Appendix on Methods

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The Geography of Health Care

1.1 Files used in the Atlas

The Atlas depends on the integrated use of databases provided by Blue Cross-Blue Shield of Michigan (BCBSM), 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

Michigan Data Files

File	Year	Source	Description and Use in Analysis
Membership	1997	BCBSM	Contains one record per month for each eligible beneficiary. Includes demographic information (age and sex) and product eligibility information (e.g., drug benefit eligibility). Used to determine denominators for utilization rates, calculated as member-months of eligibility and expressed as person-years.
Facility	1997	BCBSM	Contains records for outpatient and hospitalization services provided by health care institutions. Includes date of service, diagnosis and procedure codes (ICD-9). Used to identify inpatient events (hospitalizations and procedures) for numerators of utilization rates.
Professional	1997	BCBSM	Contains records for services provided by health care professionals, including physicians, therapists, etc. Includes date of service, diagnosis (ICD-9) and procedure (CPT) codes. Used to identify procedures (inpatient and outpatient) for numerators of utilization rates.
Pharmacy	1997	BCBSM	Contains records for prescription drugs dispensed. Includes date of dispensation, generic and trade name of drug dispensed, and dose and amount dispensed. Used to identify prescriptions by drug type for numerators of drug utilization rates.

Medicare Data Files

File	Year Used (Sample)	Source	Description and Use in Analysis
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 specifiedyear. 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 procedures and preventive services.

Resource Files

File	Year Used	Source	Description and Use in Analysis
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

File	Year Used	Source	Description and Use in Analysis
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 through 1999 editions of the Dartmouth Atlas were retained in the BCBSM Atlas. HSAs were originally defined in three steps using 1993 provider files and 1992-93 Medicare 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. 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 1998 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 may have changed between the different editions of the Atlas. In most HSAs, the majority of Medicare hospitalizations occurred in a hospital or hospitals located within the HSA.

Michigan contains 109 HSAs. The total population of Michigan HSAs ranges from 1,018 in Berrien Center, containing 209 Medicare beneficiaries and 165 BCBSM person-years of eligibility, to 1,098,646 in Detroit, containing 124,463 Medicare beneficiaries and 133,298 BCBSM person-years.

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 1998 population from 126,329 (Minot, North Dakota) to 9,288,694 (Los Angeles) in the Cardiovascular Atlas.

Michigan contains 19 HRRs; of these, 15 are entirely contained within the state and are reported in the Atlas. The total population of Michigan HRRs ranges from 148,901 in St. Joseph, containing 39,623 Medicare beneficiaries and 23,184 person-years of BCBSM eligibility, to 1,902,947 in Detroit, containing 461,527 Medicare beneficiaries and 335,730 person-years of BCBSM eligibility.

1.4 Populations of HSAs and HRRs

Total population counts were estimated for residents of all ages in each HSA using 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 CASAs and HRRs are the sum of the counts of the constituent HSAs. These serve as denominators for estimating rates for hospital resources and physician workforce allocations.

For rates that apply to the Medicare population for the years 1995 and 1996, 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, and were summed to give person-years. For all rates, the numerator and the denominator counts exclude those who were enrolled in risk bearing HMOs on June 30.

For rates that apply to the BCBSM population, enrollee counts for 1997 were obtained from the BCBSM membership file. Months of eligibility for each beneficiary under age 65 were summed to give person-years. For drug rates, denominator counts were limited to enrollees eligible for drug coverage and member months were summed to give person-years.

For rates that apply only to one gender, denominator counts were limited to enrollees of that gender. For rates that apply to children, the denominator counts include enrollees less than 18 years of age. For BCBSM rates that apply to adults, denominator counts include enrollees between ages 18 and 64, inclusive.

2. 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.

2.1 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.

2.2 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 accom-

plished 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.

2.3 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.

3. 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.

3.1 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 (following page).

3.2 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

TABLE 2.

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

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	

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.

4. Hospitalization, Diagnostic, 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). For rates among the Medicare population, counts of discharges are based on the MEDPAR files for 1995-96. The denominator is the 1995-96 Medicare enrollee population 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 records with a length of stay over 365 days; hospitalizations in psychiatric, rehabilitation or long term care units; records where an HMO paid the provider. For rates among the BCBSM population, counts of discharges are based on the facility file for 1997. The denominator is the BCBSM population enrolled during 1997 and eligible for Blue Cross and Blue Shield benefits, calculated as person-months of eligibility and converted to person-years.

