Heart Failure

The Economic Effect of a Tertiary Hospital-Based Heart Failure Program

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OBJECTIVES

This study was designed to determine the economic effect of a tertiary heart failure (HF) program at an academic medical center.

BACKGROUND

Most hospitals use cross-sectional financial models to analyze the economic contribution of clinical programs for a budget period. We estimated the incremental value of a tertiary hospital HF program on the basis of the longitudinal utilization of a sample of HF patients.

METHODS

The primary data source was a sample of 82 HF patients referred for cardiac transplant evaluation at an academic medical center during calendar years 2000 to 2001. Cumulative recurrent rates of utilization, cost, and reimbursement for hospital services were computed as functions of time using reliability models. The economic contribution of patients transplanted was contrasted with those not transplanted.

RESULTS

Mean hospitalizations and outpatient encounters per patient at the end of the first year of follow-up for those transplanted were 2.1 (95% confidence interval [CI] 1.6 to 2.7) and 11.9 (95% CI 9.2 to 15.4), compared with 1.1 (95% CI 0.8 to 1.6) and 6.0 (95% CI 4.8 to 7.6), respectively, for those not transplanted. Mean revenue and direct cost per patient were $194,470 (95% CI $136,683 to $276,689) and $146,623 (95% CI $96,377 to $233,065), respectively, for transplanted patients and $43,587 (95% CI $28,149 to $67,503) and $33,424 (95% CI $21,584 to $51,760), respectively, for non-transplanted patients. The point estimates of first-year contribution margins per patient for transplanted and non-transplanted patients were $47,847 and $10,163, respectively.

CONCLUSIONS

Newly evaluated patients for cardiac transplantation at an academic medical center generated substantial incident demands for inpatient and outpatient services over a two-year follow-up period. The estimated contribution margin associated with these services was positive. Hospitals without cardiac transplantation that serve high-acuity HF patients may generate favorable long-term contribution margins, on the basis of the results for the non-transplant group. (J Am Coll Cardiol 2005;46:660–6) © 2005 by the American College of Cardiology

We estimated the incremental value of patients in a tertiary hospital heart failure (HF) program on the basis of the utilization of a sample of patients evaluated for cardiac transplantation at an academic medical center and followed for two years. Using Medicare payment models for large urban teaching hospitals and the hospital’s cost accounting system, we estimated cumulative net revenue and direct cost accrual rates per patient over time. The contribution margin is estimated from the difference between net revenue and direct cost (1).

Most hospitals use budget-driven financial models to analyze the economic contribution of programs for a budget period (month or fiscal year) (2). Budget models are cross-sectional, aggregating the experience of all patients consuming a defined set of hospital services for a defined period of time. Even when hospital “service lines” are analyzed, the analysis tends to use the same cross-sectional framework stratified by service line. Cross-sectional, as opposed to longitudinal, models will misspecify the true financial contribution of programs for chronic disease patients over time. At best, such analyses may include all services consumed during a budget period (i.e., fiscal year associated with patient events with a principal diagnosis of HF).

We calculated the incremental financial contribution associated with a HF patient population. This analysis, incorporating both inpatient and outpatient diagnostic and procedural services consumed by a referral HF population, is designed to assess the financial impact of a chronic disease such as HF on a tertiary medical center.

METHODS

Patients. A sample of 82 patients evaluated for cardiac transplantation by Tufts-New England Medical Center’s academic HF program during calendar years 2000 to 2001 was followed for two subsequent years. The 82 patients included in this analysis represent all HF patients who underwent complete transplant evaluations during this period and were formally presented to the institution’s Cardiac Transplant Committee. Not all patients were listed for transplantation after the committee’s final recommendation (approximately 50% were listed). A HF cardiologist initially
screened the patients referred to the center before making the decision to initiate a complete transplant evaluation. Therefore, the patients included in the study represent a well-defined subgroup of the total HF population served by the program. All hospital admissions, outpatient ancillary tests and procedures, and clinic visits were obtained from the hospital's internal cost accounting system. Patient demographic and clinical data were obtained from medical records. Patient mortality information was obtained from Social Security death databases, internal medical records, and queries of program staff.

