Appendix on Methods

1. The Geography of Health Care in The United States

1.1 Files Used in the Atlas

The Atlas depends on the integrated use of databases provided by the American Hospital Association (AHA), the American Medical Association, the American Osteopathic Association, and several federal agencies, including the Agency for Health Care Policy and Research, the Bureau of the Census, the Health Care Financing Administration, the National Center for Health Statistics, and the Department of Veterans Affairs. Table 1 lists these files and provides a short description of the uses made of them in the Atlas.

Table 1.

Data Files Used in Analysis

File	Year Used (Sample)	Source / Provider	Description and Use in Analyses
Medicare Files			
Denominator File	1995 & 1996 (100%)	HCFA	Contains one record for each Medicare beneficiary, and includes demographic information (age, sex, race), residence (ZIP Code), program eligibility and mortality. Used to determine denominators for utilization rates and to determine mortality.
MEDPAR File	1995 & 1996 (100%)	HCFA	One record for each hospital stay by Medicare beneficiaries. Includes data on dates of admission / discharge, diagnoses, procedures and Medicare reimbursements to the hospital. Used for (1) allocation of acute care resources and physicians and (2) numerators for utilization rates.
Continuous Medicare History Sample File	1995 (5%)	HCFA	Includes a record for each beneficiary in a 5% sample for each year. Includes summary expenditure data. Used to estimate Medicare spending by program component.
Medicare Provider of Services File	1997	HCFA	Includes a record for each hospital eligible to provide inpatient care through Medicare. Includes location and resource data. Used in measuring acute care resource investments.
Medicare Cost Reports	1994	HCFA	Includes a record for each hospital and provides detailed accounting data for the specified year. Used in measuring acute care resource investments.
Part B Standard Analytical Variable Length File	1995 & 1996 (5%)	HCFA	Includes physician/supplier claims for services paid by the Part B program in 1995b and 96. A majority of services are provided in office, inpatient, outpatient, home, and nursing home settings. Used to measure physician visit rates, and rates of certain diagnostic procedues and preventive services.

TABLE 1. (CONTINUED)

File	Year Used	Source/Provider	Description and Use in Analyses
Resource Files			
American Hospital Association Annual Survey of Hospitals	1996	American Hospital Association	Includes a record for each hospital registered with the AHA. Used in measuring acute care resources (beds, personnel).
Physician File	1995	American Medical Association	Includes one record for each allopathic physician with practice ZIP Code, self-designated specialty, major professional activities, and federal / non-federal status. Used to determine specialty-specific counts of physicians in each health care market.
Osteopath File	1995	American Osteopathic Association	Includes one record for each osteopathic physician with practice ZIP Code, self-designated specialty, major professional activities, and federal / non-federal status. Used to determine specialty-specific counts of physicians in each health care market.
Federal hospital utilization and resources	1993-1994	U.S. Medicine Directory 1993-94 ISSN 0890-6637	Provides location, counts and occupancy rates of federal hospital beds.
VA patient travel pattern file	1989	VA Outcomes Group, White River Jct VA	ZIP Code level patient origin file for veterans using VA hospitals in 1989. Used to allocate VA physicians to appropriate HSAs.
UPIN File	1996	HCFA	Provides unique physician identifier, their primary and secondary specialties and zip code locations of practice, credentials, age, and licensing state. Used in the analysis of physician visit rates.
Other Files			
Geographic Practice Cost Index	1993	HCFA	Records for each MSA and non-MSA area of each state. Records include area-level values for each of the components of the GPCI (physician work, practice cost, malpractice) and summary index value. Used for price adjustment.
National Hospital Discharge Survey	1989	NTIS	Provides age-sex specific hospital discharge rates for the U.S. as a whole, which were used as the basis for the age-sex adjustment of acute care resources.
National Ambulatory Medical Care Survey (NAMCS)	1989-1994	NTIS	Ambulatory services from samples of patient records selected from a national sample of office-based physicians. Allows estimation of age-sex specific use rates by specialty. Used for age-sex adjustment of physician workforce.
Population files	1998	Claritas, Inc., Arlington, VA	1990 STF3 data from the U.S. Bureau of the Census was adapted by Claritas, Inc. to 1997 ZIP Code geography; includes 1998 age-sex specific estimated counts of residents in the ZIP Code. Used (1) for age-sex adjustment, (2) as denominator for rates of allocated and adjusted resources.
ZIP Code boundary files	1997	Geographic Data Technology, Lebanon, NH	Includes records for each ZIP Code with the coordinates of the boundary precisely specified. Used as basis for mapping HSAs and HRRs and for assigning ZIP Codes appropriately.

1.2 Defining Hospital Service Areas

Hospital Service Areas (HSAs) represent local health care markets for community-based inpatient care. The definitions of HSAs used in the 1996 edition of the Atlas were retained in the 1999 edition. HSAs were originally defined in three steps using 1993 provider files and 1992-93 utilization data. First, all acute care hospitals in the 50 states and the District of Columbia were identified from the American Hospital Association Annual Survey of Hospitals and the Medicare Provider of Services files and assigned to a location within a town or city. The list of towns or cities with at least one acute care hospital (N=3,953) defined the maximum number of possible HSAs. Second, all 1992 and 1993 acute care hospitalizations of the Medicare population were analyzed according to ZIP Code to determine the proportion of residents' hospital stays that occurred in each of the 3,953 candidate HSAs. ZIP Codes were initially assigned to the HSA where the greatest proportion (plurality) of residents were hospitalized. Approximately 500 of the candidate HSAs did not qualify as independent HSAs because the plurality of patients resident in those HSAs were hospitalized in other HSAs.

The third step required visual examination of the ZIP Codes used to define each HSA. Maps of ZIP Code boundaries were made using files obtained from Geographic Data Technologies (GDT) and each HSA's component ZIP Codes were examined. In order to achieve contiguity of the component ZIP Codes for each HSA, "island" ZIP Codes were reassigned to the enclosing HSA, and/or HSAs were grouped into larger HSAs (See the Appendix on the Geography of Health Care in the United States for an illustration). Certain ZIP Codes used in the Medicare files were restricted in their use to specific institutions (e.g., a nursing home) or a post office. These "point ZIPs" were assigned to their enclosing ZIP Code based on the ZIP Code boundary map.

This process resulted in the identification of 3,436 HSAs, ranging in total 1996 population from 604 (Turtle Lake, North Dakota) to 3,067,356 (Houston) in the 1999 edition of the Atlas. Thus, the HSA boundaries remained the same but the HSA populations might have changed between the two editions of the Atlas. In

most HSAs, the majority of Medicare hospitalizations occurred in a hospital or hospitals located within the HSA. See the Appendix on the Geography of Health Care in the United States for further details.

1.3 Defining Hospital Referral Regions

Hospital referral regions (HRRs) represent health care markets for tertiary medical care. As defined previously in the 1996 Atlas, each HRR contained at least one HSA that had a hospital or hospitals that performed major cardiovascular procedures and neurosurgery in 1992-93. Three steps were taken to define HRRs.

First, the candidate hospitals and HRRs were identified. A total of 862 hospitals performed at least 10 major cardiovascular procedures (DRGs 103-107) on Medicare enrollees in both years. These hospitals were located within 458 HSAs, thereby defining the maximum number of possible HRRs. Further checks verified that all 458 HSAs included at least one hospital performing the specified major neurosurgical procedures (DRGs 1-3 and 484).

Second, we calculated in each of the 3,436 HSAs in the United States the proportion of major cardiovascular procedures performed in each of the 458 candidate HRRs in 1992-93. Each HSA was then assigned provisionally to the candidate HRR where most patients went for these services.

