CHAPTER 7

Utilization of Cardiac Rehabilitation in Medicare

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This chapter describes a study that measures important predictors for enrollment in cardiac rehabilitation (CR). The study showed an overall national CR utilization rate of only 12.2% among Medicare beneficiaries. Rates of participation in CR were higher among Medicare beneficiaries who received revascularization procedures (coronary artery bypass graft [CABG] surgery, percutaneous coronary intervention [PCI]), were hospitalized in facilities with coronary laboratory catheterization capabilities, were treated in rural and suburban areas as opposed to in urban areas, and lived close to a CR facility; those who were female, were also eligible for Medicaid, were non-Whites, were extremely elderly, lived in a poorer neighborhood, or had more comorbidities were much less likely to participate. Of note is the finding of remarkably higher rates of participation in CR in north central states as compared to other regions of the United States. This pattern shows that although high rates of CR use do not apply in most of the country, they do occur when the right environment is present.

Approach

This section describes the method of obtaining administrative data files from Medicare and the analytical procedures for their analysis.

Data Files

Data files from Medicare were the most important source of data for this study. This section will describe in detail the various Medicare files that were used, as well as the different classification systems used by Medicare to describe diagnoses, procedures, and reimbursement categories for acute inpatient care.

Medicare has many administrative data files containing information about beneficiaries, providers, and services reimbursed. Current and historical information about each enrollee, including personal identifiers (i.e., Social Security Number [SSN] and Medicare Health Insurance Claim Number [HICNO]), demographics (date of birth, sex, and race), address, enrollment status, entitlements (Part A and Part B), and group health plan (e.g., health maintenance organization) membership over time, is stored in a master file called the enrollment database (EDB). Beneficiary enrollment and entitlement information for a given calendar year is stored in a file called the denominator file (DF). Information about providers is stored in a provider of services extract file, which includes an individual record for each provider containing provider number, name, address, and other characteristics (Warren, Klabunde, Schrag, Bach, and Riley 2002).

The national claims history file (NCH) is the repository of all Medicare claims and is the source of all the research files created by the Centers for Medicare & Medicaid Services (CMS), the branch of the U.S. Department of Health and Human Services that runs the Medicare program. The final action files, those containing all claims with the CMS final decisions on reimbursement and payment adjustments on an annual basis, are called standard analytical files (SAF). Generally included in these files are provider identifier, patient's demographic information, principal and other diagnosis codes, procedures codes, dates, charges, and reimbursement information. CMS stores a number of different SAF files containing claims data for research purposes. Based on the type of service covered by Medicare, the following files are available (Warren et al. 2002):

- Files with Part A services
  - *Medicare provider analysis and review (MEDPAR):* This file contains 100% of the claims for all the hospitalizations (in Medicare-certified hospitals and skilled nursing facilities) of Medicare beneficiaries occurring in a calendar year.
  - *Hospice/home health file:* This file contains 100% of the claims for all the hospice admissions and home health services provided to Medicare beneficiaries in a calendar year. A number of home health services are provided under Part B.
- Files with Part B services
  - *Hospital outpatient file:* This file contains 100% of the hospital outpatient claims for services provided to Medicare beneficiaries enrolled in the Part B insurance.

- *Physician/supplier data file:* This file contains 100% of the bills submitted by physicians and other providers to Medicare for services rendered to Medicare beneficiaries with Part B.

Each claim processed by Medicare contains relevant information about the beneficiary (such as the HICNO), the provider (provider identification number for hospital, physician, or other provider), and the hospitalization/procedure or service rendered (dates of services, types of services, principal diagnosis, secondary diagnoses, procedure[s] performed), and charges (reimbursement requested, coinsurance, deductibles, and reimbursement provided).

To code claims, Medicare uses some combination of 3 major classification systems, the International Classification of Diseases (ICD-9), the Healthcare Common Procedure Coding System (HCPCS), and the Diagnosis-Related Groups (DRGs), to describe the disease, complications, comorbidities of the beneficiary, and the procedures performed on the patient.

Analytical Overview

This study defines a study cohort, an intervention variable (CR), and 5 types of adjustor variables:

- Demographics
- Socioeconomic characteristics
- Health status
- Institutional characteristics
- Geographic characteristics

Both descriptive and multivariate analytical approaches were used.

The Study Cohort

CHD Research Associates in Columbia, Maryland, a subcontractor to the Lifestyle Modification Program Demonstration (LMPD) Evaluation, constructed the study cohort in 2004. The LMPD Evaluation is a project awarded by CMS to the Schneider Institutes for Health Policy at Brandeis University, Waltham, Massachusetts. The cohort is composed of a sample of Medicare beneficiaries who were candidates for CR services after an index coronary hospitalization in 1997, as described later in this chapter.

Beneficiaries who were identified by the intersection of 2 different methodologies were selected to be in the study cohort. The first approach identified people in the MEDPAR records who had at least 1 hospital admission during 1997 in a U.S. nonfederal acute care hospital with a "qualifying" coronary-related event determined by the International Classification of Diseases (9th edition, Clinical Modification, ICD-9 CM) codes for principal diagnoses or procedures. In the decimal values,

the nomenclature of xx is used to denote that any character, including blank, may be entered. Principal diagnosis codes included acute myocardial infarction (AMI) (410.xx), other acute coronary syndrome codes (411.xx), stable coronary syndrome codes (413.xx), and other chronic ischemic heart disease condition codes (414.xx). Procedure codes included 36.1x for CABG and 36.01, 36.02, 36.05, or 36.06 for PCI or stent placements. For patients with more than 1 qualifying admission during 1997, the earliest admission was considered the "1" admission. Patients who had the index hospital admission but who either had an inpatient stay longer than 32 days or did not survive at least 30 days after the index discharge were dropped from the sample. When qualifying patients were identified, their individual information was retrieved and matched with the denominator and EDB files by HICNO. Files that showed any discrepancy in the values of common variables were dropped from the sample of participants. CHD Research Associates finally retained a total of 805,553 potential sample participants.

The second approach consisted of obtaining a sample of participants included in a prior study, the Ischemic Heart Disease (IHD) Cohort, carried out by Research Triangle Institute (RTI). This study included participants with a mailing residence in the 50 states and the District of Columbia who also had at least 1 hospital admission in a short-stay acute care hospital during 1996 or 1997 1 "qualifying" coronary-related indicators. The prior study developed a series of variables describing the socioeconomic and educational status of the participants based on U.S. Census track–level information. The number of participants included in this prior study was 700,682 (Cromwell, Urato, McCall, and Burton 2003).

The next step in selecting the sample of participants was to merge participants from the 2 approaches, and only those participants who matched in HICNO, index admission date, and index admission discharge were retained. A total of 632,391 participants were matched, and this group resulted in our initial study cohort. CHD Research Associates reported that of these participants, 536,928 qualified based on the principal diagnosis alone; 89,354 qualified based on the principal diagnosis, a procedure, and a DRG; and 6,109 based on both the principal diagnosis and a procedure.

Once the sample of participants for our study was identified, the next step was to obtain all Parts A and B utilization of services recorded in Medicare files for each participant for the period of time including 1 year before the index admission (depending on age at index admission) to 5 years following the index admission, or up to the patient's death or disenrollment from Medicare entitlement, whichever occurred first. The total number of records identified for each of the Medicare files breaks down as follows:

- *EDB:* 632,391 records
- *Part A services:* These were MEDPAR (3,794,498 records) and the hospice/home health file containing hospice admissions (142,442 records) and home health services (2,213,474 records).

- *Part B services:* These were the hospital outpatient file (16,763,294 records), and the physician/supplier data file (202,271,392 records).

Next, the initial cohort of 632,391 participants was reduced further by applying certain exclusion criteria. Only beneficiaries with the following characteristics were finally included in our study:

- Medicare beneficiaries with both Part A and Part B entitlements.
- Index hospitalizations in the 50 U.S. states and the District of Columbia determined by address ZIP codes of the hospital. Patients with index hospitalizations in Puerto Rico or U.S. territories were excluded due to the small number of patients from those sites.
- Uninterrupted enrollment in the fee-for-service (FFS) scheme from 1 year before the day of admission of the index hospitalization up to 1 year after the day of discharge of that hospitalization or patient's death, whichever occurred first. These eligibility criteria were to avoid missing utilization data for those beneficiaries who were enrolled in Medicare managed care risk contracts for which there were not claims for services provided while in this scheme.
- Age 65 or above at the time of admission.
- An index hospitalization stay shorter than 32 days.
- Patient survival of at least 30 days after discharge.

Patients whose files showed any discrepancy in the values of common variables across different files were also excluded. All beneficiaries in the final cohort of 601,099 were considered candidates for receiving CR services within the first year after discharge from the index hospitalization.

Intervention Variables

Most variables available for this study came from Medicare data files or were derived from them. Additional variables were obtained from the IHD cohort or alternative sources. The full set of variables available can be classified into 2 main groups: intervention and adjustor variables. The most important set of variables is those related to the utilization of CR services (intervention). During our analysis, special attention was paid to the following characteristics of the intervention:

- *Enrollment:* If the patient attended at least 1 CR session
- *Onset:* When CR services began following discharge from the index hospitalization
- *Intensity:* How many sessions per month the patient received
- *Duration:* The number of months the patient received CR services
- *Amount:* Total number of sessions received

- *Completion:* If the patient received the maximum initial quantity of sessions paid by Medicare (36 sessions)

Beneficiaries participating in the intervention were identified by the existence of hospital outpatient invoices (institutional outpatient providers) for CR services submitted to and reimbursed by Medicare. Those bills were identified based on the 2 HCPCS codes available and accepted by Medicare for reimbursement of CR services, and are thus considered to have very good sensitivity and specificity for CR services. They are:

- *93797:* Physician in cardiac rehabilitation without electro-cardiogram (ECG) monitoring
- *93798:* Physician in cardiac rehabilitation with ECG monitoring

In order to estimate the number of CR sessions provided within a bill reimbursed by Medicare, CHD Research Associates followed an algorithm beginning with the assumption that the revenue units field in each claim counted the number of sessions provided. Because a significant number of claims had the revenue units' field filled with the number 1 (suggesting the provision of 1 session) but the charges sometimes exceeded hundreds of dollars, some revisions were needed. Those revisions were made based on the median and mode of the charges per session and by HCPCS codes for all the beneficiaries who received CR services. The use of CR was examined in relationship to the adjustor variables.