Diagnostic and surgical rates represent counts of the number of admissions or procedures that occurred in a defined time period (the numerator) for a specific population (the denominator). For Medicare beneficiaries, the counts of admissions or procedures were based on Medicare Part A data for 1995-96. The denominator is as described above. For BCBSM beneficiaries, the counts of diagnostic and therapeutic procedures were based on the professional file. The denominator is as described above.

4.1 Hospital Admissions, Diagnostic Tests and Procedures Examined in the Atlas

The specific admissions or procedures, or "numerator events", and the codes used to identify the events in the BCBSM data files are given in Table 3. For the codes used in the Medicare analysis, consult the Dartmouth Atlas of Health Care 1999. Selection of codes was based on review of the literature and/or consultation with clinical experts. "ambulatory care sensitive conditions" refer to hospitalizations, such as asthma, pneumonia, chronic pulmonary obstructive disease and congestive heart failure, that may be preventable when access to primary care is adequate.

Patients were counted as having only one event per procedure category per day. Thus a patient with multiple CPT codes for coronary artery bypass surgery occurring on the same day was counted as having a single procedure. However, patients with codes in two or more procedure groups were counted as having multiple

TABLE 3

Admission type	Codes
Pediatric medical admissions	DRG 026, 070, 081, 091, 098, 184, 279, 298, 327, 417, 422, 448
Adult medical admissions	DRG 009-025, 027-029, 031, 032, 034, 035, 043-047, 064069, 071-073, 078-080, 082-090, 092-097, 099-102, 121-136, 138-145, 172-183, 185, 187, 188, 189, 202-208, 235-251, 253, 254, 256, 271-278, 280, 281, 283, 284, 294-297, 299-301, 316-321, 323-326, 328, 329, 331, 332, 346-352, 366-369, 395, 397-399, 403, 404, 409-414, 416, 418-423, 444, 445, 447, 449, 450, 452-457, 460, 473, 475, 487, 489, 490, 492
Ambulatory care sensitive conditions	Hospital admission and ((ICD-9 Primary Diagnosis 491-4929, 494, 496-4969, 7803-78039, 493-49391, 250-2503, 2508-25099, 5589-55896, 590-5909, 5990-59909, 5999-59999, 2765) or (Diagnosis 4660 and Secondary Diagnosis 491-4929, 494, 496-4969) or (Primary Diagnosis 481, 4822-48239, 4829, 483-4839, 485-4869 and Secondary Diagnosis 2826-28269) or (Primary Diagnosis 428-4289, 40201, 40211, 40291, 5184 and Procedure not 3601, 3602, 3605, 375, 361-3619, 377-3779) or (Primary Diagnosis 4010, 4011, 4019, 40200, 40210, 40290 and Procedure not 3601, 3602, 3605, 375, 361-3619, 377-3779) or (Primary Diagnosis 4111, 4118, 413-41391 and no Procedure) or (Primary Diagnosis 681-6839, 686-6869 and (no Procedure or Primary Procedure 860-8609 and Secondary Procedure 0100))
Adult respiratory conditions	DRG 079, 080, 088, 089, 090, 096, 097
Adult chest pain	DRG 132, 133, 140, 143
Adult congestive heart failure	DRG 127
Adult acute myocardial infarction	ICD-9 Diagnosis 4100, 4101

Diagnostic Tests and Procedures	Codes
Adult births	DRG 370-375 and sex = F
Adult cesearean sections	DRG 370, 371 and sex = F
Adult hysterectomy for benign conditions	ICD-9 Procedure 683-6859 and ICD-9 Diagnosis not 179-1849 and sex = F
Adult cholecystectomy	ICD-9 Procedure 5121-5124
Adult back surgery	((ICD-9 Procedure 8106-8108) or (Procedure 8100 and Diagnosis 7213, 72142, 7221, 72252, 72272, 72283, 72293, 72402, 7244, 7384, 75611, 75612) or (Procedure 0309, 8050-8052, 8059 and Diagnosis 7213, 72142, 7221, 72252, 72272, 72283, 72293, 72402, 7244, 7384, 75611, 75612)) and no trauma
Arthroscopic knee procedures, all ages	CPT 29870, 29874, 29875, 29877, 29879, 29880-29883, 29888, 29889
Pediatric tonsillectomy	CPT 42820-42836, 42860
Pediatric myringotomy and tympanostomy	CPT 69420, 69421, 69433, 69436 and age lt 18
Adult echocardiography	CPT 93307-93312, 93314-93325
Adult non-imaging stress test	CPT 93015-93018
Adult imaging stress test	CPT (93015-93018 and 78460-78465, 78472-78483) or 93350
Adult diagnostic cardiac catheterization	ICD-9 Procedure 3722, 3723, 8855-8857 or CPT 93510-93529, 93539-93540, 93545
Adult coronary artery bypass graft surgery	ICD-9 Procedure 3601, 3602, 3605, 3606, 3609
Adult percutaneous coronary interventions	ICD-9 Procedure 3601-3606, 3609
Adult upper GI x-ray	CPT 74240, 74241, 74245-74247, 74249
Adult barium enema	CPT 74270, 74280
Adult colonoscopy	CPT 45378, 45380, 45383-45385
Adult EGD	CPT 43234, 43235, 43239, 43250, 43251, 43258
Adult sigmoidoscopy	CPT 45300, 45305, 45308, 45309, 45315, 45320, 45330, 45331, 45333, 45338, 45339