Third, HSAs were reassigned or further grouped to achieve (a) geographic contiguity, unless major travel routes (e.g., interstate highways) justified separation (this occurred in only two cases, the New Haven, Connecticut, and Elmira, New York, HRRs); (b) a minimum population size of 120,000; and (c) a high localization index. Because of the large number of hospitals providing cardiovascular services in California, several candidate California HRRs met the above criteria but were found to perform small numbers of cardiovascular procedures. These HRRs were further aggregated according to county boundaries to achieve stability of cardiovascular surgery rates within the areas.

The process resulted in the definition of 306 hospital referral regions which ranged in total 1996 population from 126,329 (Minot, North Dakota) to 9,288,694 (Los Angeles) in the 1999 edition of the Atlas. See the Appendix on the Geography of Health Care in the United States for further details.

1.4 Populations of HSAs and HRRs

Total population counts were estimated for residents of all ages in each HSA using either 1995 or 1998 ZIP Code level files obtained from GDT and Claritas, Inc. The Claritas file is based on the latest U.S. Census STF3B ZIP Code file, updated to account for changes in ZIP Code definitions. Population counts for HRRs are the sum of the counts of the constituent HSAs. These serve as denominators for estimating rates for hospital resource (1998) and physician workforce (1995) allocations.

For rates that apply to the Medicare population for the years 1995-96, enrollee counts were obtained from the Medicare Denominator file. The 1995 and 1996 Medicare enrollee population included those alive and age 65 to age 99 on June 30, 1995 and 1996, respectively. For preventive services and physician visit rates, the population above was further restricted to a 5% sample of Medicare enrollees having Medicare part B physician claims for 1995-96, who were selected on the basis of the terminal digits in the Social Security number; for each year, we included only those enrolled in Medicare part B on June 30, 1995 and 1996, respectively. For Medicare reimbursement rates, the Medicare population above was restricted to a 5% sample of 1996 enrollees, selected on the basis of Social Security numbers, belonging to both Medicare A and B programs. For all rates, the numerator and the denominator counts exclude those who were enrolled in risk bearing HMOs on June 30.

2. Medicare Program Reimbursement Rates

The numerators for Medicare reimbursement rates are from the 1996 Continuous Medicare History Sample (CMHS), which documents reimbursements by calendar year for each component of the Medicare program. The data are for a 5% sample of Medicare enrollees selected on the basis of the terminal digits in the Social Security

TABLE 2.

Definitions for Categories of Reimbursement

Category of Reimbursement	For each service, the specified components were selected from the file and summed as indicated. All fields refer to packed-decimal, variable length, EBCDIC, mainframe record layout locations.
All Services	Sum of Individual Services
Professional and Laboratory Services	File: Payment trailer 1. Total Reimb., cols. 11-13 2. Medical line items, cols. 14-15 (TOS=1, 3, Y, Z) 3. Medical Reimb., cols. 19-21 4. Surgical line items, cols. 22-23 (TOS=2, 8) 5. Surgical Reimb., cols. 27-29 6. Lab/X-ray line items, cols. 30-31 (TOS=4, 5) 7. Lab/X-ray Reimb., cols. 35-37 Professional and Lab. reimb. = 3+5+7
Acute Care Hospital Services	File: Short Stay trailer Stays, cols. 6-7 LOS, cols. 10-11 Reimbursement, cols. 20-23 Passthrough amount, cols. 64-67
Outpatient Hospital Services	Outpatient trailer Total bills, cols. 6-7 Total Reimb., cols. 11-13 Outpatient POS bills, cols. 14-15 Outpatient POS Reimb., cols. 19-21 Inpatient POS bills, cols. 22-23 Inpatient POS Reimb., cols. 27-29 Total Reimb. = Outpatient POS Reimb. + Inpatient POS Reimb.
Home Health Care Services	HHA trailer Part A Reimb., cols. 11-13 Part B Reimb., cols. 19-21 Total Reimb. = Part A + Part B

number. The denominator for rates is the corresponding 5% sample of the enrollment file for persons enrolled in both Medicare parts A and B (see Section 1.4).

2.1 Categories of Medicare Reimbursement

Categories of Medicare reimbursement in the Atlas are listed in Table 2 with their definitions from the CHMS file.

2.2 Calculation of Adjusted Medicare Reimbursement Rates

Medicare reimbursement rates were indirectly adjusted for sex, race and age, with the corresponding 1996 Medicare population as the standard, as described in Section 9.1, and were further adjusted for illness, as described in Section 9.2, and regional differences in price, as described in Section 9.3. Total noncapitated Medicare reimbursement rates were computed as the sum of the component rates.

2.3 Precision of the Aggregate Medicare Reimbursement Rates

The precision of the HRR-specific aggregate Medicare reimbursement rates varies according to the population of the HRR but in general, these rates are precisely determined. For all HRRs with at least 12,000 Medicare enrollees, the width of the approximate 95% confidence interval for the reimbursement rate is 20% of the corresponding national rate. For HRRs with a minimum Medicare population of 48,000 enrollees, it is 10% of the national average.

3. Hospital Resources.

Acute care hospital resources consist of hospital beds and personnel. Three tasks were required to estimate the hospital resource rates. First, the resources for each hospital were determined; second, resources were allocated to populations, proportionate to their rates of use; third, rates were computed and adjusted to take into account differences in age, sex and illness among regions.

3.1 Measuring Hospital Resources

Hospitals were eligible for inclusion if they were located within the 50 states or the District of Columbia and were classified either by Medicare or the AHA as short

term general medical and surgical hospitals (AHA service code = 10), specialty hospitals listed as obstetrics and gynecology (code 44), eye, ear, nose and throat (code 45), orthopedic (code 47), or other specialty (code 49); and children's hospitals (codes 50,59). For inclusion in this study, hospitals must have been open on June 30, 1996. Certain specialty hospitals were excluded if additional information gathered from external sources (e.g., telephone calls) indicated they did not meet the inclusion criteria, or if they fell into the following categories: Shriners' hospitals, crippled children's hospitals, hospital units of institutions (prisons, colleges, etc.), institutions for mental retardation, psychiatric facilities, rehabilitation or chronic disease facilities, addiction treatment facilities, communication disorders facilities, podiatry facilities, small surgery centers, obstetrics and gynecology clinics, and hospices. Department of Veterans' Affairs hospitals were excluded from this edition of the Atlas because of the non-comparability of expenditure and personnel data.

The 1996 American Hospital Association Annual Survey file and the Medicare Provider file were searched to identify all non-federal hospitals (AHA control code = 12-33) and federal PHS Indian Service hospitals (control code = 47) that met the criteria for inclusion. Short term general hospitals (N= 4912), children's hospitals (N=48), and specialty hospitals (N=52) located in the 50 states or the District of Columbia as of June 30, 1996 were identified.

The resources for each hospital were determined as follows:

Hospital beds were ascertained primarily from the AHA file. The field selected was "hospital beds (including cribs, pediatric and neonatal bassinets) that were set up and staffed at the end of the reporting period". Our measure of intensive care beds included both "medical/surgical intensive care" and "cardiac intensive care" beds. For the 699 hospitals that were non-reporting in 1996, we used data from the Medicare Cost Reports for "total beds available in the hospital" and "intensive care" plus "coronary care beds" as the measure of intensive care beds. For 37 remaining non-reporting hospitals (including 16 PHS Indian Service hospitals) that also lacked

Cost Report data, AHA data were used to measure all resources, even though the data came from a prior year's Annual Survey. For 27 hospitals lacking both AHA and Cost Report data, Medicare Provider file data were used, supplemented by previous years' AHA and Cost Report data, when available.

Full time equivalent hospital personnel were defined as the sum of full time employees and 1/2 of the part time employees. Hospital employees do not include medical or dental interns or residents or trainees. For the 699 hospitals that were non-reporting in 1996, the Medicare Cost Report value for "average number of employees, hospital total" was used to estimate hospital personnel at these hospitals.