Demographic Adjustors

The demographics break down into the following categories, which are discussed in further detail in the following sections:

- Age
- Sex
- Race
- Individual socioeconomic characteristics

AGE

The utilization of CR can be affected by age: The older the patient, the less likely the patient will receive CR services. Some potential reasons are that older patients usually have more comorbidities and more severe coronary disease, which place them in a higher risk category for exercise training. Physicians can have lower expectations about the benefit of CR, and recommend or refer older patients to CR less often than if they were younger with the same disease and comorbidity profile. Each patient's date of birth was obtained from the Social Security Administration's EDB file. This study calculated the exact age at the date of admission and divided subjects into 3 age strata: 65–74, 75–84, and 85 or older.

SEX

Previous research found that females are less likely to receive CR services. Sex differences in utilization, if confirmed in our study, can have many explanations. For example, females may be less likely to go to CR because they may be older than men at the onset of the disease; they also can have more comorbid conditions, and/or more severe coronary disease.

RACE

We considered race as a social construct rather than a biological determinant, indicating potential differences in socioeconomic status, access to care, and provision of services. Blacks usually have more comorbidities, are more severely ill, and have access to fewer health services than Whites (Bach, Hoangmai, Schrag, Tage, and Hargraves 2004; Iezzoni 1997).

The EDB file has a field for race. The level of validation of race for whites and Blacks is very high in terms of sensitivity, specificity, and positive predictive value; however, it does not have a similar level of validation for other racial groups such as Asian Americans, Hispanics, and Native Americans. For example, since 1980, the EBD file contains a field for Hispanic ancestry retrieved from the Social Security application, but this information has been misused to classify spouses of beneficiaries (e.g., nonworking wives) regardless of their real ancestry. Approximately 18% of the living beneficiaries could have been misclassified as Hispanics (Bach et al. 2004). For this reason, we used only 2 race-ethnicity categories: Whites and non-Whites.

INDIVIDUAL SOCIOECONOMIC CHARACTERISTICS

The socioeconomic characteristics break down into the following categories:

- Socioeconomic status
- Educational level
- Disability
- Dual eligibility for Medicare and Medicaid

Low socioeconomic status may affect utilization of CR services and survival. Medicare data files contain only 1 individual-level variable, called "dual eligibility," that reflects socioeconomic status of a beneficiary. This variable indicates the number of months the state has provided supplemental insurance by Medicaid. Only those eligible beneficiaries that apply can be considered for this benefit. Although the specificity of this indicator of low income is very high, its sensitivity is low because not all potential candidates apply for coverage (Bach et al. 2004).

We flagged beneficiaries as Medicaid recipients if they had dual eligibility (Medicare + Medicaid) at the time of the index hospitalization during 1997. The

low income of this group may suggest that these beneficiaries may not understand the benefits of CR as well, or they may face additional barriers, such as lack of car ownership, in accessing CR.

Health Status Adjustors

This study used proxies for beneficiaries' health status similar to those used in the IHD cohort (Cromwell et al. 2003). The proxies include the following:

- Type of index admission based on principal diagnosis
- Type of coronary treatment during index hospitalization
- Severity of index hospitalization
- Comorbidities
- Date of death

TYPE OF INDEX ADMISSION BASED ON PRINCIPAL DIAGNOSIS

Principal diagnosis is usually defined as the leading disease that explains the patient's main reason for which services are sought. The coronary heart disease diagnosis for the index admission was classified into 2 mutually exclusive groups based on the ICD-9 CM classification in the principal diagnosis of the index hospitalization: AMI (except old AMI) and non-AMI for unstable angina, stable coronary disease, and other chronic coronary conditions. Coronary disease treatments during the index hospitalization were classified into 3 groups: medical treatment, PCI, or CABG. Patients who received both CABG and PCI during the index hospitalization were classified as CABG.

TYPE OF CORONARY TREATMENT DURING INDEX HOSPITALIZATION

Beneficiaries were classified into 4 groups based on the level of coronary treatment received during the index hospitalization: medical treatment (no thrombolysis), thrombolysis (by intravenous or intracoronary infusion), PCI (with or without stent), or CABG.

SEVERITY OF INDEX HOSPITALIZATION

Proxies for severity of the index admission were evaluated by the following indicators:

- *Admission into an intensive care unit:* We created a dummy variable (i.e., 0 or 1 variable or flag) if there was any use of the intensive care unit during the index hospitalization.
- *Admission into a coronary care unit:* We created a dummy variable if there was any use of a coronary care unit during the index hospitalization.

- *Patient origin for the index hospitalization:* Patient origin for the index hospitalization was classified into 3 strata: no transfer, transferred from an acute short-stay facility, or transferred from a skilled nursing (SNF) or long-term care facility.
- *Length of stay in acute care facility:* We analyzed the length of stay of the beneficiary during the index hospitalization and created a dummy variable for length of stay above the median.
- *Patient destination after the index hospitalization:* Patient destination after the index hospitalization was classified into 3 groups: discharged home, transferred to another acute hospital, or transferred to an SNF or long-stay hospital. A flag was created for a transfer to a long-stay hospital or SNF.
- *Prior hospitalizations within 12 months before the index hospitalization:* Flags were used for any prior hospitalization during 1 year before the index hospitalization for any condition or AMI.

COMORBIDITIES

Comorbidities are defined as any additional health conditions in conjunction with the patient's main condition. They should be taken into consideration when analyzing the utilization of CR services or their impact on any health outcome including survival. Comorbidities, and not the intervention per se, could be responsible for a health outcome. This is particularly true for observational studies comparing outcomes by the intervention of 2 nonrandomized groups (intervention and control). Comorbidities usually increase the risk of complications and death, and increase the use of additional health care resources. In the case of CR, they can be a contraindication or a limitation for exercise training or they can affect a patient's ability to receive, tolerate, or respond to a treatment. For this reason, comorbidities were accounted for when evaluating CR utilization or its impact on health outcomes including the risk of death.

Three basic approaches were considered to select comorbid conditions (Klabunde, Warren, and Legler 2002). These approaches are:

- Request the opinion of clinical experts
- Determine the most relevant conditions via multivariate analysis
- Use preexisting comorbidity indexes or algorithms such as the Charlson's index (Charlson, Pompei, Ales, and MacKenzie 1987)

The Charlson's index is the most commonly used comorbidity index (Groot, Beckerman, Lankhorst, and Bouter 2003). It was based on a cohort of 559 patients admitted to medical services in an acute hospital, and it includes 19 conditions, each of which receives a weight for its potential role in influencing mortality (Charlson et al. 1987). This index has been adapted by some research groups to be used with claims databases (Romano, Roost, and Jollis 1993). A validation

study found that the comorbidity index based on claims (administrative) data "generally agree" with those from chart review and proved an equally good predictor of in-hospital mortality (Quan, Parsons, and Ghali 2002).

It is possible to use both inpatient and outpatient claims to identify potential comorbid conditions that occurred prior to or during a particular event (e.g., index admission) or intervention (e.g., CR). The length of the period (e.g., 6 months, 1 year) prior to the event, as well as the source of data (inpatient only, outpatient only, or both), increase the number of claims from which it is possible to detect particular conditions. The accuracy of the diagnoses reported in the outpatient claims have not been studied in as much depth as those reported in hospital claims.

Based on the opinion of clinical experts and on the peer-reviewed cardiovascular literature, this study has selected the following comorbid conditions, which also resembled the conditions included in the Charlson's index, to control for cardiovascular disease and all other comorbidities:

- *Cardiovascular diseases:* Prior acute myocardial infarction, prior other coronary diagnosis, hypertensive heart disease, congestive heart failure, arrhythmias, heart conduction disorders, valvular heart disease, cardiac arrest, peripheral vascular disease, or cerebrovascular disease
- *All other comorbidities flag:* Dementia and central neurological condition, musculoskeletal condition and bone fractures, chronic pulmonary disease, chronic liver disease and other liver disease, malnutrition, gastric ulcer, renal disease, urinary tract disease, hematological (nonmalignant) disease, diabetes both with and without complications, malignancies and metastatic malignancies, and infectious diseases

To identify these comorbidities in each of the patients of our cohort, we used the DxCG software (DxCG, Inc., Boston, Massachusetts) to analyze diagnostic and procedure codes registered during the index hospitalization or any other hospitalization within 1 year before the index admission. The software recognized codes and allocated them into 186 condition categories. Based on these categories, we finally created 27 comorbidity groups that were both relevant to our study and resembled Charlson's grouping (Charlson et al. 1987). Additionally, we created 2 flags for prior history of coronary disease (AMI or non-AMI).

DATE OF DEATH

Survival was the main outcome of interest of this study. The reported death date of a beneficiary is provided in the EDB file. Because payment from Social Security usually ends by the end of the month following a beneficiary death, there is an excess of the reported dates of death toward the end of each month.