events. For example, a patient with codes for both echocardiography and coronary angiography on a single day would be included in the rates for each procedure.

For any given procedure, we placed no restrictions on the total number of numerator events one patient could have in a single year. Although multiple events were common for some diagnostic tests (e.g., stress tests), very few patients have two or more surgical procedures of a single type in one year (<2%).

An algorithm was necessary to discriminate among non-imaging stress tests, imaging stress tests and nuclear imaging studies performed at rest since they share the same CPT code ranges. Because the imaging component of an imaging stress test may be performed the day before or after the stress component, a one day window was used to associate the stress and imaging components of an imaging stress test. Non-imaging stress tests are therefore defined by stress components without an imaging component within a one day window. Similarly, nuclear imaging studies at rest are defined as imaging components that do not fall within a one day window of a stress component. The only exception to this definition is the stress echocardiogram (CPT=93350), which is unambiguously an imaging stress test. For these we did not require a corresponding stress component to define the event.

4.2 Adjusted Admission, Diagnostic Test and Surgical Procedure Rates and their Precision

Rates were adjusted using the indirect method for age, sex and race, using the corresponding 1996 or the 1996-97 national Medicare population as the standard, as described in Section 6. No rate was based on a count of fewer than 11 observed counts for reasons of data confidentiality or 26 expected events for reasons of statistical precision.

Although standard errors of the rates were not reported, these estimates are, for the most part, precisely determined. 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 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 standard error is (p/N)^0.5 and the precision, expressed as a percent of the true rate, is (s.e.(p)/p)*100%.

4.3 Proportions of patients with one event who also had another event

In several situations, we calculated the proportion of patients with one event who also had another event, such as the proportion of births that were cesarean sections. The usual confidentiality suppression rules were applied separately to the events in the numerator and denominator: rates were suppressed for observed counts of fewer than 11, or for when the difference between the numerator and denominator was less than 11 events. For reasons of statistical precision, the rate was also suppressed when there were fewer than 26 denominator events. Therefore, all such proportions that differ from the national proportion by more than 0.2 on an absolute scale are statistically significant.

5. Drug Rates

Drugs utilization rates are based on BCBSM data. Drugs were grouped into therapeutic classes. Utilization rates are composed of the number of individuals receiving at least one prescription for a particular drug class (the numerator) and the number of BCBSM enrollees eligible for drug benefits (the denominator). The denominator was calculated by cumulating person-months of eligibility for drug benefits and converting to person-years. Separate rates were calculated for children and adults as previously described.

In the case of antibiotics, we were interested in the rates of utilization of “expensive” versus “inexpensive” antibiotics. We classified antibiotics into two categories based on their generic names and their associated prices from the PDR Generics 1997 (3rd edition) Montvale, NJ: Medical Economics Press 1997.

6. Quality Measures

In order to assess variation in the quality of care delivered to cardiac patients, we identified a cohort of BCBSM enrollees with demonstrated coronary artery disease (CAD) and evaluated the use of several well-established therapies among these patients. Cohort members were those who were hospitalized during 1997 for acute myocardial infarction or coronary revascularization. The date of first admission was defined as the index event and patients discharged alive were followed for 30 days after discharge. In order to allow a full 30-day follow-up for all patients, patients had to have been discharged alive by December 2, 1997, to be eligible for this study.

6.1 Readmission Rates.

Thirty-day readmission rates for CAD patients were calculated using the BCBSM facility file. Those patients discharged alive were linked, using contract number, birth year, and first initial, to the facility file to identify any admission subsequent to discharge from the index admission. Those readmissions occurring within 30 days of discharge from the index admission served as the numerator events. The denominator consisted of all patients in the CAD cohort discharged alive.