Full time equivalent registered nurses were defined as the sum of full time nurses and 1/2 of the part time nurses. For the 699 hospitals that were non-reporting for 1996, the Medicare Provider of Services file count of "licensed registered nurses" was used to estimate the number of registered nurses at these hospitals.

3.2 Allocation of Hospital Resources

In order to account for the use of care by patients who live in one HSA but obtain care in another, hospital resources for acute care short-term hospitals have been allocated to the HSAs in proportion to the actual patterns of use. This was accomplished using the proportion of all Medicare patient days (1996) provided by each specific hospital to each HSA. For example, if 60% of total Medicare inpatient days at a hospital were used by residents of the HSA where the hospital was located, then 60% of that hospital's resources would be assigned to its HSA. If 20% of the Medicare patient days provided by that hospital were used by a neighboring HSA, 20% of the hospital's resources would be assigned to that neighboring HSA.

Children's hospitals and specialty hospitals were found to have too little actual utilization data in the Medicare files to allow their allocation based on hospital-specific proportionate utilization. These hospitals were allocated according to the utilization patterns of all Medicare enrollees residing in the HSA. In other words, if 80% of the patient days in an HSA were provided by hospitals within the HSA, then 80% of

the resources of any specialty or children's hospital located within that HSA would be assigned to it.

The use of Medicare data to estimate resources allocated to populations of all ages is justified by studies which show that the geographic patterns of use of hospital care by patients under and over sixty-five years of age are similar. Our own analyses of data from both New York and New England revealed that travel patterns for those under age 65 are nearly identical to those over age 65. Radany and Luft (1993) found similar results in California.

Once each of the hospital resources had been allocated to HSAs, the allocated resources were summed. For example, the allocated beds of each HSA were equal to the sum of allocated acute short-term beds and allocated specialty/children's beds. For the HSAs located in a given HRR, resources were further summed to obtain the total for the HRR. Crude rates were then calculated for HRRs using the 1998 population for all ages described in Section 1.4.

3.3 Calculation of Adjusted Per Capita Hospital Resource Rates

The resource allocation rates were adjusted for differences in age and sex, and age, sex and illness using the indirect method as described in Sections 9.1 and 9.2, using the 1998 U.S. population as the standard.

4. Physician Workforce Rates

The methods for allocating and estimating the per capita rates of physicians serving HSAs and HRRs are analogous to the methods used for estimating and allocating hospital resources described in Section 3.2. The sources of information on physicians are the American Medical Association (AMA; January 1, 1996) and the American Osteopathic Association (AOA; June 1, 1996) Physician Masterfiles. These files have been used extensively to study physician supply and are the only comprehensive data available on physician location, specialty and level of effort devoted to clinical practice. Both the AMA and the AOA physician files classify physicians according to self-reported level of effort devoted to clinical practice. In this study, we excluded physicians who reported that they worked the majority of the time in medical teaching, administration or research, and part time physicians working fewer than 20 hours a week in clinical practice. Both files also list ZIP Code fields indicating the physician's primary place of practice, which was complete in more than 90% of records. When this information was not available, we used the physician's preferred professional address to indicate location. Based on these criteria, 495,510 physicians resident in the 50 states and District of Columbia constituted the clinically active physician workforce for 1996. There were also 99,972 physicians in residency or fellowship programs.

4.1 Physician Specialties

The AMA and AOA physician files include the physician's primary self-designated specialty from a list of 243 specialties. We grouped these into the categories in Table 3.

TABLE 3.

Categories of Clinically Active Physicians

Classification of physician specialties and type of utilization used for allocation and age adjustment

Dartmouth Specialty	AMA or AOA Specialty	AMA/AOA Code	Allocation	Age Adjustment
All Physicians	All except Unspecified (Codes US, T)			
Primary Physicians	Adolescent Medicine-GP	AGP	Medical	Family Practice
	Family Practice	FP		
	Geriatrics Medicine (Family Practice)	FPG		
		FSM		
	General Practice	GP		
	Sports Medicine-GP	SGP		
	Internal Medicine-Emergency Medicine	IEM	Medical	Internal Medicine
	Internal Medicine	IM		
	Internal Medicine-Pediatrics	IPD		
	Pediatrics	PD	Medical	Pediatrics
Specialty Physicians	All except Primary Physicians and Unspecified (Codes US, T)			
Anesthesiology	Anesthesiology	AN	Surgical	Surgery
	Cardiothoracic Anesthesiology	CAN		
	Obstetrics Anesthesiology	OBA		
	Pediatric Anesthesiology	PAN		
Cardiology	Cardiology	C	Medical	Cardiology
	Cardiovascular Diseases	CD		
		CVD		
	Cardiac Electrophysiology	ICE		
General Surgery	Abdominal Surgery	AS	Surgical	General Surgery
	Colon and Rectal Surgery	CRS		
	General Surgery	GS		
	Surgery-General	S		
Obstetrics/ Gynecology	Gynecological Oncology	GO	Surgical	Ob/Gyn
	Gynecological Surgery	GS		
	Gynecology	GYN		
	Maternal & Fetal Medicine	MFM		
	Obstetrics & Gynecology	OBG		
	Obstetrics	OBS		
	Obstetrics/Gynecology Surgery	OGS		
	Reproductive Endocrinology	RE		
	Reproductive Endocrinology	REN		
Ophthalmology	Ophthalmology	OPH	Surgical	Ophthalmology

Table 3. (continued)

Dartmouth Specialty	AMA or AOA Specialty	AMA/AOA Code	Allocation
Orthopedic Surgery	Hand Surgery (Ortho Surgery)	HSO	Surgical
	Adult Reconstructive Orthopedics	OAR	
	Pediatric Orthopedics	OP	
	Orthopedics	OR	
	Orthopedic Surgery	ORS	
	Sports Medicine (Orthopedic Surgery)	OSM	
	Orthopedic Surgery - Spine	OSS	
	Orthopedic Trauma	OTR	
Psychiatry	Child Psychiatry	CHP	Medical
	Psychiatry	P	
	Pediatric Psychiatry	PDP	
	Psychoanalysis	PYA	
	Geriatric Psychiatry	PYG	
	Psychosomatic Medicine	PYM	
Radiology	Angiography/Interventional Radiology	ANG	All
	Diagnostic Radiology	DR	
	Diagnostic Ultrasound	DUS	
	Nuclear Medicine	NM	
	Nuclear Radiology	NR	
	Neuroradiology	NRA	
	Pediatric Radiology	PDR	
	Radiology	R	
	Diagnostic Roentgenology	RTD	
Urology	Urological Surgery	U	Surgical
	Urology	URS	

4.2 Allocation of Clinically Active Physicians

Clinically active Physicians were assigned to the HSA of their primary place of practice or preferred professional address. Since physicians, like hospitals, provide services to patients residing outside of the HSA in which their practices are located, the physician workforce was allocated to adjust for patient migration. Unfortunately, allocations could not be based on information about the travel patterns of the patients of individual physicians or information about the use of care outside acute hospitals. For clinically active non-federal physicians (N = 480,761), the adjustments are closely analogous to the method used for hospital resources, with an

important exception. Since the hospital affiliations of the physicians were not determined, the physicians were allocated on the basis of the patterns of inpatient care of all the hospitals located in their HSAs. The 1995-96 MEDPAR records selected for allocation, which depended on the physician's specialty, are given in Table 3. For example, primary physicians were allocated on the basis of medical DRGs. If an HSA had 4 primary care physicians and if 25% of the medical DRG patient days at the local hospital(s) in 1995-96 were for residents of a neighboring HSA, then the four primary physicians would be estimated to contribute 1.0 FTE primary care physician to the neighboring HSA.