Institutional Adjustors

The study hypothesizes that some of the institutional characteristics of the index hospitals may influence the likelihood of a patient's participation in a CR program. CMS stores information in the provider of service (POS) file about institutions eligible to provide Part A services (inpatient services). This study used some of the information available in the POS file to characterize the hospital of each beneficiary's index hospitalization. The POS file was complemented with the American Hospital Association (AHA) annual file. The objective was to characterize the institutional characteristics of the index hospitalizations. The following variables were used:

- State in which hospital is located
- Availability of cardiac catheterization
- Availability of angioplasty
- Availability of open heart surgery
- Medical school affiliation
- Hospital size

Hospital characteristics were not obtained for all of the hospitals, so we created dummy variables to indicate missing values on these characteristics.

Geographic Adjustors

The geographic characteristics break down into the following categories, which are discussed in further detail in the following sections:

- Residence location
- Residence census division
- Location of index hospitalization
- Distance from residence address to nearest CR program
- Neighborhood income, educational level, and disability

RESIDENCE LOCATION

A variable reflecting the proportion of people within each ZIP code living in urban areas was created and linked to the patient's residence ZIP code. After dividing the values of this variable in quintiles, each beneficiary was matched with his or her corresponding quintile.

RESIDENCE CENSUS DIVISION

Utilization of CR services can display geographic variations, as seen in the ample variations in the treatment of patients with AMI (O'Connor et al. 1999). This

study analyzed utilization of services by Census division and states. The U.S. Census Bureau uses 9 divisions: New England, Middle Atlantic, South Atlantic, East North Central, East South Central, West North Central, West South Central, Mountain, and Pacific.

LOCATION OF INDEX HOSPITALIZATION

We created indicator variables to identify the state in which the index hospitalization occurred to examine state variations in the use of CR.

DISTANCE FROM RESIDENCE ADDRESS TO NEAREST CARDIAC REHABILITATION PROGRAM

We determined the distance from the patient's residence address to the nearest CR center. Though we were not assuming that proximity to a CR center is equivalent to access to it by every beneficiary, this study hypothesized that proximity to a CR and, consequently, travel distance, may influence CR utilization. Distance in linear miles was determined based on patient's residence ZIP code's latitude and longitude and exact latitude and longitude of the CR facility (from its street address). We then grouped distances in quintiles and matched each patient with the corresponding distance quintile. We assumed patients would not cross state borders to receive CR.

NEIGHBORHOOD INCOME, EDUCATIONAL LEVEL, AND DISABILITY

Medicare does not have other individual-level socioeconomic indicators such as income or level of education. Using geo-coding software, this study assigned the ZIP code's median income, poverty level, and level of education generated by the 2000 U.S. Census to the Medicare beneficiary. Median income is believed to be correlated with self-reported income, regardless of the level of aggregation (Bach et al. 2004). We assigned an income to each beneficiary based on the median income for head of household age 65–74 and 75 or older of the patient's residence ZIP code. To correct for extreme outliers, income values were trimmed (winsorized) at the 1st and 99th percentiles. Income was then divided into quintiles and each beneficiary was matched to his or her corresponding income quintile.

Each beneficiary was assigned a value for a variable reflecting the proportions of people within the ZIP code of his or her residence living under the poverty line (adjusted by race and age groups—65 to 74 and 75+) and then the variable was divided into quintiles. Each beneficiary was then matched with a poverty-level quintile. A similar approach was followed for each beneficiary's level of education. Each beneficiary was assigned a value corresponding to the proportion of people (adjusted by gender and race) within the patient's residence ZIP code who

attained some college education. The proportion of people with some college education was divided into quintiles and each beneficiary was matched to his or her corresponding education quintile. Finally, this study also assigned each patient with a proxy value for the proportion of people having any disability (adjusted by race, gender, and age groups) according to the patient's residence ZIP code. After creating quintiles for disability, each beneficiary was matched with a quintile.

Data Sources and Study Population

The primary data sources were the final action files (final decisions on reimbursement and payment adjustments on an annual basis) and the standard analytical files (SAFs) in Medicare's national claims history file (NCH). We used unique identifiers for beneficiaries and providers to create a single record per patient.

For qualifying patients, we linked the inpatient claims with the Medicare master EDB through the unique beneficiary identification number—Medicare HICNO—to obtain beneficiary information about demographics (date of birth, sex, race, death), patient's residence ZIP code, enrollment status over time, entitlements (Part A and Part B), and group health plan (e.g., HMO) membership.

As mentioned earlier, additional sources of data were Census 2000, the American Hospital Association (AHA), and the Behavioral Risk Factor Surveillance System (BRFSS) from the Centers for Disease Control and Prevention. Next, this study linked Census 2000 data of each patient's residence ZIP code to the retrieved ZIP code–specific statistics as proxies for the patient's socioeconomic, educational, and disability status. Hospital characteristics were obtained from both Medicare and AHA files. From the BRFSS, we obtained state rates of beta-blocker use after heart attack, pneumococcal vaccine, and smoking in people ages 65 or older for the year 1997.

Predicting Cardiac Rehabilitation Use

Participation in a CR program was considered the intervention of interest in this study. Our first question concerned predicting CR use. The analysis of this question was performed in 2 steps. First, we performed univariate and bivariate analyses of the outcomes of interest (use of CR) and the explanatory variables. Univariate analyses were used to determine the proportion of patients receiving any CR. Additionally, CR utilization was evaluated according to how soon after discharge from the index hospital admission it began, its intensity determined by the number of sessions received within 1 year after index discharge, the duration of CR treatments, and the maximum number of sessions received. Bivariate analysis was used to describe differences in any CR use by multiple patient demographics and clinical conditions; by characteristics of index hospitalization, hospital, and patient's residence ZIP code; as well as by Census

region and states. We used t-tests for continuous variables and chi squared for categorical variables.

Second, multivariate analyses were used to predict the use of CR. Binary logit analysis, estimated by maximum likelihood, was used to estimate the goodness of fit of the model. However, in order to adjust for patients clustered in hospitals for their index hospitalization, we ran estimations through generalized estimating equations (GEE). This technique provided efficient estimates and standard errors in the face of clustering within hospitals. A single correlation (exchangeable option) affecting any pair of patients within each cluster (hospital) was used, and then calculations of the level of intra-cluster correlation and adjusted odds ratios (ORs) of CR use for each of the variables included in the model were obtained.

The final GEE model for any CR use included the following categories of variables from the adjustors above: patient demographics and medical conditions, characteristics of index hospitalization and of inpatient facility during index hospitalization, socioeconomic profile and disability prevalence of the patient's ZIP code, distance to the nearest CR facility, and flags for states.

Results

Both descriptive and multivariate results are presented. The descriptive results examine CR utilization rates by each characteristic, whereas the multivariate rates show the effect of each factor while controlling statistically for all others. The multivariable results are important, for example, in distinguishing the effects of older age and increased comorbidity. These 2 factors are correlated and, as it turns out, each is an impediment to CR use.

Demographic Findings

As noted earlier, we identified 601,099 patients with an index hospitalization in 1997 who met all the criteria of this study. All these patients were considered candidates for CR. **Table 7.1** displays the proportion of patients and crude rate of CR use by sociodemographic characteristics of patients, characteristics of the index hospitalization and hospital, and Census regional division. A total of 73,049 candidates, or 12.2% of the full cohort, received at least 1 session of outpatient CR.

Males represented 51.7% and Whites 90.8% of the cohort. Half of the cohort were ages 65–74 (49.6%), 39% were ages 75–84, and 11.4% were 85 years or older. Crude CR rates were higher among men (15.0%), Whites (12.9%), young elders (16.1%), and non-Medicaid enrollees (13.5%) than among women (9.1%), non-Whites (4.6%), old elders (2.1%), and Medicaid enrollees (3.2%). Patients receiving revascularization procedures during the index hospitalization were more likely

Table 7.1 Cohort Characteristics and Crude Rates of Cardiac Rehabilitation (CR) Use

Characteristic	Percent of the Cohort (n = 601,099)	CR Use Within Group
Entire cohort		**12.2%**
Sociodemographic characteristics of patients		
Gender		
Males	51.7%	15.0%
Females	48.3%	9.1%
Race		
Whites	90.8%	12.9%
Non-Whites	9.2%	4.6%
Age group		
65–74 years	49.6%	16.1%
75–84 years	39.0%	10.1%
85+	11.4%	2.1%
Medicaid at discharge		
No	87.2%	13.5%
Yes	12.8%	3.2%
Index hospitalization		
Coronary principal diagnosis at discharge		
AMI	32.1%	13.9%
No AMI	67.9%	11.3%
Coronary revascularization procedure		
CABG (with or without PCI)	14.8%	30.9%
PCI without CABG	18.2%	13.6%
Neither CABG nor PCI	67.1%	7.7%
Intensive care unit use		
No	53.8%	8.7%
Yes	46.2%	16.2%
Coronary care unit use		
No	66.3%	11.0%
Yes	33.7%	14.5%

(continues)

Table 7.1 Cohort Characteristics and Crude Rates of Cardiac Rehabilitation (CR) Use *(cont'd)*

Characteristic	Percent of the Cohort (n = 601,099)	CR Use Within Group
Length of stay		
1–4 days	57.9%	9.5%
5–32 days	42.1%	15.7%
Origin of hospitalization		
Home	94.2%	12.5%
Transferred from acute hospital	2.2%	8.9%
Transferred from SNF or LCF	3.6%	4.0%
Patient destination		
Home	79.8%	11.4%
Transferred to acute hospital	14.4%	17.7%
Transferred to SNF or LCF	5.8%	8.6%
Prior hospitalizations within 12 months before index hospitalization		
For any condition		
No	65.3%	14.4%
Yes	34.7%	8.0%
For AMI		
No	97.5%	12.2%
Yes	2.5%	9.8%
Facility characteristics of index hospitalization		
Availability of cardiac catheterization		
No	18.9%	9.2%
Yes	63.1%	12.8%
Unknown	18.0%	11.3%
Availability of angioplasty		
No	32.6%	9.2%
Yes	49.4%	14.4%
Unknown	18.0%	11.2%
Availability of open heart surgery		
No	34.2%	9.2%

(continues)

Table 7.1 Cohort Characteristics and Crude Rates of Cardiac Rehabilitation (CR) Use *(cont'd)*

Characteristic	Percent of the Cohort (n = 601,099)	CR Use Within Group
Yes	47.8%	14.6%
Unknown	18.0%	11.2%
Medical school affiliation		
No	54.2%	11.1%
Yes	42.0%	13.6%
Unknown	3.9%	11.9%
Census division of index hospital		
New England	5.2%	13.4%
Mid Atlantic	15.5%	9.4%
South Atlantic	21.1%	8.8%
East North Central	19.2%	15.9%
East South Central	8.3%	7.6%
West North Central	8.2%	25.5%
West South Central	10.8%	8.8%
Mountain	3.9%	13.1%
Pacific	7.9%	11.5%

AMI denotes acute myocardial infarction; CABG denotes coronary artery bypass graft; PCI denotes percutaneous coronary intervention; SNF denotes skilled nursing facility; LCF denotes long-term care facility.

to receive CR (30.9% for those who underwent CABG and 13.6% for those who underwent PCI) than those without either of those procedures (7.7%).