6.2 Drug Utilization Rates. The proportion of CAD patients receiving two types of drug therapy were calculated using the pharmacy file. For this analysis, the cohort was limited to those enrollees eligible for drug benefits. Patients discharged alive from the index admission were linked to the pharmacy file to identify prescriptions for beta blockers and lipid lowering agents. The numerator for each rate consisted of the number of enrollees prescribed each drug type within 30 days of discharge. The denominator consisted of the number of enrollees discharged alive and eligible for drug benefits.

7. Calculation of Age, Sex and Race Adjusted Rates

Medicare procedure and diagnostic test 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 hospitalization and procedure

rates was the 1995-96 Medicare population corresponding to the numerator (see Section 1.5). 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 CASA and HRR levels. For procedures and diagnostic tests, these 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 adjustment procedure was modified for rates based on BCBSM data. No data on enrollee race was available and rates were calculated separately for children and adults. Thus adjustment strata were, for children, sex and age (0-4, 5-9, 10-14, 15-17); for adults, sex and age (18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64). The standard population was the BCBSM population corresponding to the numerator.

8. Measures of Variation and Association

8.1 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 1 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 has 27.6 employees per thousand residents, is represented by the highest point on the graph. Chicago, which has 21.8, and Manhattan, which has 21.6 employees per thousand residents, are represented by the two next lowest points on the graph. Thus, some areas which do 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.

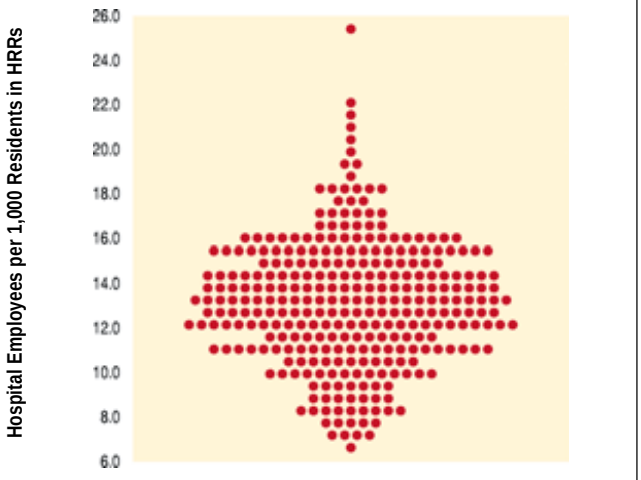

Figure 1. Hospital Employees Allocated to Hospital Referral Regions (1995)

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.

8.2 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, 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 2, 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 2.

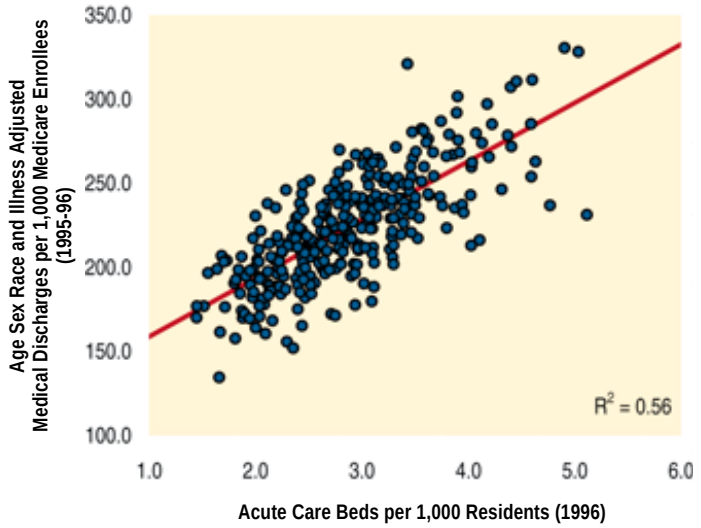

Figure 2. The Association Between Hospital Beds per 1,000 Residents and Age, Sex, Race and Illness Adjusted Hospitalization Rates for Medical Conditions per 1,000 Medicare Enrollees

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 2, 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.

The Dartmouth Atlas of Health Care in Michigan is based, in part, on data supplied by

The American Hospital Association
The American Medical Association
Blue Cross Blue Shield of Michigan
The American Osteopathic Association
The Health Care Financing Administration
The National Center for Health Statistics
The United States Census
The United States Department of Defense
Claritas, Incorporated

Data analyses were performed using

Software developed by the Center for the Evaluative Clinical Sciences
using SAS® on HP® equipment running the UNIX® system software

Maps and map databases were generated using

MapInfo® software
Highway map coordinates from MapInfo®
ZIP Code map coordinates from GDT®
Claritas 3H. Custom Dataset for US ZIP Codes from Claritas®