conceivable that the better outcomes demonstrated by our data are a result of a higher quality of care rendered at our institution. Alternatively, the discrepancy may be a general reflection of the advances in medical and surgical care in the period since the development of the predictive equations used in APACHE III during our study.

An unexpected finding was that of longer length of stay and hospital costs associated with patients in the lowest category of predicted mortality. The explanation may rest in the fact that APACHE scores are calculated at the time of patient presentation to the ICU; those with milder severities of illness are, perhaps, more amenable to temporary stabilization of factors such as vital signs and laboratory data before transfer, resulting in miscategorization of patients who, in fact, have a higher degree of underlying disease severity. Lead-time bias, that is, the duration of intensive care received at the original institution before transfer, may also be a confounding factor. APACHE III, in contrast to its older versions, adjusts for admission source in its predictive equations; however, it does not account for length of hospitalization at the referring facilities before transfer. The effect of this lead-time bias may not be uniform across categories of disease severity. Thus, presentation to the AMC earlier in the course of their disease may have resulted in a greater need for elements of care, such as investigative procedures, at the university hospital for patients with milder degrees of illness, ultimately resulting in a longer hospitalization and greater costs. A limitation of our study is collection of insufficient data to test these hypotheses, and therefore, the explanation for the finding remains speculative. In addition, our study may have lacked sufficient power to detect a true difference between the comparison groups in the subcategories with higher severities of illness because the numbers in these brackets were relatively small. Future studies could be designed to specifically evaluate the accuracy of APACHE and other prognostic models in their determination of length of stay for patients with varying disease severity.

A number of other investigators have documented the different characteristics and outcomes of patients transferred to tertiary referral centers. Schiff et al. (27), in 1986, examined medical and surgical transfers to Cook County Hospital in Chicago and demonstrated that patients were mainly transferred for economic reasons, with the vast majority being unemployed or otherwise lacking medical insurance. Borlase et al. (16) compared surgical ICU patients according to admission source and found that transfers had a higher mortality, 36%, compared with 12% in nontransfers. After severity adjustment using APACHE II, they found mortality in transfer patients to be twice that of nontransfers. In 1996, Bernard et al. (18) reviewed all hospitalizations to the internal medicine, surgery, and pediatric services of the University of Michigan hospital. They found that transfers were more likely to be Medicare length-of-stay outliers and had higher mortality compared with nontransfers (9.4% vs. 2.5%). Using a diagnosis-related–group method of case-mix adjustment, they also found that more ancillary services were used for transfers. Similar results were reported by Gordon and Rosenthal (17) in 1996 in their study of hospital admissions to a Midwestern AMC. Using the MedisGroups methodology for severity adjustment, they found the risk of in-hospital death to be almost twice as high in transfers than in direct admissions. The problem has also been studied by Combes et al. (20) in France; they found ICU mortality and standardized mortality ratios to be significantly higher for patients transferred from another ICU when compared with non-ICU, interhospital transfers and directly admitted patients.

The APACHE III model has been used in only one previous study. Rosenberg et al. (19) reported a study of 4,579 medical ICU patients, comparing lengths of stay and hospital mortality rates. They used several models for case-mix and severity adjustment. When using full case-mix and acute physiology clinical information to adjust for severity of illness, they found transfer patients had a 38% longer medical ICU stay, 41% longer hospital stay, and 2.2-times greater odds of hospital mortality than directly admitted patients. However, even after using APACHE III to

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correct for source of admission, they still found transfer patients to have a significantly higher mortality rate (odds ratio, 2.0; 95% CI, 1.5–2.6) and to be more likely to die before discharge from the hospital. These findings are in contrast to our study, in which we have demonstrated comparable odds of mortality between the two groups after APACHE III case-mix adjustment. The disagreement in findings could, in part, be explained by differences in the mix of patients between our ICU, in which both surgical and medical patients are treated, and that studied by Rosenberg et al., which was primarily a noncardiac medical ICU. Thus, our study grossly validates the transfer correction factor used in the APACHE III model for mortality prediction, an observation that may not necessarily hold true in other types of ICUs and hospitals.

That transfer patients consume more resources has also been demonstrated in previous studies (16–18, 28–30). Various methods have been used to look at the cost differential. For example, Bernard et al. (18) used a relative value unit measure to approximate ancillary resource consumption, whereas Gordon and Rosenthal (17) compared total hospital charges. In this study, we had the advantage of using the University of Wisconsin's accounting system and thus had access to actual costs, not simply charges. The higher cost of caring for transfer patients is congruent with the length-of-stay data. The increment is substantial, despite being a small percentage of the total hospital costs. Moreover, in this study, we have considered only patients brought directly to our ICU from other facilities as transfers. If those patients initially transferred to general medical and surgical wards and intermediate care areas had also been categorized as transfers, the cost differential would arguably have been even greater.

Implications of Findings. Providing specialized and high-technology tertiary services, acting as a regional safety net, and playing a crucial role in the care of the indigent and uninsured remain key social missions of AMCs. Frequently, these are activities involving critical care medicine and are not optimally supported in competitive markets. It is currently estimated that critical care medicine costs represent 13.3% of hospital costs, 4.2% of national health expenditures, and 0.56% of the gross domestic product (31). The relative percentage of critical care costs is likely higher in AMCs. Koenig et al. (32) defined the mean hospital cost and mission-related costs for academic health centers ($8,817), teaching hospitals ($5,822), and all hospitals ($4,926). Total AMC mission-related costs were $27 billion in 2002; they were 28% of the cost per case, with maintenance of standby capacity for medically complex cases accounting for the majority, followed by indirect medical education and research costs. Albeit the costs are higher, there is evidence that outcomes are more favorable, over a range of locations, conditions, and populations, for routine and complex conditions (33).

AMCs have been struggling for fiscal survival for many years now. The effects of the Balanced Budget Act of 1997, rising healthcare costs, decreases in levels of research funding, and reduced reimbursements from third-party payers have all contributed to the financial strain. The substantial increase in costs related to the acceptance of critically ill transfer patients illustrates the challenge of sustaining the multiple missions of AMCs. Thus, ensuring the support of AMCs will be pivotal to maintenance of their community and societal roles. As recommended by the Commonwealth Fund Task Force on Academic Health Centers, we believe that the mission-related activities of AMCs and their associated expenses should be supported at the national level (1).

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