About 12.8% of the cohort had dual eligibility Medicare/Medicaid at the time of discharge from the index hospitalization. The rate of CR use in this subgroup was 3.2%.

Health Status Findings

As discussed in this section, patients with revascularization procedures (CABG or PCI) had much higher rates of CR use than patients who did not. Concurrent other problems, termed comorbid conditions, were prevalent and generally proved obstacles to CR use.

PROCEDURES

Within the cohort, nearly one-third (32%) of patients were discharged with a principal diagnosis of AMI, 15% received CABG, and 18% received PCI during the index hospitalization. More than 94% of the patients were hospitalized from home, and the rest were transferred from either another acute hospital or a skilled nursing or long-term care facility. Two-thirds of the cohort had no hospitalization within 1 year prior to the index hospitalization. Only 2.5% of the cohort had a prior hospitalization for AMI within 1 year. One out of five patients (20.2%) was transferred from the index hospitalization to either an acute hospital (14.4%) or a skilled nursing or long-term care facility (5.8%).

DIAGNOSES AND COMORBIDITIES

Comorbidities were common among patients within this cohort. The overall number of comorbid conditions among those who received CR was 24% less than among those who did not receive CR (mean 2.06, standard deviation [SD] 1.70 vs. mean 2.71, SD 2.22). **Table 7.2** presents the frequency, crude rates of use, and adjusted ORs of CR use by comorbid condition.

Some comorbid conditions were very common, such as:

- Hypertension (55%)
- Congestive heart failure (30%)
- Diabetes (31%)
- Arrhythmias (25%)
- Chronic pulmonary disease (21%)
- Musculoskeletal conditions (mainly arthritis) (20%)

Several comorbid conditions had a strong negative impact on the use of CR. For example, the proportion of patients who received CR was very small among those with history of dementia (1.7%), bone fracture (3.1%), metastatic cancer (4.1%), or malnutrition (4.6%). Some other conditions were associated with moderate reductions in the use rates of CR: diabetes with complications, or chronic respiratory, liver, or renal diseases. Patients with a history of other cardiovascular conditions such as valvular disease, arrhythmias, conduction disorders, or cardiac arrest were not associated with important reductions in the use of CR. However, patients with a history of cardiac failure or hypertensive disease showed a rate of any CR use much lower than those with other cardiovascular comorbid conditions. Finally, some comorbidities did not have any appreciable effect on CR use; for example, patients with a history of uncomplicated diabetes had a CR use rate close to the overall cohort.

Impact of Institutional Characteristics

Other characteristics of the patient hospitalizations associated with a higher utilization rate of CR were: a stay in specialized intensive (16.2%) or coronary

Table 7.2 Frequency of Comorbid Conditions, Unadjusted Rates of Cardiac Rehabilitation (CR) Use, and Adjusted Odds Ratios of CR Use by Comorbid Condition

			Adjusted Odds Ratios (OR)		
Characteristic	**% of the Cohort *n* = 601,099**	**CR Use Within Group (%)**	**OR**	**OR Lower 95% CI**	**OR Upper 95% CI**
Cardiovascular disease					
Prior acute myocardial infarction	3.5%	9.5%	1.18	1.12	1.25
Prior any other coronary diagnosis	23.1%	7.3%	0.89	0.85	0.92
Hypertensive heart disease	54.7%	12.0%	0.88	0.77	1.02
Congestive heart failure	29.8%	7.9%	0.77	0.75	0.79
Arrhythmias	25.5%	12.6%	0.93	0.91	0.95
Heart conduction disorders	16.1%	10.6%	1.00	0.97	1.02
Valvular heart disease	16.3%	10.0%	0.99	0.96	1.02
Cardiac arrest	5.5%	12.3%	0.98	0.95	1.02
Peripheral vascular disease	18.1%	10.1%	0.91	0.89	0.94
Cerebrovascular disease	9.8%	8.8%	0.79	0.76	0.82
Dementia	4.0%	1.7%	0.32	0.29	0.35
Central neurological condition	2.0%	6.6%	0.68	0.63	0.74
Musculoskeletal condition	20.1%	9.6%	1.00	0.97	1.02
Bone fractures	1.7%	3.1%	0.54	0.48	0.61
Chronic pulmonary disease	20.9%	8.7%	0.77	0.75	0.79
Chronic liver disease	0.3%	5.6%	0.65	0.53	0.80
Other liver disease	1.5%	8.3%	0.97	0.89	1.05
Malnutrition	1.2%	4.6%	0.62	0.54	0.72
Gastric ulcer	6.6%	7.4%	0.84	0.80	0.87
Renal disease	6.0%	6.1%	0.68	0.65	0.72
Urinary tract disease	15.5%	8.0%	0.88	0.85	0.91

(continues)

Table 7.2 Frequency of Comorbid Conditions, Unadjusted Rates of Cardiac Rehabilitation (CR) Use, and Adjusted Odds Ratios of CR Use by Comorbid Condition *(cont'd)*

			Adjusted Odds Ratios (OR)		
Characteristic	**% of the Cohort *n* = 601,099**	**CR Use Within Group (%)**	**OR**	**OR Lower 95% CI**	**OR Upper 95% CI**
Hematological (nonmalignant) disease	18.8%	13.5%	1.04	1.02	1.07
Diabetes without complications	26.0%	10.7%	0.94	0.92	0.96
Diabetes with complications	4.8%	7.0%	0.78	0.74	0.83
Malignancies	4.3%	8.3%	0.85	0.80	0.89
Metastatic malignancies	0.7%	4.1%	0.42	0.36	0.49
Infectious diseases	6.9%	6.5%	0.87	0.83	0.91

The average number of comorbid conditions were 2.02 (SD 1.70) for CR users and 2.71 (SD 2.22) for non-CR users.

Adjusted odds ratios were obtained from generalized estimation equations (GEEs) that included covariates for patient demographics, index hospitalization including coronary diagnosis and coronary treatment, hospital characteristics, quintiles for patient ZIP code characteristics, quintiles for distance to nearest CR facility, and states, in addition to CR use and comorbid conditions.

CI denotes confidence interval.

(14.5%) care units, a hospital length of stay longer than 5 days (15.7%), an index hospitalization that originated at the patient's home (12.5%), and a transfer to another acute hospital (17.7%).

Cardiac catheterization was available in 3 of 5 of the index hospitalizations. Almost half of the index hospitalizations occurred in hospitals where angioplasty (49.4%) and/or open heart surgery (47.8%) were available. Forty-two percent of the hospitalizations were in settings affiliated with medical schools.

Some hospital characteristics of the index hospitalization were associated with a mild increase of CR use: availability of coronary catheterization (12.8%), angioplasty (14.4%) or open heart surgery (14.6%), and affiliation with a teaching hospital (13.6%).

Overall use of CR varied markedly by geographic U.S. Census division of the index hospitalization, from a low 7.6% in the East South Central region to a high 25.5% in the West North Central region.

Impact of Geographic Characteristics

The geographic characteristics consist of the following categories:

Table 7.3 Crude Rates of Cardiac Rehabilitation (CR) Use and Adjusted Odds Ratios and 95% Confidence Intervals of CR Use for Quintiles of Distance from Patient ZIP Code to Nearest CR Facility

Quintile	Distance in Miles: Mean and (Range)	Crude CR Rate	Adjusted Odds Ratios and (95% CI)
1	0.96	16%	1
	(0.3–1.63)		Reference group
2	2.38	14%	0.95
	(1.64–3.24)		(0.91–0.98)
3	4.61	13%	0.81
	(3.25–6.50)		(0.77–0.83)
4	10.17	12%	0.61
	(6.51–14.92)		(0.58–0.63)
5	31.83	6%	0.31
	(14.93–231.00)		(0.29–0.33)

Upper bound of quintile 5 was windsorized at 231 miles for 1,100 observations. For about 2% (14,969) of the cohort, distance was not calculated because of lack of ZIP code information.

Adjusted odds ratios were obtained from a multiple logistic regression estimated by generalized estimating equations. Besides distance to CR facilities, the model included variables for patient: demographics, comorbidities, and index hospitalization including coronary diagnosis and coronary treatment, hospital characteristics, quintiles for patient ZIP code characteristics, and states.

CI denotes confidence interval.

- ▶ Patient's residence ZIP code characteristics
- ▶ CR rates and number of CR facilities within states

PATIENT'S RESIDENCE ZIP CODE CHARACTERISTICS

We estimated crude CR rates according to the U.S. Census ZIP code in which the patient resided. Definition of quintiles for each of the variables studied is presented in **Table 7.3**. As shown in **Figure 7.1**, for all beneficiaries' residence ZIP code characteristics, with the exception of urbanization, the most favorable level of the characteristic (high income, low poverty, high college, and low disability) was associated with the highest rate of CR use.