We included clinically active federal physicians (N = 14,749) in the study, since these physicians serve populations counted by the U.S. census, such as veterans, residents of Indian reservations, residents of medically underserved areas, and military personnel and their dependents. Federal physicians were assigned to either the Department of Defense/Public Health Service (DoD/PHS) or the Department of Veterans Affairs (VA) in proportion to the mix of staffed federal beds within each HSA (U.S. Medicine; DoD technical document). All federal pediatricians and obstetrician/gynecologists were assigned to the DoD/PHS. DoD/PHS physicians were allocated to HSAs in the same proportion as the non-federal physicians. Since VA utilization data were available that were analogous to the Medicare Part A data, VA physicians were allocated to areas in proportion to VA inpatient utilization (e.g., if 25% of the patient days of VA hospitals in Manhattan were provided to veterans residing in the Bronx, then 25% of the VA physicians in New York were assigned to the Bronx). If no federal inpatient facility (DoD, VAH, PHS, Indian Health Service) was present within the HSA, then the physicians were assumed to represent primary care and were allocated in the same proportion as non-federal primary care physicians (using inpatient medical days).

When all physician specialty groups had been allocated to HSAs, their allocated FTEs were summed. The physicians allocated to an HSA represent the total of all federal and non-federal FTE physicians allocated from local as well as remote HSAs. For the HSAs in a given HRR, physician resources were further summed to obtain

the total for the HRR. Crude rates were then calculated for HRRs using the 1995 population for all ages described in Section 1.4. Measures of physicians in residency training programs used in the Atlas were prepared separately using similar methods. The allocated physician rates were adjusted for age and sex using the indirect method, as described in Section 9.1 using the 1995 U.S. population as the standard.

5. Medicare Hospitalization and Surgical Procedure Rates

Hospitalization rates represent counts of the number of discharges that occurred in a defined time period (the numerator) for a specific population (the denominator). The counts of discharges for specific conditions are based on the MEDPAR files for 1995-96. The denominator is the 1995-96 Medicare enrollee population defined in Section 1.4 that was enrolled in Medicare part A on June 30, 1995 or 1996. In order to ensure that the events counted in the numerator correspond to the denominator population, certain records were excluded, including MEDPAR records with a length of stay over 365 days; hospitalizations in psychiatric, rehabilitation or long term care units (provider codes = S, T, U or V; facility type not equal to S; third digit of Medicare provider number not equal to 0); records where an HMO paid the provider (MEDPAR GHO paid code 1).

5.1 Procedures and Conditions Examined in the Atlas

The specific procedures and conditions, or "numerator events", and the codes used to identify the event in the file are given in Table 4. The "modified diagnosis-related group" (M-DRG) Classification System used in Chapter Three to examine the pattern of variation in hospitalizations among the Medicare population is given in Table 5. "Ambulatory Care Sensitive Conditions" refer to hospitalizations, such as asthma, pneumonia, chronic pulmonary obstructive disease and congestive heart failure, that are preventable when access to primary care is adequate, and are defined in Table 6.

TABLE 4.

Conditions and Procedures	Codes Used to Define Conditions and Procedures[1]
All Discharges	
Inhospital Deaths	(Discharge status = 'B')
Medical Discharges	
Low/moderate variation medical	DRGs 174, 175, 14, 121-123
High variation medical	DRGs 9-13, 15-35, 43-48, 64-74, 78-102, 124-145, 172-173, 176-190, 202-208, 235-256, 271-284, 294-301, 316-333, 346-352, 366-369, 372, 373, 376, 378-391, 395-399, 403-405, 409-414, 416-423, 425-437, 444-457, 460, 462-467, 473, 475, 487, 489, 490, 492
Surgical Discharges	DRGs 1-8, 36-42, 49-63, 75-77, 103-108, 110-120, 146-171, 191-201, 209-234, 257-270, 285-293, 302-315, 334-345, 353-365, 370, 371, 377, 392-394, 400-402, 406-408, 415, 424, 439-443, 458, 459, 461, 468, 471-472, 476-486, 488, 491, 493, 494, 495
General Surgery	
cholecystectomy	Procedure code 51.2-51.23
resection for colorectal cancer	Procedure code 45.7-45.79, 45.8, 48.5, 48.6-48.69 and Diagnosis code 153-153.9, 154-154.1
mastectomy for cancer[f]	Procedure code 85.41, 85.43, 85.45, 85.47 and Diagnosis code 174-174.9 (but not 233.0)
partial mastectomy[f]	Procedure code 85.20 - 85.23 and Diagnosis code 174-174.9, not (233.0)
Vascular Surgery	
carotid endarterectomy	Procedure code 38.12
abdominal aortic aneurysm repair	Procedure code 38.44, 39.25 and Diagnosis code 441.3-441.9
lower extremity revascularization	Procedure code 39.25, 39.29 and Diagnosis codes not = 441.3-441.9
major leg amputation	Procedure code 84.15-84.17
Cardiothoracic Surgery	
Coronary artery bypass surgery	Procedure code 36.10-36.19
aortic / mitral valve replacement	Procedure code 35.20-35.24
lung resection	Procedure code 32.29-32.5 and Diagnosis code 162-162.9
PTCA	Procedure code 36.01, 36.02, 36.05
coronary angiography	Procedure code 37.22, 37.23, 88.55-88.57
Urology	
radical prostatectomy[m]	Procedure code 60.5
TURP for BPH[m]	Procedure code 60.2 and Diagnosis code (1-5) = 600-601.4, 601.8, 601.9, 602-602.1, 602.3, 602.8, 602.9, 788.2-788.29
radical nephrectomy	Procedure code 55.5-55.51 and Diagnosis code 189-189.1

TABLE 4. (CONTINUED)

Conditions and Procedures	Codes Used to Define Conditions and Procedures(1)
Orthopedic Surgery	
back surgery	Procedure code 03.0, 03.1, 03.2, 03.32, 03.39, 03.4, 03.5, 03.6, 03.93, 03.94, 03.96, 80.5-80.59, 81.0-81.09
hip replacement	Procedure code 81.51 and Diagnosis codes not = (820-821.39, 996.0-996.99)
knee replacement	Procedure code 81.54
hip fracture repair (by type) for*	
a) femoral neck fracture	Diagnosis code 820-820.19, 820.8-820.9 and
- total hip replacement	-Procedure code 81.51
- partial hip replacement	-Procedure code 81.52
- internal fixation	-Procedure code 78.55, 79.10, 79.15, 79.30, 79.35
- other treatment-	-None of the above procedure codes
b) other hip fracture	Diagnosis code 820.2-820.32 and
- total hip replacement	-Procedure code 81.51
- partial hip replacement	-Procedure code 81.52
- internal fixation	-Procedure code 78.55, 79.10, 79.15, 79.30, 79.35
- other treatment	-None of the above procedure codes
Fractures	
Hip	Primary diagnosis code 820-820.9
Shaft of femur	Primary diagnosis code 821-821.39
Patella	Primary diagnosis code 822.0-822.1
Tibia	Primary diagnosis code 823-823.92
Ankle	Primary diagnosis code 824-824.9
Foot	Primary diagnosis code 825-825.29
Proximal humerus	Primary diagnosis code 812-812.19
Elbow	Primary diagnosis code 812.4-812.59
Radius/ulna	Primary diagnosis code 813-813.93
Distal radius/ulna	Primary diagnosis code 813.4-813.55
Radius/ulna/wrist	Primary diagnosis code 813-813.93, 814-814.19
Diagnostic Procedures	
Carotid duplex	CPT code 93875-93888
Cardiac cathererization	CPT code 93510-93529, 93539, 93540, 93545

*Records were excluded if codes were present which indicated malunion or nonunion of fracture, aseptic necrosis of the hip, evidence of old fractures, or cancer in bone.