Descriptive statistics were used to contrast patients who were ultimately transplanted and those who were not transplanted. Chi-square and Fisher exact tests were applied to discrete variables, and t tests for two groups were used for continuous variables. Kaplan-Meier survival curves were fitted to the mortality data. Minitab (Minitab Inc., State College, Pennsylvania) was used to calculate all statistical tests. Statistical significance was defined at the 95% level.

Mean cumulative event rates per patient for inpatient hospitalizations and outpatient encounters were estimated for the total sample. Outpatient encounters included all patient visits to the hospital's clinics, emergency department, and ancillary services. Bivariate mean cumulative event rates for patients transplanted versus those not transplanted were also estimated. Mean cumulative event rates per patient are expressed as a function of time from the index evaluation event using non-parametric right-censored reliability models (3). Sometimes called “conditional event rates,” the rates are calculated over the pool of patients surviving at each point in time an event occurs. “Marginal event rates adjusted for survival” were also calculated by multiplying the conditional event rates at each point of time by the associated probability of survival estimated from the Kaplan-Meier survival curves.

**Revenue and expense.** Revenue for inpatient events was estimated from the Medicare diagnosis-related group and total charges for each admission using 2003 Medicare payment methodology. Modeled revenue included allowances for indirect medical education, disproportionate share hospital payments, and cost outliers. Base payment rates were based on large urban teaching hospital base rates for labor-related and non-labor-related components of cost (4). An average wage index of 1.15 and a geographic adjustment factor of 1.1 were used to adjust labor-related operating and capital base payment amounts. Medicare outpatient payment rates were based on cost-to-charge ratios from the Medicare cost report applied to hospital charges (5).

Direct cost for inpatient and outpatient events was calculated by the hospital's cost accounting system using Medicare capital non-payroll costs, labor cost, variable cost, and other cost. Medicare capital non-payroll costs were inflated to 2003 using the medical component of the Consumer Price Index (7). Contribution margin was calculated as the difference between revenue and inflation-adjusted direct cost (2).

Descriptive statistics were calculated for revenue and direct cost stratified by major clinical service (inpatient and outpatient or transplanted and non-transplanted patients). Revenues and costs were accrued cumulatively for each event using statistical reliability models. Mean cumulative costs and revenues were weighted by survival probabilities at each event time to calculate the mean cumulative costs and revenues adjusted for survival.

**Example.** We present an example of how this methodology could be used to analyze the growth in a HF patient population. The economic effect of adding 100 new patients each year for three years was estimated from the cumulative revenue and direct cost accrual rates. Cumulative revenues and costs were computed for each annual cohort stratified by cardiac transplant status. Annual cumulative contribution margins for each year are calculated as the difference between cumulative revenues and direct costs. The result is a table of cumulative revenues, costs, and contribution margins stratified by transplant status representing the cumulative economic effect of adding 300 new patients over three years.

**RESULTS**

**Descriptive statistics.** Table 1 presents summary statistics of the sample of HF patients segmented into two groups: those with and without a transplant during the two-year follow-up period. Of 82 patients evaluated for cardiac transplantation, 27 underwent transplantation. The average age of the patients was 52 years, 79% were men, and 57% had an etiology of ischemic heart disease with no significant differences between the subgroups. Survival was significantly different between the subgroups, as 95% of the transplanted patients survived, whereas only 57% of the non-transplanted patients survived (p < 0.004) over the observation period, which varied from two to three years depending on when the patient was evaluated. Consequently, the mean observation period was significantly shorter for the non-transplanted patients compared with transplanted patients, 22.3 months versus 31.6 months, respectively (p < 0.0001).

Figure 1 plots the Kaplan-Meier mortality curves for all patients. The first-year mortality rate was 20% (95% CI 11% to 28%). For non-transplanted patients the mortality rate was 27% (95% CI 16% to 39%), and for transplanted patients it was 4% (95% CI 0% to 10%). All 82 patients had New York Heart Association functional class III to IV HF.