Patients living in either very rural or very urban areas (lowest quintile of urbanization) were associated with lower CR utilization rates (11%) than those living in ZIP codes with intermediate levels of urbanization. There was a three-fold variation in CR use between the extreme quintiles for household median income,

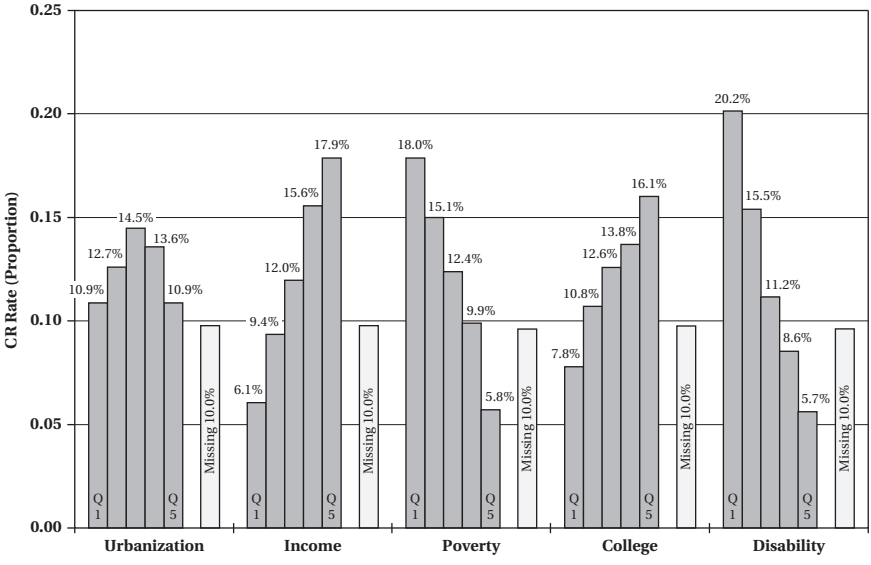

Figure 7.1 Crude rates of cardiac rehabilitation (CR) use by quintile of patients' residence ZIP code characteristics

poverty level, college education, and disability. As shown in Figure 7.1, rates of CR use were low (6–8%) when median household income and college education were low or when levels of disability and poverty in the community were high. Rates for CR consistently changed across quintiles to a maximum of 16% to 20% from the lowest to the highest quintiles of income or college education and for the highest to the lowest quintiles of poverty level or disability.

We observed that the shortest distance from the centroid of the patient's residence ZIP code to the nearest CR facility given by their latitude and longitude locations (distance to CR facility) was also associated with the use of CR. Whereas utilization rates were 15.8% for those patients in the closest quintile, those rates dropped constantly to a 6.0% for those patients' residences located furthest from a CR center. These findings were presented in Table 7.3, along with the adjusted odds ratios of CR use by distance to a CR facility. Adjusted odds ratios will be explained later in this chapter.

CARDIAC REHABILITATION RATES AND NUMBER OF FACILITIES WITHIN STATES

As shown in **Figure 7.2**, we found a strong positive linear association between crude rates of CR use at state level and the number of CR facilities per 10,000 people age 65 or older ($r = 0.82$, $p < 0.001$, weighted estimate), indicating that states with more facilities per population had higher CR rates.

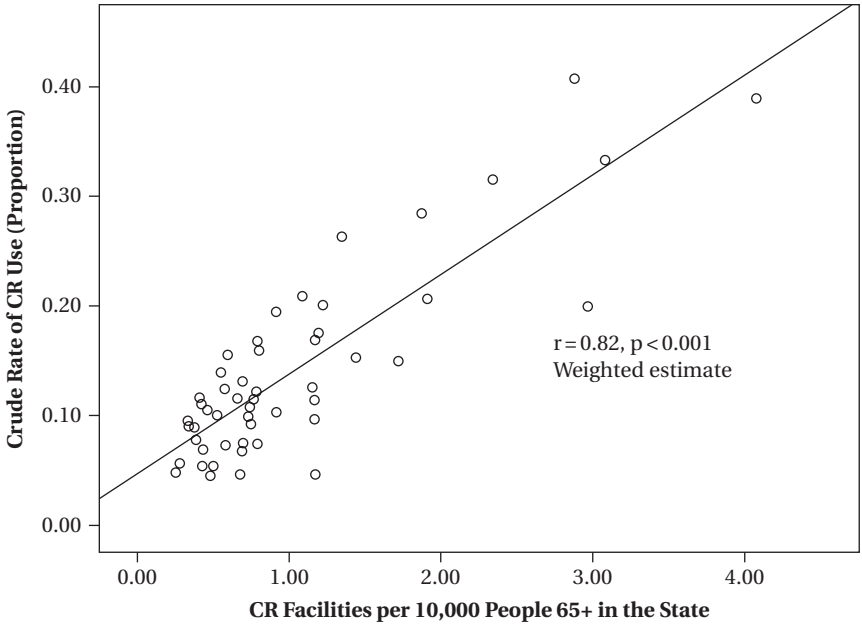

Figure 7.2 Association between crude rates of cardiac rehabilitation (CR) use and state-level density of CR facilities

Characteristics of Cardiac Rehabilitation Use

CR recipients received an average of 24 sessions. Among CR recipients, 22.5% received 1–12 sessions, 26% received 13–24 sessions, 43.4% received 25–36 sessions, and 8.2% received more than 36 sessions. Of CR users, 37.5% started their sessions within 1 month after discharge. An additional 30.5% and 13.3% began CR during the second and third months after discharge, respectively.

Patients who received CR started on average 60 days after discharge from index hospitalization. As shown in **Figure 7.3**, at state level, there was a strong negative linear association between average number of days from discharge to first CR session and crude rate of CR use ($r = -0.80$, $p < 0.001$, weighted estimate), indicating that patients in states with higher rates of CR use started CR earlier than those patients in states with lower rates of CR use.

Binary Logit Analysis for Cardiac Rehabilitation Use

Adjusted ORs of CR use for patient, facility, patient's residence ZIP code characteristics, distance to a CR facility, and state were obtained from the same GEE model. Initially, we ran an intercept-only binary logit regression estimated by maximum

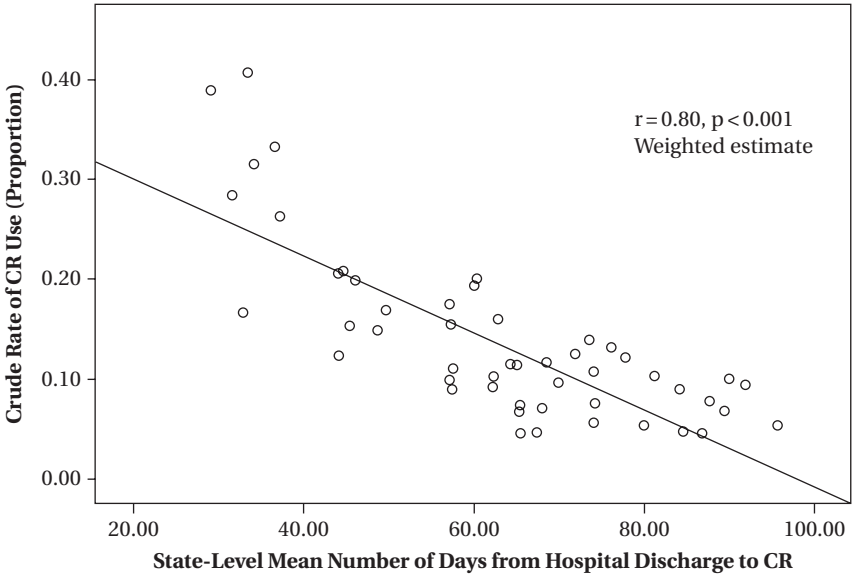

Figure 7.3 Association between crude rates of cardiac rehabilitation (CR) use and state-level initiation of CR from hospital discharges

likelihood (ML) and by GEE models. The predicted probability of CR use from the former model coincided with the actual overall CR rate, 12.2%. The predicted probability of CR using the GEE estimation, which adjusts for the clustering of patients within hospitals, was 10%—an 18% reduction in the probability of CR use.

The intra-cluster correlation observed in the intercept-only GEE model was 0.094, indicating a weak to moderate correlation among patients treated in the same hospitals. The multiple covariates binary logit regression (multiple logistic regression) via ML of the model used had an R-squared of 0.1439 and a rescaled R-squared of 0.2752, suggesting that despite the large number of covariates included in the model, about 73% of the variation in the use of CR still was not explained by the model. The c-statistics of 0.82 suggested a good accuracy and discriminating power (goodness of fit) of the model. Because of the existence of a correlation between patients treated within the same hospital, we report estimates of covariate effects and their coefficient intervals from the multiple covariates binary logit estimated (multiple logistic regression) by GEE. This model utilized the full cohort of 601,099 patients and had an intra-hospital correlation of 0.034. This intra-cluster correlation represented only one-third of the correlation observed in the intercept-only model, indicating that a large part was explained by covariates in the model, such as hospital characteristics of the index hospitalization.

As explained in the "Approach" section earlier in this chapter, the multivariate analysis included covariates from a large number of patient, index hospitalization, and hospital characteristics along with patients' residence ZIP code characteristics, distance to CR, and indicators for states. However, odds ratios of use of CR for most of the variables included in the GEE model are discussed separately by categories and presented using the format that most clearly presents the findings for that category. **Table 7.4** summarizes the OR estimates, their 95% confidence intervals of use of CR for patients (excluding comorbidities), and hospital characteristics.