NOTES:
1. Unless otherwise specified, all codes are ICD-9-CM; up to 10 diagnoses and 6 procedures were coded on 1994-95 MEDPAR records, and all fields were searched for the presence of the conditions specified. CPT refers to Current Procedure Terminology codes used for the reporting of physician procedures and services on Medicare Part B data.
2. (f) refers to procedures for which counts of women served as the denominator; (m) refers to procedures for which counts of men served as the denominator.

TABLE 5.

MDRG	DRG Description	DRGs
Nervous System		
1	Craniotomy, Other Cranial and Nervous System Procedures	1-4, 7-8, 484
2	Extracranial Vascular Procedures (Carotid Endarterectomy)	5
3	Specific Cerebrovascular Disorders Except TIA	14
4	Transient Ischemic Attack (TIA)	15
5	Seizure and Headache	24-26
6	Coma and Concussion	27-33
7	Residual Nervous System Diagnoses	9-13, 16-23, 34-35
Eye		
8	Eye Procedures	36-42
112	Eye Diagnoses	43-48
Ear, Nose and Throat		
9	Tonsillectomy and/or Adenoidectomy	57-60
10	Sinus Procedures	53-55
11	Residual Ear-Nose-Throat Procedures	49-52, 56, 61-63, 168-169, 185-187
12	Ear-Nose-Throat Diagnoses	64-74
Respiratory System		
13	Major Chest and Other Respiratory Procedures	75-77
14	Respiratory Neoplasms	82
15	Pleural Effusion and Respiratory Failure	85-87
16	Adult Respiratory Infections	79-80
109	Adult Simple Pneumonia	89-90
17	Pediatric Respiratory Infections and Pneumonia	81, 91
18	Chronic Obstructive Pulmonary Disease	88
19	Adult Bronchitis and Asthma	96-97
20	Pediatric Bronchitis and Asthma	98
21	Residual Respiratory Diagnoses	78, 83-84, 92-95, 99-102
Circulatory System		
22	Valve Procedures Other Than CABG	104-105
23	Coronary Artery Bypass Graft	106-107
110	Other Heart Procedures	108
24	Major Vascular Procedures	110-111, 478-479
25	Vascular Procedures Other Than Major (PTCA)	112
26	Cardiac Pacemaker Procedures	115-118
27	Residual Circulatory System Procedures	109, 113-114, 119-120
28	Acute Myocardial Infarction	121-123
29	Cardiac Catheterization Except for AMI	124-125
30	Heart Failure and Shock (Congestive Heart Failure)	127
31	Peripheral Vascular Disorders	130-131

TABLE 5. (CONTINUED)

MDRG	DRG Description	DRGs
Circulatory System, Continued		
32	Cardiac Arrhythmia	138-139
33	Angina Pectoris	140
34	Syncope and Collapse	141-142
35	Chest Pain	143
36	Residual Circulatory System Diagnoses	126, 129, 132-137, 144-145
111	Deep Vein Thrombosis	128
Digestive System		
37	Major Small and Large Bowel Procedures	146-149
38	Stomach, Esophageal and Duodenal Procedures	154-156
39	Anal Procedures	157-158, 267
40	Inguinal and Femoral Hernia Procedures	159-163
41	Appendectomy	164-167
42	Residual Digestive System Procedures	150-153, 170-171
43	Gastro-Intestinal Hemorrhage	174-175
44	Gastro-Intestinal Obstruction	180-181
45	Adult Gastroenteritis	182-183
46	Pediatric Gastroenteritis	184
47	Residual Digestive System Diagnoses	172-173, 176-179, 188-190
Hepatobiliary System		
48	Cholecystectomy	195-198, 493, 494
49	Other Hepatobiliary Procedures	191-194, 199-201
50	Biliary Tract Disorders	207-208
51	Other Hepatobiliary System Diagnoses	202-206
Musculoskeletal and Connective Tissue		
52	Major Joint Procedures	209, 471
53	Hip and Femur Procedures Other Than Major Joint	210-211
54	Back and Neck Procedures	214-215
55	Lower Extremity Procedures	218-219
56	Knee Procedures	221-222
57	Upper Extremity Procedures	223-224, 491
58	Residual Musculoskeletal Procedures	6, 212-213, 216-217, 220, 225-234
59	Hip, Femur, Pelvis Fracture	235-236
60	Medical Back Problems	243
61	Misc. Fracture/Sprain/Strain/Dislocation	250-255
62	Residual Musculoskeletal Diagnoses	237-242, 244-249, 256
Skin, Subcutaneous Tissue and Breast		
63	Total and Subtotal Mastectomy	257-260
64	Other Skin/Tissue/Breast Procedures	261-266, 268-270
65	Cellulitis	277-279
66	Other Skin/Tissue/Breast Diagnoses	271-276, 280-284

TABLE 5. (CONTINUED)

MDRG	DRG Description	DRGs
Endocrine, Nutritional and Metabolic		
67	Endocrine/Nutritional/Metabolic Procedures	285-293
68	Diabetes Age >=35	294
69	Adult Nutritional and Metabolic Disorders	296-297
70	Pediatric Nutritional and Metabolic Disorders	298
71	Residual Endocrine/Nutrional/Metabolic Diagnoses	295, 299-301
Kidney and Urinary System / Male Reproductive System		
72	Major Genito-Urinary Procedures	302-307, 334-335
73	Transurethral Prostatectomy	336-337
74	Transurethral Procedures Except TURP	310-311
75	Major Genito-Urinary Procedures	308-309, 312-315, 338-345
76	Kidney-Urinary Tract Infections	320-321
77	Urinary Tract Stones	323-324
78	Residual Kidney/Urinary System Diagnoses	316-319, 322, 325-333
79	Male Reproductive System Diagnoses	346-352
Female Reproductive System		
80	Uterus and Adnexa Procedures for Non-Malignant Conditions	358-359
81	Female Reproductive System Reconstructive Procedures	356
82	Residual Female Reproductive System Procedures	353-355, 357, 360-365
83	Female Reproductive System Diagnoses	366-369
Pregnancy-Related		
84	Cesarean Delivery	370-371
85	Vaginal Delivery	372-375
86	Pregnancy Not Delivered	376-384
Newborns and Neonates		
87	Newborns and Neonates	385-391
Blood and Blood Forming Organs		
88	Diagnoses of Blood and Blood Forming Organs	395-399
Myeloproliferative Diseases		
89	Chemotherapy	410, 492
90	Myeloproliferative/Lymphoma/Leukemia Diagnoses Other Than Chemotherapy	403-405, 409, 411-414
Infectious and Parasitic Diseases		
91	Septicemia	416
92	Adult Viral Disease and Fever of Unknown Origin	419-421
93	Pediatric Viral Disease and Fever of Unknown Origin	422
94	Residual Infectious and Parasitic Diseases	417-418, 423, 489-490
Mental Diseases and Disorders		
95	Psychoses	430
96	Other Mental Diseases and Disorders	425-429, 431-432

TABLE 5. (CONTINUED)

MDRG	DRG Description	DRGs
Substance Use		
97	Substance Use Treatment, Left Against Medical Advice	433
98	Substance Use Detoxification (w/o Rehab)	434-435
99	Substance Use Rehabilitation (with or w/o Detox)	436-437
Injuries and Adverse Effects		
100	Operating Room Procedures for Injuries	439-443
101	Toxic Effects of Drugs	449-450
102	Other Injury Diagnoses w/o Procedure	444-448, 451-457, 487
Health Status Factors		
103	Rehabilitation (Other Than for Substance Abuse)	462
104	Other Health Status Diagnoses	463-467
Residual MDRGs		
105	Unrelated Operating Room Procedures	468
106	Respiratory Disease with Ventilator	475
107	Residual O.R. Procedures with Case Mix Index >=3.0	103, 392, 415, 458, 472-474, 480-483, 485-486, 488
108	Residual O.R. Procedures with Case Mix Index <3.0	393-394, 400-402, 406-408, 424, 459-461

