IOM Study of Geographic Variation: Medicare and Medicaid [DRAFT]

June 2012

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1 INTRODUCTION

A large body of research indicates that there exists significant regional variation in health care spending, utilization and quality. For instance, the Dartmouth Atlas found that per capita Medicare reimbursements in Miami were more than twice as high as in Minneapolis.[1] Other studies have also found significant variation in expenditures for end-of-life care and in the likelihood that individuals are diagnosed with a specific disease.[2] In the popular media, Atul Gawande's article in the *New Yorker* magazine further advanced the notion that variation in physicians' chosen practice patterns drives variation in Medicare costs observed even in cities close to one another.[3] Gawande uses the Texan cities of McAllen and El Paso to highlight this point. By first identifying the source of this geographic variation, policymakers can potentially develop and implement initiatives to alter practice patterns in high-cost areas.

Other research has concluded that the magnitude of this regional variation in spending and quality is not as large as indicated by the studies described above. For instance, the Medicare Payment Advisory Commission (MedPAC) found that medical utilization in higher-use areas (90th percentile) is only about 30 percent greater than in lower-use areas (10th percentile).[4] In fact, 45 percent of the Medicare fee-for-service (FFS)[5] population lives in areas characterized by medical utilization levels that are within five percentage points of the national average. Further, another study found that for small areas, "much of the variation in cost of treating Medicare beneficiaries is driven by supply-induced demand," and that variation "…cannot be supported when one comprehensively controls for health status and conducts analysis at the beneficiary level…"[6] Recent research also indicates that the observed large difference in spending between places like McAllen and El Paso may be a phenomenon unique to Medicare; these large geographic differences in spending may not appear for privately-insured patients.[7] Another recent paper found that the variation across regions in private health

[1]The Center for the Evaluative Clinical Services and Dartmouth Medical School, *The Dartmouth Atlas of Health* (Chicago: American Hospital Publishing, Inc., 1996).
[2] Y Song et al., "Regional Variations in Diagnostic Practices," *New England Journal of Medicine* 2010, no. 363 (2010).
[3] Atul Gawande, "The Cost Conundrum: What a Texas town can teach us about health care," *New Yorker*(June 2009), http://www.newyorker.com/reporting/2009/06/01/090601fa_fact_gawande.
[4] Medicare Payment Advisory Committee, "Measuring Regional Variation in Service Use: Report to Congress," (December 2009), http://www.medpac.gov/documents/Dec09_RegionalVariation_report.pdf.
[5] Medicare FFS includes Medicare Parts A and B.
[6] J. D. Reschovsky et al., "Following the Money: Factors Associated with the Cost of Treating High-Cost Medicare Beneficiaries," *Health Services Research* no. doi: 10.1111/j.1475-6773.2011.01242.x.
[7] Luisa Franzini, Osama I. Mikhail, and Jonathan S. Skinner, "McAllen And El Paso Revisited: Medicare Variations Not Always Reflected In The Under-Sixty-Five Population," *Health Affairs* 29, no. doi: 10.1377/hlthaff.2010.0492 (2010).

expenditures is between 3 and 4 times less than the variation in Medicare expenditures nationwide.[8]

This study contributes to this debate by examining geographic variation in the volume and intensity of per capita health care services and spending for both Medicare and Medicaid beneficiaries. Specifically, this report aims to answer the following research questions:

1. How much variation is there in per capita volume of healthcare services across the nation?
2. What are the potential savings from adopting the best practices of regions with the lowest utilization levels?
3. Are regions with high utilization levels likely to have high utilization rates in the future?
4. Is the variation in the volume of medical services greater within or across regions?
5. Do regions that provide a high volume of medical services when treating beneficiaries for a given disease also provide a high volume of medical services when treating all other diseases?
6. What types of services are the primary drivers of regional variation in the utilization of medical services?

To answer these questions, this report relies on claims data covering the universe of Medicare and Medicaid fee-for service beneficiaries. Sections 2 through 4 describe how this study uses these data to answer the six questions above. Section 2 identifies the data sources used for the analysis and the beneficiaries that are included in the aggregate cohort and 15 condition-specific cohorts. Section 3 defines the three outcome measures. Section 4 describes the methodology, including the risk adjustment regression specifications and the geographic region definitions. Using this methodology, Acumen has produced detailed spreadsheets describing regional variation in spending, utilization and quality for Medicare and Medicaid as a whole and for fifteen cohorts of beneficiaries with specific conditions.