Table 2 presents descriptive statistics for revenue and direct cost stratified by inpatient and outpatient services, transplant and non-transplant patients, and major clinical service. Outpatient revenues and direct costs include all service...
revenues and the cost of resources utilized by the patient during the billing period. For example, an outpatient cardiology encounter for a transplant patient could include revenue and costs for a transplant clinic visit, right heart catheterization, myocardial endobiopsy, or lab tests. Consequently, cardiology outpatient encounters for transplant patients generated $1,283 in mean revenue versus $424 for non-transplant patients. The cost of resources required for outpatient cardiology services was $649 on average for transplanted patients versus $275 for non-transplanted patients. All surgical subspecialties (e.g., general surgery, cardiothoracic surgery, vascular surgery, gastrointestinal surgery) were grouped into the surgery category. Transplant surgery was displayed separately because of the magnitude of revenue and cost. All medical subspecialties except cardiology (e.g., general medicine, nephrology, gastroenterology, pulmonary, infectious disease) are included in medicine. “Outpatient ancillary services” include outpatient visits to the emergency department, radiology, laboratory, etc., without a clinic visit. Not surprisingly, the major difference between mean inpatient revenues for transplant and non-transplant patients was the revenue associated with cardiac transplantation.

Event rates. Figure 2 plots the cumulative mean inpatient and outpatient event rates for inpatient and outpatient services for transplanted and non-transplanted patients. For transplanted and non-transplanted patients, mean cumulative hospitalizations at one year were 2.4 (95% CI 1.91 to 3.02) and 1.18 (95% CI 0.85 to 1.64), respectively, whereas outpatient encounters were 11.96 (95% CI 9.24 to 15.48) and 6.20 (95% CI 4.88 to 7.87), respectively.

Revenue and cost. Figure 3 plots the conditional mean cumulative modeled revenues and direct costs associated with the inpatient and outpatient events. At one year the overall cumulative mean net revenue per patient was $99,766 (95% CI $74,620 to $133,386) compared with direct cost of $78,312 (95% CI $57,084 to $107,435). For non-transplanted patients, one-year net revenue was $43,587 (95% CI $28,146 to $67,503), and direct cost was $33,424 (95% CI $21,584 to $51,760). For transplanted patients, one-year net revenue per patient was $194,470 (95% CI $136,683 to $276,689), and direct cost per patient was $146,623 (95% CI $96,377 to $223,065). The point estimate of revenue at every event time after evaluation was greater than direct cost. The point estimate of cumulative

![Kaplan-Meier cumulative mortality rates](image)

**Figure 1.** Kaplan-Meier cumulative mortality rates were estimated for the number of days after the patient was evaluated for cardiac transplantation at the academic medical center’s heart failure program.

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**Table 1.** Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>No Transplant (n = 55)</th>
<th>Transplant (n = 27)</th>
<th>All (n = 82)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean observation period (months)</td>
<td>22.3</td>
<td>31.6</td>
<td>773</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>52.7</td>
<td>50.7</td>
<td>52</td>
<td>0.398</td>
</tr>
<tr>
<td>Gender, male</td>
<td>43 (78%)</td>
<td>22 (81%)</td>
<td>65 (79%)</td>
<td>0.729</td>
</tr>
<tr>
<td>Mortality, survived</td>
<td>35 (64%)</td>
<td>26 (96%)</td>
<td>61 (74%)</td>
<td></td>
</tr>
<tr>
<td>Etiology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic</td>
<td>30 (56%)</td>
<td>16 (59%)</td>
<td>46 (57%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>24 (41%)</td>
<td>11 (41%)</td>
<td>35 (43%)</td>
<td>0.751</td>
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</table>

*p Values are reported for t tests of continuous variables and chi-square or Fisher exact tests of discrete variables. Mortality is the crude mortality (number of decedents) over the observation period, which varied from two to three years depending on when the patient was evaluated.
conditional contribution margin per patient was $21,454 at one year and grew to $32,000 in the second year. The point estimates for conditional cumulative first-year contribution margin per patient for transplanted and non-transplanted patients were $47,847 and $10,163, respectively.