TABLE 6 – AMBULATORY CARE-SENSITIVE CONDITIONS

CONDITION	ICD – 9 – CM CODES
Convulsions	780.3
Chronic obstructive pulmonary disease	491, 492, 494, 496, 466.0 Acute bronchitis (466.0) only with secondary diagnosis of 491, 492, 494, 496
Bacterial pneumonia	481, 482.2, 482.3, 482.9, 483, 485, 486 Excluding cases with secondary diagnosis of sickle cell (282.6)
Asthma	493
Congestive heart failure	428, 402.01, 402.11, 402.91, 518.4 Excluding cases with the following surgical procedures: 36.01, 36.02, 36.05, 36.1, 37.5, or 37.7
Hypertension	401.0, 401.9, 402.00, 402.10, 402.90 Excluding cases with the following surgical procedures: 36.01, 36.02, 36.05, 36.1, 37.5, or 37.7
Angina	411.1, 411.8, 413 Excluding cases with a surgical procedure (01-86.99)
Cellulitis	681, 682, 683, 686 Excluding cases with a surgical procedure (01-86.99), except incision of skin and subcutaneous tissue (86.0) where it is the only listed surgical procedure
Diabetes	250.0 250.1, 250.2, 250.3, 250.8, 250.9
Gastroenteritis	558.9
Kidney/urinary infection	590, 599.0, 599.9
Dehydration – volume depletion	276.5

5.2 Surgical Procedure Rates

The rates of inpatient surgery in Chapter Five are based on the MEDPAR files for 1995 and 1996. The denominators are the 1995-96 Medicare enrollee population described in Section 1.4, with the same restrictions as for utilization rates above. The procedure codes used in the MEDPAR file are based on the International Classification of Disease, ICD-9-CM. Selection of procedure codes was based on review of the literature and/or consultation with clinical experts. The rates of carotid duplex diagnostic procedures and cardiac catheterization are derived from Medicare part B data and are described in Section 6. Some rates were suppressed for reasons of data confidentiality. Suppression rules meet current HCFA standards. rates with fewer than 26 expected events were suppressed for reasons of statistical precision.

5.3 Adjusted Procedure and Utilization Rates

Utilization rates were adjusted using the indirect method for age, sex and race, and further adjusted for illness using the corresponding 1995-96 national Medicare population as the standard, as described in Section 9.1 and 9.2. Surgical procedure rates were similarly adjusted, except that sex-specific population estimates were used for prostate and breast procedures. Although the majority of events occurred at most once per person during the study period, we included multiple events to the same person to allow the rates to reflect total health care utilization.

Although standard errors of the rates were not reported, these estimates are, for the most part, precisely determined. The minimum Medicare population in an HRR is 14,497 residents in Boulder, CO. The following precisions were obtained in the smallest HRR (the "worst case scenario") for an event rate of 5 per 1,000:

- For procedures related exclusively to males or females in this smallest HRR, the precision would be ±16% of the true rate.
- For procedures related to the entire HRR, the precision would be ±12%.
- For procedures in a median-sized HRR (N=64,000) the precision would be ±6%.

In general, if we denote the event rate as p and the population size as N, the stan-

dard error is (p/N)^0.5 and the precision, expressed as a percent of the true rate, is (s.e.(p)/p)*100%.

6. Preventive Services and Continuity of Care

Preventive service rates are counts of Medicare enrollees receiving at least one medical service of a particular type divided by the target Medicare population. The data were derived from Medicare part B physician claims files for 1995-96 for a 5% sample of Medicare enrollees (see Section 1.4). Mammography rates were computed for women age 65 to 69; eye examinations, HgbA1c and LDL blood lipid monitoring were computed for diabetics. Diabetics were defined as enrollees with two outpatient evaluation and management visits or one inpatient visit, with a diagnosis of diabetes (see the Endnote). We counted the number of people obtaining these services at least once in any year and then computed the average annual rate after combining years, as described in Section 9.1 and 9.2. The preventive services examined in the Atlas for Medicare enrollees are defined in Table 7 and are based on HEDIS recommendations (see the Endnote).

TABLE 7 – PREVENTIVE SERVICES

Preventive Services CPT Codes	
Pneumococcal Immunization	90732
Mammogram	76090-76092
Occult Blood Test	82270
Sigmoidoscopy	45300-45320,45330-45336,45338-45339
Eye Exam	92002,92004,92012,92014,92018,92019,9222,92226,92235,92250
HgbAlc	83036
Blood Lipids	83715-83721,80061

NOTE:
CPT refers to Current Procedure Terminology codes used for the reporting of physician procedures and services on Medicare Part B data.

Access to care is defined as the percent of Medicare enrollees who had one or more visits to a physician in 1996. Continuity of care was defined as the percent of Medicare patients who received at least 50% of their ambulatory care visits from one provider in 1996. Ambulatory visits are those whose place of service was a physician office, patient home, hospital outpatient setting, hospital emergency room, or rural health clinic. Physician visits were defined as those that were for the purpose of evaluation and management only, not including pathology, and were based on BETOS codes (see the Endnote). The data and Medicare enrollee populations are as defined above.

The rates of carotid duplex diagnostic procedures and cardiac catheterizations are derived from the Medicare part B physician claims files for 1995-96 using the population described above. The codes for these procedures are listed in Table 4.

7. Quality of Care in the Last Six Months of Life

For all rates pertaining to the last six months of life, the denominator was the 18 month 1995-96 deceased Medicare population, defined as the Medicare enrollee population who died between July 1, 1995 and December 31, 1996 (see Section 1.4). Percent of Medicare deaths occurring in a hospital was computed using as numerator event, death in a hospital (discharge status='B' in MEDPAR file). For the percent of Medicare deaths who were admitted to the ICU in the last 6 months of life, the numerator event was death in a hospital with admission to an ICU within 6 months of the death date using MEDPAR files. Rates were age, sex, and race adjusted as described in Section 9.1 and were expressed as a percentage of deaths.

Average days in the hospital, average days in the ICU and average reimbursements for inpatient care per capita were computed using only the portion of the event (hospital stay or ICU stay) falling within the 6 month period prior to death. Rates were age, sex and race adjusted as described in Section 9.1. Inpatient reimbursement rates were also price adjusted as described in Section 9.3.

Number of physician visits during the last six months of life were computed for physician visits with any place of service, that were for the purpose of evaluation and management only, not including pathology, and were based on BETOS codes. The number of physicians seen in the last six months of life was computed based on linkage with the Medicare Physician Identification Master File (UPIN) For both these measures, data were derived from Medicare part B files, as described in Section 6, and the population was the 18 month 1995-96 deceased Medicare population, as defined above, that was enrolled in Medicare part B in the month of death and belonged to the 5% sample of Medicare part B physician claims files for 1995-96.

8. The Medicare Current Beneficiary Survey (MCBS)

Chapter Three considers the correspondence among hospital bed capacity, utilization and self-reported health. This issue was also addressed by Ashby et al (1986) who found that states with higher Medicare expenditures also had lower levels of self-reported health. We turned to the Medicare Current Beneficiary Survey (MCBS) to reexamine this issue.

The MCBS is a continuous multi-purpose survey of a representative sample of the entire Medicare population, with oversampling of the old-old, the disabled, those living in institutional settings (HCFA, 1992). Survey participants complete three rounds of surveys each year throughout their participation in the study. The sample was drawn from 107 primary sampling units (PSU) consisting of counties or groups of counties intended to be representative of the U.S. Within those PSUs, sampling was further restricted to certain geographic areas (sub-PSUs, N = 1163), based on the ZIP Code of residence of the beneficiary, again with the goal of maintaining representativeness while economizing on interviewer travel. Beneficiaries within each area were then sampled randomly within age strata, with oversampling of the disabled under age 65 and the oldest beneficiaries (age 85 and over).