In addition to producing a wealth of statistics that researchers can use for future studies, this report also directly evaluates the six research questions posed above. Section 5 addresses each of these questions in turn. The initial draft of this report is limited to a discussion of the results from the Medicare analysis. A revised version of the draft—to be sent in early July 2012—will

[8] Darius Lakdawalla, Tomas Philipson, and Dana Coldman, "Addressing Geographic Variation and Health Care Efficiency: Lessons for Medicare from Private Health Insurance," *AEI Health Policy Outlook* 2, no. July (2010), http://www.aei.org/docLib/2010-7-No-2-g.pdf.

include results from the Medicaid analysis as well as a comparison to determine whether regions with high per capita volume in Medicare also have high per capita volume in Medicaid.

2 CONSTRUCTION OF AGGREGATE AND CONDITION-SPECIFIC BENEFICIARY COHORTS

This study examines regional variation in spending, utilization and quality not only for an "aggregate" cohort but also for cohorts of beneficiaries with specific health conditions. The aggregate cohort includes all beneficiaries that satisfy the enrollment restrictions and does not restrict to beneficiaries with a certain health condition. The condition cohorts include 15 conditions selected by IOM based on a variety of factors including disease prevalence, disease incidence, costs of treatment, and the likelihood of regional variation in the course of treatment due to variation in demand-side or supply-side factors. The chosen conditions include both acute and chronic conditions and three incident cancers. The acute conditions include conditions such as stroke and acute myocardial infarction (AMI); the chronic conditions include patients with long-term illnesses such as diabetes, depression, and chronic obstructive pulmonary disease (COPD). Certain exclusions are also applied to the claims data to cull the claims appropriate to the analysis.

This section describes the methodology used to transform Medicare and Medicaid claims data into useful analytical files for the aggregate and fifteen condition cohorts. This section proceeds in two parts. Section 2.1 presents the data sources used in this study. Section 2.2 describes the steps the analysis uses to define the aggregate and 15 condition cohorts.

2.1 Data Sources

To synthesize all of the medical events that comprise each Medicare and Medicaid beneficiary's expenditure levels, treatments, and health history, this analysis relies on the universe of Medicare and Medicaid claims data from 2005 through 2010. Although the years of analysis are 2007 through 2009, this study uses data from 2005 through 2006 to capture additional beneficiary health history information. This study uses 2010 data to capture claims information for episodes beginning in 2009 that end in 2010. The remainder of this section contains two parts. Section 2.2.1presents the Medicare data sources and Section 2.2.2discusses the Medicaid data sources that this study employs.

2.1.1 Medicare Data Sources

The Medicare investigation uses claims, enrollment, and assessment data sources listed in Table 2.1 to produce relevant analytical files. Medicare Part A, B, and D claims files are episodic, rather than longitudinal, data files where observations occur when Medicare beneficiaries interact with providers who are to be paid by Medicare. The data on the claims describe the cost for services rendered, what services were provided during the interaction, who provided these services, and a wide range of information regarding the beneficiary's

demographics and health condition. Next, Medicare Part A, B, C, and D enrollment data files are historical with an observation every time a beneficiary's status changes. These files contain detailed data on all individuals entitled to Medicare, including demographic information, enrollment dates, third party buy-in information, and Medicare managed care (MC) enrollment.

Table 2.1: Medicare Data Sources

Data Source	Years	Data Files
Medicare Parts A and B Claims	2005 - 2010	Common Working Files (CWF) for Home Health (HH), Physician (PB), Inpatient (IP), Skilled Nursing Facility (SNF), Outpatient (OP), Hospice (HS), and Durable Medical Equipment (DME) claims
Medicare Part D Claims	2006 - 2009	Prescription Drug Event (PDE)
Medicare Part A, B, and C Enrollment Data	2005 - 2010	Enrollment Database (EDB) Common Medicare Environment (CME) Enterprise Cross-Reference (ECR) Files
Medicare Part C and D Enrollment Data	2005 - 2010	*MARx files*: Full Enrollment Files, Monthly Membership Files, Risk Scores Risk Adjustment Processing System (RAPS) *HPMS Files*: Beneficiary Cost, Formulary and Pharmacy Files for Part D