DEMOGRAPHICS

For each age group, males were more likely to receive CR than females, and independently from gender, the likelihood of use decreased with increasing age groups. The significance of the interaction between gender and age group means females were less likely to receive CR than what would have been expected for gender or age groups alone. As also shown in **Figure 7.4**, although females ages

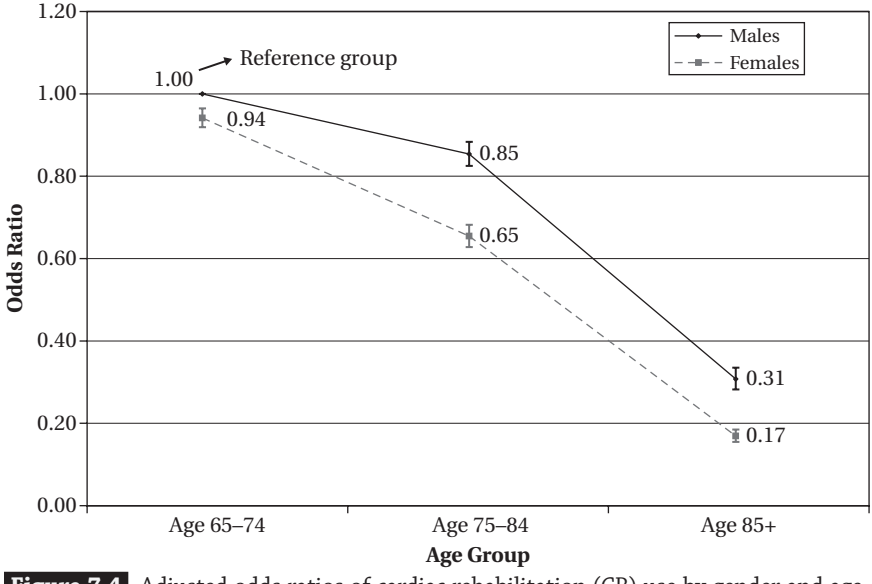

Figure 7.4 Adjusted odds ratios of cardiac rehabilitation (CR) use by gender and age groups

Note: The adjusted odds ratios were obtained from a multivariate generalized estimating equation regression. Besides these variables, the model included the following variables for patients: demographics, index hospitalization, comorbidities, and hospital characteristics as well as quintile for patients' residence ZIP code characteristics and states.

Table 7.4 Adjusted Odds Ratios (ORs) of Cardiac Rehabilitation (CR) Use by Patient, Hospitalization, and Hospital Characteristics

Characteristic	Number of Patients	Estimate	Lower 95% CI	Upper 95% CI
Sociodemographic characteristics of patients				
Gender by age group				
Male, ages 65–74		1.00	Reference group	
Female, ages 65–74		0.94	0.92	0.96
Male, ages 75–84		0.85	0.83	0.88
Female, ages 75–84		0.65	0.63	0.68
Male, ages 85+		0.31	0.28	0.33
Female, ages 85+		0.17	0.15	0.19
Race				
White		1.43	1.36	1.51
Non-White		1.00	Reference group	
Medicaid at discharge				
No		1.00	Reference group	
Yes		0.44	0.42	0.46
Index hospitalization				
Type of coronary diagnosis and revascularization				
AMI, No PCI, No CABG		1.00	Reference group	
AMI + PCI		1.95	1.85	2.05
AMI + CABG		3.30	3.09	3.52
No AMI, No PCI, No CABG		0.51	0.49	0.52
No AMI + PCI		0.97	0.92	1.03
No AMI + CABG		3.40	3.22	3.59
Intensive care unit use				
No	323,468	1.00	Reference group	
Yes	277,631	1.16	1.12	1.21
Coronary care use				
No	398,336	1.00	Reference group	
Yes	202,763	1.16	1.12	1.21
Length of stay				
1–4 days	348,001	1.00	Reference group	
5–32 days	253,098	1.17	1.14	1.20
Origin of hospitalization				
Home	566,393	1.00	Reference group	

(continues)

Table 7.4 Adjusted Odds Ratios (ORs) of Cardiac Rehabilitation (CR) Use by Patient, Hospitalization, and Hospital Characteristics *(cont'd)*

Characteristic	Number of Patients	Estimate	Lower 95% CI	Upper 95% CI
Transferred from acute hospital	13,156	0.94	0.88	1.01
Transferred from SNF or LTC	21,550	0.73	0.68	0.79
Patient destination				
Home	479,482	1.00	Reference group	
Transferred to acute hospital	86,761	2.50	2.40	2.60
Transferred from SNF or LTC	34,856	0.65	0.62	0.69
Prior hospitalizations				
Within 12 months prior index hospitalization				
No	391,611	1.00	Reference group	
Yes	208,488	1.05	1.02	1.08
Prior hospitalization within 1 year for AMI				
No	586,196	1.00	Reference group	
Yes	14,903	1.18	1.12	1.25
Facility characteristics of index hospitalization				
Availability of cardiac catheterization				
No	113,400	0.81	0.75	0.88
Yes	379,352	1.00	Reference group	
Unknown	108,347	0.87	0.41	1.85
Hospital size				
1–160 beds (quintiles 1–4)	195,813	1.34	1.17	1.53
161+ beds (quintile 5)	296,939	1.00	Reference group	
Unknown	108,347	1.48	0.70	3.14
School affiliation				
No	325,517	1.28	1.16	1.40
Yes	252,373	1.00	Reference group	

Note: These estimates were obtained from a multiple logistic regression estimated by generalized estimating equations. Besides these variables, the model included variables for patient history of AMI or other coronary diagnoses and comorbidities, quintiles for patient ZIP code characteristics, quintiles for distance to nearest CR facility, and states.

CI denotes confidence interval; AMI denotes acute myocardial infarction; CABG denotes coronary artery bypass graft; PCI denotes percutaneous coronary intervention; SNF denotes skilled nursing facility; LTC denotes long-term care facility.

65–74 were only 6% less likely to use CR than males of the same age category (ORs 0.94 vs. 1.00), the relative difference in likelihood of use increased by 24% (ORs 0.65 vs. 0.85) in the middle age group, and by 44% (ORs 0.17 vs. 0.31) in the oldest group. Whites were 43% more likely to receive CR than non-Whites (ORs 1.43 vs. 1.00).

HEALTH STATUS

An additional component of Table 7.2, which was already described earlier, displays OR estimates of CR use and their 95% CI by comorbid condition. The existence of some conditions was associated with a very low likelihood of CR use. For example, patients with dementia (OR 0.32) or metastatic malignancies (OR 0.42) were 70% and 60%, respectively, less likely to receive CR than those without those conditions.

INSTITUTIONAL CHARACTERISTICS

We identified 3 major medical predictors of CR use: CABG, PCI, and AMI. As shown in **Figure 7.5**, patients who underwent CABG during the index hospitalization independently from their coronary diagnosis (AMI or no AMI) were 3

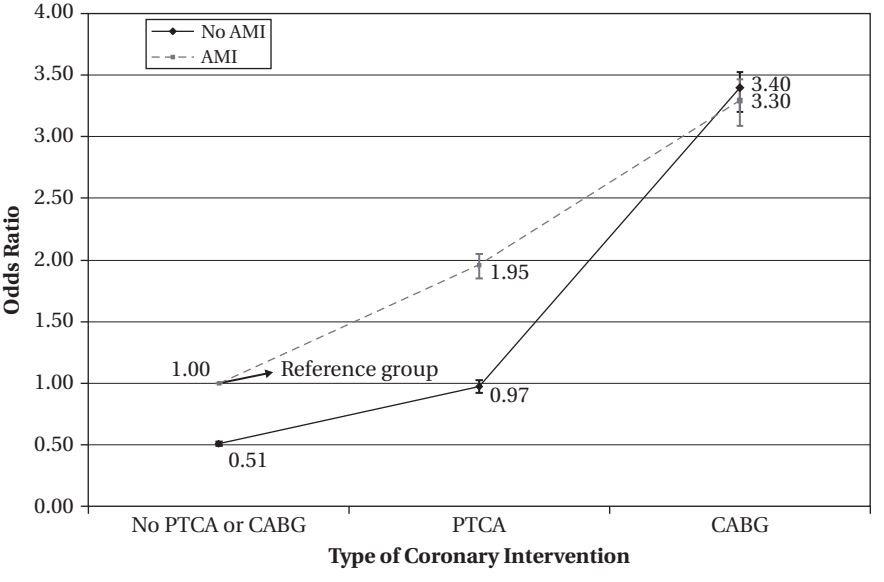

Figure 7.5 Adjusted odds ratios of cardiac rehabilitation (CR) use by principal diagnosis and coronary revascularization during index hospitalization

times more likely to receive CR than those with AMI but who did not receive any revascularization procedure (ORs 3.30 vs. 1.00). Patients who received PCI were 2 times more likely to receive CR than those with AMI without revascularization (ORs 1.95 vs. 1.00) and those without both AMI and revascularization (ORs 0.97 vs. 0.51) during their index hospitalization.

Patients transferred to another acute hospital were 2.5 times more likely to receive CR than those discharged home (ORs 2.5 vs. 1.0). Whereas being admitted into a hospital within a year prior to the index admission increased the likelihood of receiving CR by only 5% (OR 1.05), a prior admission for AMI increased its likelihood by 18% (OR 1.18). Some facility characteristics were associated with patients being more likely to use CR: hospital size of 160 beds or less (OR 1.34), availability of cardiac catheterization (OR 1.00), or no medical school affiliation (OR 1.28), compared to size larger than 160 beds (OR 1.00), unavailability of cardiac catheterization (OR 0.81), or medical school affiliation (OR 1.00), respectively.

PATIENT'S RESIDENCE ZIP CODE

The patient's residence ZIP code is the first geographic characteristic. **Figure 7.6** summarizes adjusted ORs of CR use according to patient ZIP code characteristics. Urbanization was inversely associated with the use of CR. Level of education was positively associated with CR use. Finally, level of poverty and disability were inversely associated with CR use. However, differences in likelihood of CR use between extreme quintiles were narrower than the unadjusted estimates, indicating that much of the variation initially observed was removed with multivariate analysis.