Participants are interviewed three times each year, wherever they reside and with the interview tailored to reflect the setting and using proxy respondents where necessary.

Survey items include a core of data that are repeated at each subsequent interview on utilization, charges and payments for health care and a supplement that focuses on other domains. Critical to this analysis is the Supplement on Access and Satisfaction, which was carried out on Round 1 (Fall 1991) and is repeated annually thereafter (Rounds 4, 7, 10 etc.). In addition to data on access and satisfaction, this supplement includes detailed questions on self-assessed health status, current health conditions and physical function.

The study population for this analysis (N=8860) was created by taking Round 4 of the 1992 wave of the MCBS and excluding persons under age 65, those who were institutionalized and answered questions by proxy, and those enrolled in risk-bearing HMOs. We matched each individual with his or her 1993 Medicare claims data on health care utilization and appended regional-level information about health resources from the Atlas database. This made it possible for us to measure health characteristics of people who live in regions with relatively high, and relatively low, levels of hospital beds or Medicare spending.

Individuals' total 1993 hospital days were summed and hospital days per capita were computed by self-reported health status (poor, fair, good, very good, and excellent). To assess the dependence on hospital resources, they were also computed separately by hospital bed supply in the region (above vs. below the median). These were indirectly standardized by age and sex using the 1993 Medicare population as the standard, as described in Section 9.1.

To compute the expected number of hospital days as predicted by self-reported health status, according to quintile of hospital beds, we used regression analysis to predict hospital days based on self-reported health, age and sex in each quintile of hospital beds. Quintiles (20th percentiles) were computed by taking (weighted) intervals of the sorted data for MCBS respondents and ranged from the lowest quintile with the fewest hospital beds to the highest quintile with the most hospital beds.

9. Calculation of Adjusted Rates

9.1 Calculation of Age, Sex and Race Adjusted Rates

Medicare procedure, condition, preventive services and reimbursement rates were adjusted using the indirect method for the following strata: sex, race (black, non-black) and age (65-69, 70-74, 75-79, 80-84, 85-99). The standard population for reimbursement rates was the 1996 Medicare population, and for procedure, condition, and preventive services rates, the 1995-96 Medicare population corresponding to the numerator (see Section 1.4). The expected counts within HSAs were computed as weighted averages of the stratum-specific crude rates in the standard population and were obtained using weighted least squares regression, weighting by the stratum-specific population. Observed and expected counts at the HSA level were summed to the HRR level. Procedures, counts and preventive services were obtained separately for each year and summed across years before summing to the HRR level. Indirectly standardized rates for HRRs were then computed from observed and expected counts (Breslow and Day, 1987).

This procedure was slightly modified for hospital resource and physician workforce rates. The hospital resource rates were adjusted for differences in age and sex using the indirect method using the 1998 U.S. population as the standard. Since the national age-sex specific bed supply rates are not obtainable, these were estimated using the national age-sex specific patient day rates obtained from the 1989 National Hospital Discharge Survey. These estimates were used to calculate the expected bed supply in each HSA and HRR. Under the assumption that employee allocations across age and sex groups are also proportionate to patient days, a similar strategy was used to adjust employees.

The allocated physician rates were adjusted for age and sex using the indirect method using the 1995 U.S. population as a standard. As with hospital bed supply rates, the national age-sex specific physician workforce rates are not known. These were estimated using outpatient age, sex and specialty specific physician visit rates from the combined 1989-1994 National Ambulatory Care Survey (NAMCS). These estimates were used to calculate the expected physician supply in each HSA,

by specialty. Specialties that had too few visits to reliably estimate age-sex specific visit rates (< 800 total NAMCS) used the visit rates of allied specialties, as indicated in Table 3. Four NAMCS specialty categories could not be age and sex adjusted because of the low frequency of ambulatory visits and the lack of allied specialties: pathology, radiology, critical care and "unspecified". Expected counts of resident physicians were prepared separately using similar methods. The expected counts were summed to the HRR level and were used to calculate indirectly standardized rates. Rates for combined generalists, combined specialists and combined total physicians were obtained by first summing expected counts of the component specialties to the HRR level.

9.2 Calculation of Illness Adjusted Rates

Rates published in the Atlas were further adjusted for the Medicare population illness characteristics. The measures of illness used were the 1995 and 1996 HSA age-sex-race stratum specific mortality and incidence rates for five conditions. The conditions selected consisted of specific events for which hospitalization is a proxy for the incidence of disease: hospitalizations for hip fracture, cancer of the colon or lung treated surgically, gastro-intestinal hemorrhage, acute myocardial infarction or stroke (Wennberg, NEJM 1984; Wennberg, Lancet 1987; see the Endnote).

For procedures, conditions and reimbursements, we obtained age-sex-race-illness adjusted rates using regression methods as follows. For each outcome, we regressed the crude HSA stratum-specific rate against age, sex, race and all higher order interactions as well as the crude HSA age-sex-race specific illness rates, for each year separately, weighting by the HSA stratum Medicare population. The resulting expected counts and dollars were summed across years and across strata to the HSA level. The observed and expected counts were then summed to the HRR level and used to calculate age-sex-race-illness standardized rates using the usual formula for indirectly standardized rates (Breslow and Day, 1987; see the Endnote).

This procedure was modified for hospital resource and physician workforce rates. Here, we first obtained HSA-level age-sex adjusted rates, as described in Section 9.1.

These rates were then regressed against the age-sex-race adjusted HSA mortality and incidence rates of the five conditions above, weighting by the HSA Medicare population, to produce predicted physician and resource rates for each HSA. The expected counts were obtained from the predicted rates, corrected for bias so that the sum of the observed and expected counts were equal, and then used in the usual formula for indirect standardization. This technique was used because of the lack of information on stratum-specific national resource and physician counts. The estimated rates correlated very highly with the usual regression-based rates for variables where this information was obtainable.

9.3 Calculation of Price Adjusted Rates

Medicare program expenditure rates were further adjusted to account for regional differences in price. Two different price adjustors were used, depending on the category of Medicare spending, the Dartmouth Price Index and the HCFA Part B Index, both of which are based on the Geographic Practice Cost Index (GPCI) developed by Zuckerman, Welch, and Pope (1990) (see the Endnote). These price indexes are described below.

Dartmouth (Modified GPCI) Price Index. Seeking to avoid a price adjustment that depended on physician or hospital market conditions, we focused on cost of living indices using non-medical regional price measures. We relied on the Geographic Practice Cost Index (GPCI) applicable to fiscal year 1995 Medicare physician claims. The index is the weighted sum of three components: the relative cost of non-physician professional labor across areas, the relative cost of physician practice inputs (principally rents and wages to office employees) and the relative cost of malpractice. The weights are based on the national proportions of these costs in physician services. We re-weighted the index, excluding the malpractice costs. We also used the full professional labor component in our revised index (HCFA used only one-quarter of the professional labor component). While not perfectly exogenous to health care (as it includes physician office expenses), this modified GPCI index is both available at the level of geographic analysis needed in this study, and is preferable to the major alternative, Medicare's hospital wage index. (The hospi-

tal wage index is based on actual wages paid to hospital employees in each area and is thus distorted by differences in occupational mix and market conditions. Hospitals that hire more highly paid staff have those costs reflected in the wage index.) The Dartmouth index was available for each metropolitan statistical area (MSA) and for non-MSA areas of each state. The values for the area-specific modified GPCI were assigned to each HSA according to the location of the principal city or town of each HSA.