2.1.2 Medicaid Data Sources

The Medicaid investigation relies on the universe of Medicaid claims data in the Medicaid Statistical Information System (MSIS) for 2005-2010 to create the episode level analytical files. MSIS consists of quarterly files submitted by states on a rolling basis that contain Medicaid paid claims, retroactive adjustments, and enrollment information. The Medicaid data includes claims and enrollment information which are analogous to the Medicare data sources described in Section 2.1.1, but the claims data differs substantially. Specifically, Medicaid claims data use a different file structure, different variable definitions, and reflect a different payment system than does the Medicare claims data. Whereas the Medicare claims contain seven different file types, MSIS has five different file types. These file types include eligibility records (EL), inpatient hospital (IP), long-term care (LT), other services/therapy (OT), and prescription drugs (RX). Whereas the IP and RX files have clear Medicare equivalents, the OT and LT file contain information that is spread out across multiple file types in Medicare claims. Table 2.2 presents the Medicaid data sources and Medicare equivalents.

Table 2.2: Medicaid Data Sources and Medicare Equivalents

Data Source	Years	Data Files	Medicare Equivalent(s)
Medicaid Statistical Information System(MSIS)	2005-2010	Inpatient stays (IP)	IP
		Long-term care stays (LT)	SNF
		Other therapy (OT)	HH, DME, PB, OP
		Prescription drugs (RX)	PDE
		Eligibility records (EL)	EDB

Working with Medicaid data presents a number of unique challenges compared to the Medicare data. Although most Medicaid states programs now use HCPCS/CPT codes to report procedures and equipment in OT, ICD-9 procedure codes in IP claims and report prescription drug use in the RX file using 11-digit NDC codes, states deviate from national coding standards, for instance, by reporting local provider identification numbers or DEA numbers to identify service providers and insurers in place of NPI. Also, several states, including Maine and New York, report a significant number of procedures on their claims using unique local coding systems rather than HCPCS/CPT codes. Thus, identifying providers and procedures in Medicaid claims is complicated by the lack of unified, nationwide databases containing all local Medicaid provider identification numbers or local procedure codes.

Medicaid's heterogeneous coverage system makes the calculation of summary variables—such as annual expenditure levels—significantly more complex than in Medicare. Unlike Medicare data, knowing a beneficiary's enrollment status as reported in the EL file, for instance, does not exclusively determine the claim types reported for that beneficiary due to state waivers and "carve outs." Waivers, such as Section 1915(c) for home and community based services (HCBS), allow states to adopt unique payment systems specifically for these services. Carve outs occur when a state reimburses providers for certain services on a FFS basis regardless of whether the beneficiary is enrolled in a FFS or MC plan. In 2007, 20 states with full-risk MC plans implemented carve-outs for at least some drug classes, and 11 of these states included all drugs in the carve-out.[9] In 2007, over 64 percent of enrolled Medicaid beneficiaries were at least partially covered by an MC program. Table 2.3 describes the number of beneficiaries in various enrollment classifications in more detail.

[9] "2007 State Perspectives Medicaid Pharmacy Policies and Practices," National Association of State Medicaid Directors, http://ccf.georgetown.edu/index/cms-filesystem-action?file=issue+areas%2Fpharmacyrpt1107.pdf.

Table 2.3: Size of Potentially Recoverable FFS Medicaid Population (2007)

Medicaid Enrollment Classification	Number of Beneficiaries
Full FFS care	22,060,890
Mixed type of care	13,332,548
Sporadic FFS participation	*10,805,605*
MC with encounter claims	*1,400,215*
Ineligible	*1,126,728*
Full MC care	20,010,031

2.2 Cohort Definitions

This report examines regional variation in cost, utilization, and quality for the aggregate Medicare and Medicaid cohorts and for fifteen condition cohorts. The aggregate cohort includes all beneficiaries and counts those beneficiary's claims during the months they are enrolled over the observation period, which is a calendar year.