Example. Table 3 presents the results of computing the survival-adjusted incremental revenues, direct costs, and contribution margins for each of three cohorts of 100 patients evaluated for cardiac transplantation over a 3-year period. We assumed a 15% transplant rate in the year patients were evaluated. After three years, cumulative revenue would total an estimated $26 million, direct cost would be $19 million, and contribution margin would be approximately $7 million. The cumulative survival-adjusted revenue, direct cost, and contribution margin for patients transplanted would be $11 million, $8 million, and $3 million, respectively, over the three-year period.

DISCUSSION
This paper has presented estimates of the longitudinal economic effect of patients evaluated for cardiac transplantation in a HF program at an academic medical center. Although the specific estimates are applicable to similar settings, the methodology is applicable to evaluating any hospital program for patients with a progressive chronic disease.

Most hospitals use budget- and cost-center-driven financial models to analyze the economic contribution of programs such as those for HF patients. Even when hospital “service lines” are analyzed, the analysis tends to use the same framework stratified by service line. Such models may misspecify the financial contribution of programs for chronic disease patients. For example, a one-year analysis of
the cost centers associated with a HF program may focus on
the revenues and expenses associated with a HF outpatient
clinic or a dedicated inpatient unit. A service line analysis
may focus exclusively on HF hospitalizations such as
diagnosis-related group 127, “Heart Failure and Shock.” At
best, such analyses may include all services consumed during
a budget period (i.e., fiscal year) associated with patient
events with a principal diagnosis of HF. What they typically
fail to do is to track a sample of new HF patients over time
to calculate the incremental economic contribution of the
HF patient population. Such an analysis will demonstrate
the multitude of inpatient and outpatient, diagnostic, med-
cal, and procedural services required by chronically ill HF
patients. The bundle of services required by these patients is
not limited to the HF program or to the departments of
cardiology or cardiothoracic surgery. By providing high-
quality HF programs that meet the multiple interdiscipli-
nary service needs of this patient population, hospitals may
improve both the quality of care and their bottom line by
attracting additional patients with HF.

Hospitals have an obligation to meet demonstrated stan-
dards for high-quality care, such as the evolving consensus
for HF care, irrespective of economics. As mentioned,
however, short-term decision making with respect to such
programs is a frequent consequence of the current emphasis
on hospital budgets and reimbursement.

The analysis presented here estimated the mean rates of
utilization, net revenue, and cost accumulation over time
associated with a population of HF patients with high acuity
and high likelihood of cardiac transplantation. Thus, the
specific findings may be most applicable to similar settings
with similar patient populations, for example, academic
medical centers with a cardiac transplantation service. The
methodology presented here for estimating the economic
contribution of HF programs, however, is applicable to all
settings. Moreover, the non-transplant group may be rep-
resentative of HF patient populations served by many
community hospitals. The first-year mortality rate of 27%
and survival-adjusted first-year expected hospitalization rate
of 0.96 hospitalizations per patient may be characteristic of
community hospitals with HF programs that attract high-
acuity patients. In this case, the non-transplant economic
analysis in Table 2 may be indicative of the economic impli-
cations of adding incremental HF patients. The percentage
contribution margins (contribution margin divided by revenue)
for transplant and non-transplant patients were comparable at
25% and 23%, respectively. In addition, the total economic
contribution of non-transplant patients in Table 2 was greater

Figure 3. Net revenue was modeled by 2003 Medicare national teaching hospital rates, including adjustments for indirect medical education, regional
relative wages, disproportionate share hospital allowance, and capital and operating cost allowances. Direct cost was inflated to 2003 by the medical
component of the Consumer Price Index. Mean cumulative accrual rates of revenue and direct cost per patient stratified by transplant status were estimated
from right-censored non-parametric reliability models and are conditional on survival.
for non-transplant patients (given the greater incidence of non-transplant patients): $4 million versus $3 million. Hospitals without cardiac transplantation but with strong HF programs should be encouraged by these results.