HCFA Part B Index. Because Medicare Part B payments compensate for only one-quarter of the difference in professional wage adjustments across areas and include an adjustment for malpractice insurance costs, these adjustments were made in reverse to recover the original value of the Part B billings.

For both indexes, HRR-level modified GPCIs were calculated as weighted sums of the HSA-specific indexes, using the number of Medicare enrollees in the HSA as the weight. The Dartmouth Price Index was used to adjust all components of Medicare expenditures except professional and laboratory services. This latter component was adjusted using the HCFA Part B regional price measure.

To implement the adjustment, each component of the Medicare program was first either age-sex-race adjusted or age-sex-race-illness adjusted at the HSA level. Observed and expected dollars were then summed to the HRR level and indirectly standardized rates were computed. HRR-specific Medicare expenditure rates were then divided by the index for that HRR to adjust for regional differences in price.

9.4 Predicted Rates

Predicted rates were computed as the expected counts or dollars in an area divided by the corresponding HSA or HRR population count (see Section 1.4). These were used to measure the rate that would have been observed if age, sex and race or age, sex, race and illness alone determined the variations in that outcome.

10. Measures of Variation and Association

10.1 The Distribution Graph

The distribution graphs used in the Atlas provide a simple way to show the dispersion in particular rates of health care resources and utilization across the 306 hospital referral regions. For example, Figure 2.2 shows the distribution of hospital employees per thousand residents for each of the 306 hospital referral regions. The vertical axis shows the rate of hospital employees per thousand residents. The Bronx, which had 25.7 employees per thousand residents, is represented by the highest point on the graph. Hattiesburg, Mississippi, which had 19.34 employees per 1,000 residents, and Bismarck, North Dakota, which had 19.26 employees per 1,000 residents, are represented by two points that are side by side on the graph. Areas which did not have exactly the same number of hospital employees per thousand residents are arrayed on a single line because their rates fall into a "bin" between two values.

This chart summarizes two features of the data. The first is a measure of dispersion; if the number of employees per thousand (or whatever measure is on the vertical axis) for the highest hospital referral region is two or three times higher than the number of employees per thousand for the lowest hospital referral region, it suggests substantial variation in health care resources. Second, the distribution graph shows whether the variation is caused by just a few outliers — hospital referral regions that for various reasons are very different from the rest of the country — or whether the variation is pervasive and widespread across the country. In the example above, there is widespread dispersion across the country, but one area, the Bronx, does stand apart from all other areas.

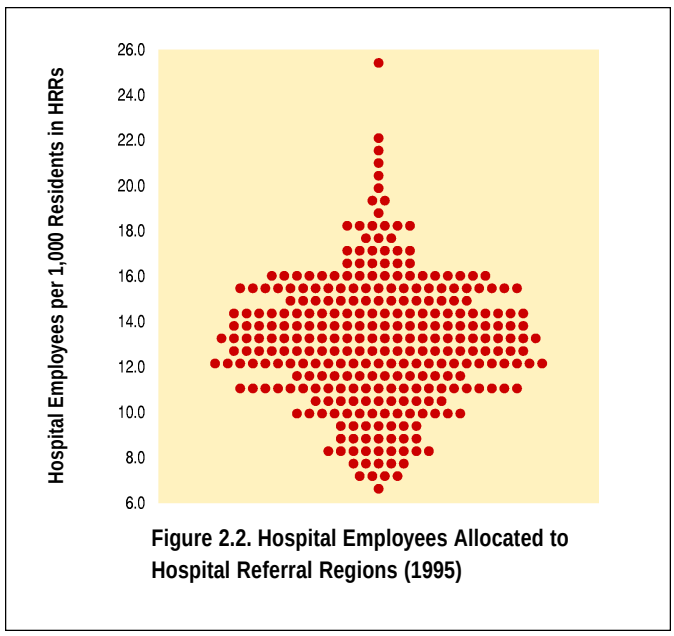

Figure 2.2. Hospital Employees Allocated to Hospital Referral Regions (1995)

10.2 Measures of Association (R^2 and Regression Lines)

In this Atlas, we often suggest that some factors may be related in a systematic way to other factors. For example, in Chapter Three we hypothesize that regions with high rates of beds per thousand residents also have high rates of hospitalization for medical conditions. To capture the degree and extent of the association between hospital beds and medical hospitalizations in Figure 3.5, we put hospital beds per thousand residents on the horizontal axis and hospitalization rates per thousand residents on the vertical axis, and placed a point on the graph for each of the 306 hospital referral regions. If hospital beds and hospitalization rates were negatively correlated, so that regions with higher beds per thousand residents had lower per capita expenditures, then we might expect to see the cloud of points tilted downward, running from northwest to southeast. Conversely, if they were positively correlated — as they in fact are — the cloud of points would run from southwest to northeast on the graph, as seen in Figure 3.5.

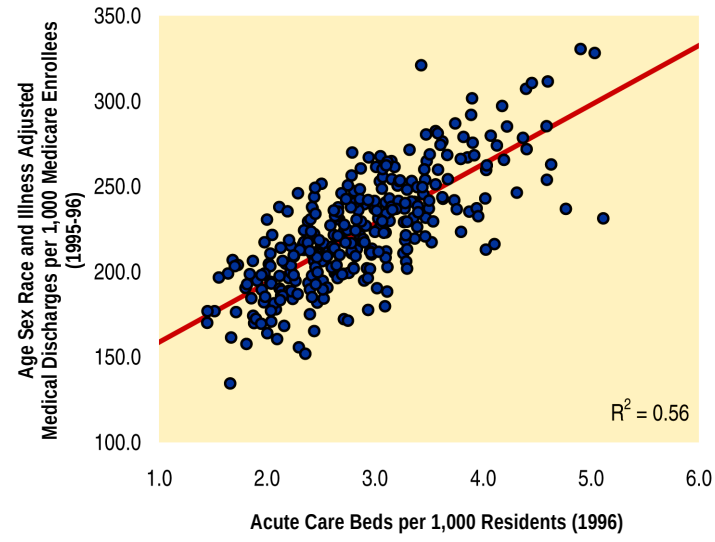

Figure 3.5. The Association Between Hospital Beds per 1,000 Residents and Age, Sex, Race and Illness Adjusted Hospitalization Rates for Medical Conditions per 1,000 Medicare Enrollees

It is sometimes difficult to discern from this cloud of points the relationship between two variables. A linear regression line provides the best fit of the data and summarizes the relationships between them. A measure of the "goodness of fit" or the extent to which hospital beds per 1,000 predicts hospitalizations per 1000 residents is R^2, which is defined as the proportion of total variation in the vertical axis (hospitalizations) that is explained by variation in the horizontal axis (beds). It ranges from 0 to 1, where 1 is perfect correlation and 0 means that the two variables are completely unrelated. In Figure 3.5, the R^2 for the relationship between medical hospitalizations and hospital beds is 0.56, which means that the two are closely related — that 56% of the variation in medical hospitalizations per 1000 residents is related to the bed supply.

The regression lines and R^2 statistics given in the text are not weighted for the size of the population. Weighted and unweighted R^2 statistics were similar.

10.3 Index of Variation: the SCV

The Systematic Component of Variation (SCV) was developed as a measure of the variation among the rates of admission across different areas that is not affected by the mean rate or the size of the population studied, as are other measures of variation. It can, therefore, be used to compare relative variations of different procedures or conditions, even when the mean rates differ substantially. It is typically used to classify procedures into categories of low, moderate, high and very high variation. Differences in the SCV among causes of admission can be tested by computing ratios of two SCVs and comparing them to the F distribution. The SCV is computed by subtracting the random component of variation from the total variance. Further details on the computation of the SCV and its use are given in McPherson et al. (1982) and Wennberg et al (1984) (see the Endnote).