DISTANCE TO CARDIAC REHABILITATION

As previously shown in Table 7.3, distance to CR was an important predictor of CR use; for example, patients living in the furthest quintile (mean distance: 32 miles) were 70% less likely to participate in CR than those living closest to a CR facility (mean distance: 1 mile).

State and Regional Variation in Cardiac Rehabilitation Use

State variations were pronounced with a nine-fold difference between the state with the lowest and the highest crude rates of CR use (Hawaii, 4.56% vs. Nebraska, 40.65%). **Table 7.5** shows crude and adjusted rates of CR use by state. Evident state variations of CR use remained after the multivariate analysis. **Figure 7.7** shows a map of the United States with states grouped in quartiles of rates of CR use. There were remarkable regional variations in the use of CR, with states clustered by regions.

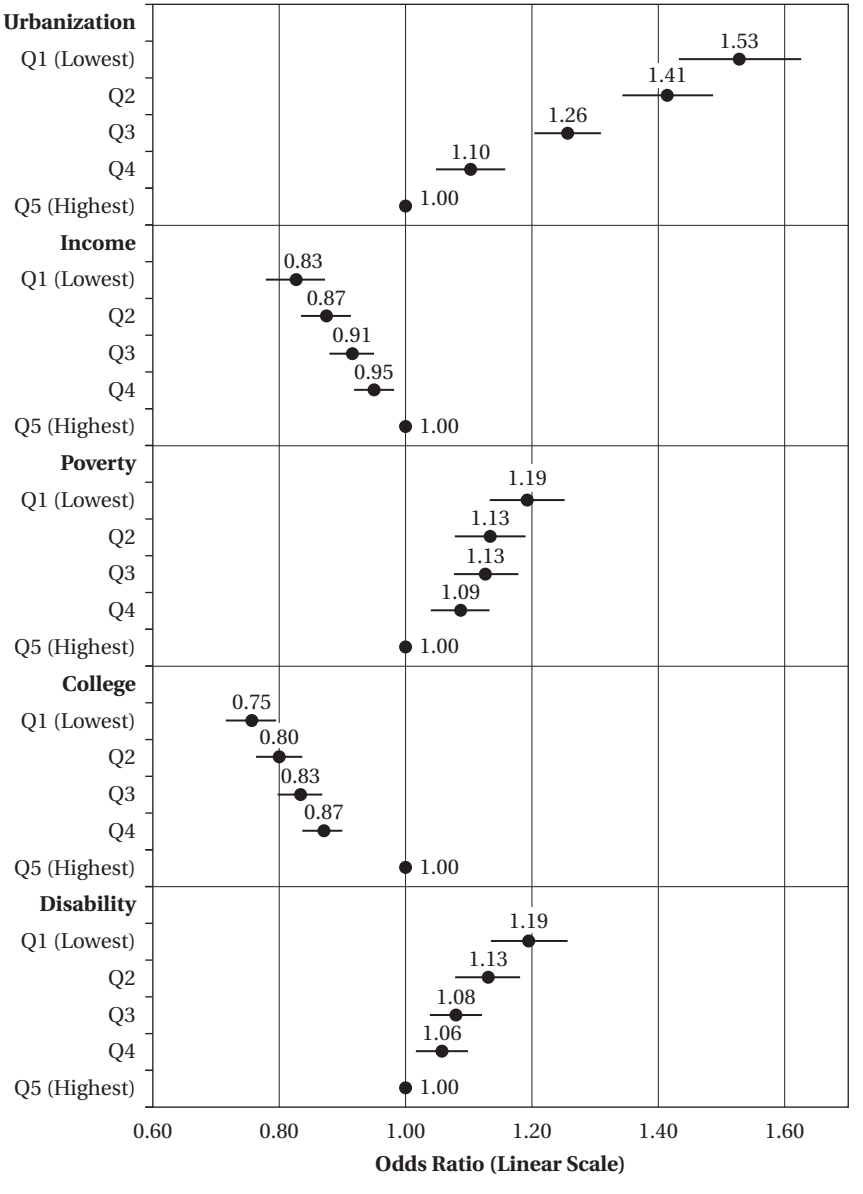

Figure 7.6 Adjusted odds ratios and 95% confidence intervals of cardiac rehabilitation (CR) use for patients' ZIP code quintile characteristics

Note: Adjusted odds ratios were obtained from a multivariate binary logistic regression estimated by generalized estimating equations. Besides these covariates, the model included the following variables for patients: demographics, comorbidities, and index hospitalization characteristics.

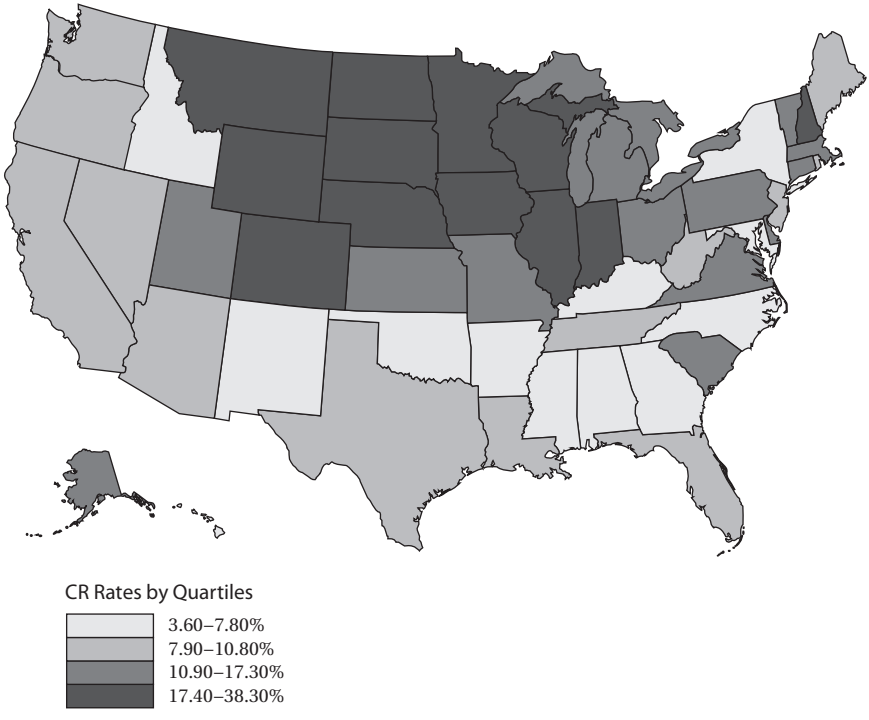

Figure 7.7 Adjusted rates of cardiac rehabilitation use by state, 1997

Conclusions

This population-based, nationwide study on the use of CR among elderly Medicare beneficiaries with coronary heart disease is, to our knowledge, the largest study in size (601,099 patients) and the most comprehensive study ever performed. It describes CR use and confirms and clarifies the types and importance of predictors of utilization after controlling for demographic, clinical, index hospitalization–related, hospital-related, socioeconomic, and geographic characteristics. Utilization of CR was examined using multivariate methods, which allowed an estimation of the impact of each characteristic while controlling for the simultaneous effect of other factors.

Cardiac Rehabilitation Use Varies by Patient Sociodemographic Characteristics

The study showed an overall national CR utilization rate of 12.2% among Medicare beneficiaries, with female gender, non-White race, and increasing age as

Table 7.5 Crude and Adjusted Rates of Cardiac Rehabilitation (CR) Use by State

	CR Candidates	CR Rate Unadjusted	CR Rate Adjusted
Alabama	13,817	7.5%	6.0%
Alaska	478	14.9%	12.9%
Arizona	7,132	10.4%	9.4%
Arkansas	8,053	6.7%	4.8%
California	34,057	11.6%	10.8%
Colorado	4,143	20.8%	21.1%
Connecticut	7,657	13.9%	14.3%
Delaware	1,615	15.5%	16.6%
District of Columbia	2,116	6.9%	6.8%
Florida	46,175	9.0%	8.6%
Georgia	15,929	5.4%	4.9%
Hawaii	1,173	4.8%	3.8%
Idaho	2,065	4.6%	3.7%
Illinois	26,859	19.4%	19.7%
Indiana	16,722	16.9%	17.6%
Iowa	8,735	31.5%	31.3%
Kansas	6,382	15.3%	14.6%
Kentucky	11,813	7.4%	7.7%
Louisiana	10,800	10.3%	10.3%
Maine	4,309	12.5%	9.3%
Maryland	10,297	5.4%	4.7%
Massachusetts	12,799	13.1%	13.4%
Michigan	28,900	11.5%	11.8%
Minnesota	8,955	28.4%	29.1%
Mississippi	7,588	4.6%	3.6%
Missouri	15,989	17.5%	16.3%
Montana	2,131	20.6%	21.7%
Nebraska	4,312	40.7%	38.3%
Nevada	2,560	8.9%	9.3%
New Hampshire	2,440	20.0%	20.9%

(continues)

Table 7.5 Crude and Adjusted Rates of Cardiac Rehabilitation (CR) Use by State *(cont'd)*

	CR Candidates	CR Rate Unadjusted	CR Rate Adjusted
New Jersey	19,576	10.0%	10.0%
New Mexico	1,991	5.7%	5.7%
New York	36,903	7.8%	7.8%
North Carolina	19,958	7.2%	6.7%
North Dakota	2,202	33.3%	26.5%
Ohio	29,871	12.1%	12.5%
Oklahoma	8,836	4.5%	3.7%
Oregon	3,893	12.4%	9.8%
Pennsylvania	36,457	10.7%	12.0%
Rhode Island	2,440	9.4%	10.4%
South Carolina	8,964	15.9%	15.4%
South Dakota	2,513	38.9%	36.5%
Tennessee	16,473	9.2%	8.5%
Texas	37,397	9.8%	8.9%
Utah	2,654	16.7%	17.3%
Vermont	1,417	11.4%	13.5%
Virginia	14,551	11.5%	11.2%
Washington	7,789	11.0%	10.7%
West Virginia	7,407	9.6%	10.0%
Wisconsin	13,068	26.3%	26.8%
Wyoming	738	19.9%	20.1%

demographic factors associated with lower participation. Prior studies, though substantially smaller in sample size, have reported similarly low rates of CR use and similar trends in gender, race, and age variations (Centers for Disease Control and Prevention 2003; Thomas et al. 1996; Wyer, Joseph, and Earll 2001). For example, a national survey in 1990 estimated that among elderly respondents, only 7% of post-AMI, 10% of post-PCI, and 22% of post-CABG patients participated in CR. The same survey found that females were 40% less likely than males to participate in CR (Thomas et al. 1996). Another survey, conducted in 2001 by telephone, with 65,253 respondents ages 18 years or older from 19 states and the

District of Columbia, found that 26% participated in CR. Rates varied by sex and level of education, with females and low education both associated with lower participation rates. Again, the survey results showed that females were 30% less likely to receive CR (Centers for Disease Control and Prevention 2003).