Revenues were higher for transplant than for non-transplant patients for two reasons. First, the rates of hospitalization and outpatient encounters per patient for transplant patients are about double the corresponding rates for non-transplant patients. Second, the percentage of hospitalizations for surgical procedures is higher for the transplant group (55%) than for the non-transplant group (42%), and surgical procedures result in higher contribution margins (23.3% on average) than medical hospitalizations (16.6% on average). These differences are attributable in part to the greater incidence of diagnostic catheterizations and clinic visits required for monitoring of transplant patients. Moreover, hospitalizations of after-transplant patients for toxicity due to immunosuppressive therapy and for after (transplant) surgical complications also generate greater utilization of both inpatient and outpatient resources.

This analysis is limited by the small sample size and high acuity of the patient population sampled. In addition, the use of Medicare payment models to estimated revenue may not be representative of local hospital reimbursement. Finally, the analysis is limited to hospitalization and outpatient events at the study hospital. In this instance, we believe that patients evaluated for cardiac transplantation in this institution were likely to receive most, but not necessarily all, of their care at the study hospital.

Conclusions. Newly evaluated patients for cardiac transplantation at an academic medical center were shown to generate substantial incident demands for inpatient and outpatient services over a two-year follow-up period. For example, mean inpatient Medicare revenue per patient associated with non-transplanted patients is over $40,000 in the first year and nearly $200,000 for transplanted patients. These services appeared to generate, on average, a positive contribution margin for the hospital. Hospitals without cardiac transplantation that serve high-acuity HF patients may generate favorable long-term contribution margins on the basis of results for the non-transplant group. Hospital programs that address the multiple interdisciplinary needs of patients with HF may attract additional patients, with consequent beneficial economic effects for the hospital. Focused multidisciplinary programs directed toward patients with HF are needed to meet the complex needs of these patients and optimize their care and clinical outcomes. Hospitals should be encouraged by our analyses that, far from being a drain on institutional resources, such programs should actually generate positive margins for the institution. In order to properly gauge the financial impact of such programs, it is essential to augment traditional budget analyses of clinical programs with strategic longitudinal analyses of the type presented here.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Transplant</th>
<th>Non-Transplant</th>
<th>Total</th>
<th>Transplant</th>
<th>Non-Transplant</th>
<th>Total</th>
<th>Transplant</th>
<th>Non-Transplant</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of new HF patients</td>
<td>15</td>
<td>85</td>
<td>100</td>
<td>15</td>
<td>85</td>
<td>100</td>
<td>15</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>Cumulative new HF patients</td>
<td>15</td>
<td>85</td>
<td>100</td>
<td>30</td>
<td>170</td>
<td>200</td>
<td>45</td>
<td>255</td>
<td>300</td>
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<tr>
<td>Cumulative revenue</td>
<td>$2,383,443</td>
<td>$3,027,197</td>
<td>$5,410,640</td>
<td>$5,632,496</td>
<td>$7,059,645</td>
<td>$12,692,141</td>
<td>$11,067,811</td>
<td>$14,724,557</td>
<td>$25,792,368</td>
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<tr>
<td>Cumulative direct cost</td>
<td>$1,797,025</td>
<td>$2,321,351</td>
<td>$4,118,376</td>
<td>$4,251,031</td>
<td>$5,252,032</td>
<td>$9,503,063</td>
<td>$8,333,199</td>
<td>$10,787,413</td>
<td>$19,120,612</td>
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<tr>
<td>Cumulative contribution margin</td>
<td>$586,417</td>
<td>$705,846</td>
<td>$1,292,264</td>
<td>$1,381,465</td>
<td>$1,807,613</td>
<td>$3,189,078</td>
<td>$2,734,612</td>
<td>$3,937,144</td>
<td>$6,671,756</td>
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</table>

Cumulative revenues and direct costs are the cumulative conditional revenues and direct costs from Figure 3 multiplied by the survival probabilities at each event time from Figure 1. Revenues and costs are calculated for each cohort of 100 patients for each year. Contribution margin is the cumulative difference between revenue and direct cost. HF = heart failure.
REFERENCES