Our study found that females and non-White beneficiaries were less likely to receive CR than males and White beneficiaries. More importantly, we showed that the interaction of female gender with age was a key predictor of participation in CR. Older women were substantially less likely to receive CR than their male counterparts and younger women, independent of the characteristics of the illness episode, type and number of comorbidities, or socioeconomic and geographic factors. Although we did not address the reasons for this difference, a combination of patient-centered and physician-centered factors may explain this gap. Elderly females are more likely than elderly males to be widowed, be living alone, and have no convenient means of transportation. They may also think that CR is not suitable for them. Physicians may mistakenly believe that older females would not benefit from CR.

Cardiac Rehabilitation Use Varies by Patient Medical Condition

Important predictors of CR use were receiving revascularization procedures (CABG, PCI) and/or a coronary event (AMI), as well as patient stay in an intensive or coronary care unit or a hospital with cardiac catheterization laboratories available. These factors suggest that cardiologists and/or allied health staff have interacted with patients and recommended participation in CR.

Longer lengths of stay during the index hospitalizations and transfers to another acute hospital also were positive predictors of CR use, suggesting that the time a patient spends in a hospital increases the opportunity of an internist, cardiologist, or nurse to inform the patient about the availability and benefits of CR use.

Cardiac Rehabilitation Use Varies by Hospital Characteristics

Patients hospitalized in facilities where coronary laboratory catheterization is available were more likely to receive CR. In addition, patients in hospitals with 160 or fewer beds or in hospitals not affiliated with medical schools were more likely to receive CR than patients in larger hospitals or those in hospitals affiliated with medical schools. The reasons for these findings are not clear. Perhaps the former groups may need CR as a source of revenue for the hospital and/or are better able to obtain the space required for CR programs. Smaller hospitals may enjoy a closer bond with their community and be more committed to a community mission. An additional factor that could be important, but cannot be studied given the available data, was the organizational status of the CR program (whether the program was affiliated with the hospital or a physician practice).

Cardiac Rehabilitation Use Varies by Patient's Residence ZIP Code Characteristics

In a multivariate analysis that included distance to CR, we found that coronary patients in rural and suburban areas were more likely to receive CR than those in urban areas. This finding may indicate that patients feel more comfortable participating in CR in more homogeneous racial, ethnic, cultural, and socioeconomic settings. Area safety and convenient and inexpensive parking may also contribute to the higher use observed in less urbanized areas. Also, physicians in small communities are more likely to know CR program staff and may recommend CR more strongly, they may be the only medical provider responsible for the patient's health, or they may have more time to interact with the patients. Physicians in smaller hospitals may be more proud of their CR programs and perceive them with a sense of ownership. Also, physicians and patients may be located in more stable environments, with lower migration. Patients in more urban areas may be challenged by traffic congestion or public transportation, by receiving care from multiple providers, by physicians with overbooked schedules, and by poor after-discharge follow-up.

Quintiles of socioeconomic indicators of patients' residence ZIP code were remarkably powerful predictors of CR use in crude, unadjusted analyses; however, the prediction power of each of these indicators narrowed considerably when their effects were simultaneously adjusted by multiple covariates. Specifically, unadjusted analyses showed a three- to four-fold difference in CR use between extreme quintiles of income, poverty, education, and disability. Likely, there is correlation among these ZIP code characteristics, so that multivariate analyses divide the effects of 1 factor among other factors. For example, patients in the lowest quintiles of household income and level of education were, in a multivariate analyses, 17% and 25% less likely, respectively, to receive CR than those in the most affluent or educated quintiles. These differences are considerably smaller than in the unadjusted analyses.

Another critical finding of our multivariate analyses is that Medicare and Medicaid dual eligibility, which is the only patient-level indicator of socioeconomic status used in the study, remained an important negative predictor of CR use. Dual-eligible beneficiaries were 66% less likely to use CR than those with Medicare eligibility alone.

Cardiac Rehabilitation Use Varies by Distance of Patient Residence to Nearest Facility

Distance to the nearest CR facility was a predictor of CR use. Travel time seems to be a barrier to participation (Ades et al. 1992). If this is the case, alternatives to conventional CR programs, such as community-based and home-based CR

programs, which seem to be equally safe and effective (Miller, Haskell, Berra, and DeBusk 1984), need to be explored.

Cardiac Rehabilitation Use Varies by Geography

Geographic variations across states remained prominent in multivariate analysis, suggesting differences in patterns of medical care by state. Moreover, regional patterns of CR use were apparent. Much of this geographic variation could not be explained by the characteristics of patients, hospitalizations, hospitals, patients' residence ZIP code, and distance to nearest CR. Rather, as described in the "Results" section, the density of facilities by state was highly correlated with CR use. Therefore, there remains a question as to whether the supply of CR induced demand or vice versa.

We initially thought that states associated with high rates of CR use were simply more health conscious. If this were true, these states would also experience high rates of use of other primary or secondary prevention interventions among elders, such as use of pneumococcal vaccine or use of beta-blockers post-AMI. To test these hypotheses, we obtained from the BRFSS state utilization rates of pneumococcal vaccine and beta-blockers among elders in 1997. The lack of any association between CR rates and the rates of pneumococcal vaccine and beta-blockers use suggests that states with high CR use do not necessarily experience high rates of use of other preventive medical interventions. We also obtained smoking rates among elders in 1997 by state. The lack of any association between CR rates and smoking rates suggests that the elderly population in states with high CR rates is not simply health conscious. In general, caution should be taken when drawing conclusions at the individual level based on ecological data. In this study, however, the ability to control for other characteristics at the same level of aggregation (states) suggests differences among states' differential attitudes about the use of CR by physicians and patients. Because physicians play a key role in persuading patients to use CR, physician attitudes about CR need to be further studied.

Implications for Health Insurers

Automatic and web-based information management and telecommunications referrals are 2 strategies that have been shown to increase CR enrollment. Successful approaches in the north central United States, where enrollment is markedly higher than in other areas of the United States, can be used to guide other regions to improve CR enrollment. Discussions with practitioners from this region demonstrate a collective belief about the importance of CR, shared by physicians and staff of CR facilities, and commitment to refer each patient to a facility that is convenient in time and location, and to ensure the patient follows up with the referral and begins CR.

Raise Awareness of Successful Strategies to Increase Cardiac Rehabilitation Referrals

This study measured enrollment in CR and important predictors for enrollment; however, this study was unable to include some plausible predictors of CR enrollment such as referral to CR or physician and patient's knowledge, perceptions, attitudes, and motivation regarding the benefits of CR. Referral is a prerequisite for CR enrollment. Medicare could promote a literature review of successful strategies for increasing rates of referral to CR at the time of patient discharge from a coronary hospitalization. For example, the use of automatic referrals or web-based technology has proven to be effective in increasing CR enrollment rates and reducing disparities in CR use. In order to measure the rate of referrals to CR in a tertiary hospital that implemented an automated referral system, a random sample of 501 patients from a pool of 1,501 coronary patients discharged was analyzed. Of the sample, 23% were considered ineligible for the study because of the lack of updated contact information or proficiency in English, medical condition, or death. Seventy-one percent of the 384 eligible candidates participated in the survey. The rate of CR was 73% for a CR assessment session and 69% for CR sessions (Grace, Evindar, Kung, Scholey, and Stewart 2004). As an attempt to develop a model for a national program aimed to improve cardiovascular outcomes, the AHA implemented a web-based management tool piloted for 1 year in 24 hospitals in Massachusetts. Based on AHA and American College of Cardiology secondary prevention guidelines, the tool consisted of drop-down reminder screens viewed by physicians prior to patient discharge, providing access to the guidelines and alerts concerning possible omission of CR and other quality indicators. Among patients age 65 or older, the rate of referral to CR increased from 27% to 62% in a 1-year period (LaBresh, Ellrodt, Bliklich, Liljestrand, and Peto 2004). Because these 2 approaches described are based on clinical guidelines, they eliminate potential bias of clinicians in favor of referring patients to CR based on gender, young age, or racial status. Conclusions from a comprehensive literature review of successful interventions for increasing referrals to, participation in, and retention in CR programs can then be shared with acute hospitals and medical providers for consideration for implementation (LaBresh et al. 2004).

Our study found remarkably higher rates of participation in CR in north central states as compared to other regions of the United States. The reasons for this finding need to be examined and used to analyze and guide other states in selecting strategies to increase the use of CR. Attitudes of physicians and patients and the availability of cardiac rehabilitation specialists are among the factors to examine.

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