The condition cohorts include beneficiaries with certain health conditions and count their claims during the months they are enrolled. The chosen conditions include both acute and chronic conditions and three incident cancers. The acute conditions include acute/ischemic stroke, acute myocardial infarction (AMI), pneumonia, cataracts, and cholecystectomy. The acute condition cohorts cholecystectomy and cataracts are defined, in part, using procedures. The chronic conditions include diabetes, rheumatoid arthritis, depression, congestive heart failure (CHF), coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), and low back pain. The three incident cancer cohorts include breast cancer, lung cancer, and prostate cancer. Each condition cohort algorithm follows a three step procedure:

1. Select diagnostic and procedural criteria for inclusion in each cohort,
2. Identify the start of an episode using a clean period requirement (if any)
3. Define the observation period for each episode.

Sections 2.2.1 through 2.2.3 describe each of these three steps in detail. Section 2.2.4 discusses challenges to the cohort-based approach, and Section 2.2.5 outlines the restrictions that are applied to both the aggregate and condition cohorts.

2.2.1 Criteria for Beneficiary Inclusion in Each Condition Cohort

This study defines beneficiaries as members of a given condition cohort using diagnosis, procedure, and prescription drug codes. Medical experts on the IOM Committee selected the codes deemed most predictive of the conditions represented by each of the twelve chronic and acute condition cohorts using a consensus process. This study, in consultation with IOM and

Peter Bach of the Sloan Kettering Cancer Center, selected the diagnosis, procedure, and prescription drug codes to predict membership in the three incident cancer cohorts using an empirical approach based on the academic literature. Appendix A.1 classifies the cohorts as acute or chronic and gives their clean period requirements, which are discussed below. Appendix A.2 provides a full listing of the condition cohort algorithms, and Appendix A.3 has a full listing of the condition cohort codes. Appendix A.4 describes the methodology used to determine the cancer condition cohort specifications.

To reduce the number of false-positives included in the condition cohorts, the analysis applies a number of restrictions to refine the cohort definitions. Diagnosis and procedure codes on claims made up entirely of laboratory services are not eligible to qualify a beneficiary for a cohort.[10] This restriction aims to reduce the likelihood that "rule-out" diagnoses affect beneficiary health status measures. Rule-out diagnoses occur when providers indicate whether the beneficiary received a test for a given disease rather than indicating whether he or she has the given condition. The analysis also excludes claims reporting zero costs, where costs include both Medicare and beneficiary payments. If no payment was made, it is unlikely that a service was rendered.[11] The analysis also excludes interim inpatient claims because finalized claims contain the latest available information, and thus are generally more accurate. For instance, an interim claim may indicate that the beneficiary suffers from a specific disease, but further diagnostic testing may subsequently reveal that an alternative disease is the true cause of the beneficiary's symptoms. The updated diagnostic information would appear on the finalized claim, but not necessarily the interim claim. Finally, claims with a non-clinician listed in the physician specialty field are not used to determine a beneficiary's eligibility in a cohort.[12] For example, a claim for ambulance transportation may contain a diagnosis code, but this study prohibits that claim from determining beneficiary membership in a cohort. This requirement ensures diagnoses used to determine cohort membership are reported by clinicians.

2.2.2 Identifying the Start of an Episode

To identify the beginning of a new episode of care, the cohort definitions for the acute conditions - acute/ischemic stroke, acute myocardial infarction, and pneumonia - and all incident cancers - breast cancer, prostate cancer, and lung cancer - require a "clean period." During the

[10] Lab codes are defined using HCPCS codes. HCPCS codes that begin with "EKABCLV," codes that have a BETOS code that begins with I or T, codes that are in the range 70010-76999 or 78000-78999, and codes that are included in the 2010 clinical lab fee schedule are included in the labs category.
[11] PB claims must have a valid line item where a valid line item has a pricing indicator of A, R, or S indicating the claim was paid.
[12] The physician specialty field must contain a code that is eligible for risk adjustment: "Acceptable Physician Specialty Types for Risk Adjustment Data Submission," Centers for Medicare & Medicaid Services, http://www.csscoperations.com/internet/Cssc.nsf/files/Risk-Adjust-Physn-Spec-Types031511_040811.pdf/$FIle/Risk-Adjust-Physn-Spec-Types031511_040811.pdf.

clean period, claims must not contain diagnosis or procedure codes related to the condition in question, as determined in step 1. If a beneficiary's claims submitted during the clean period do contain a combination of codes determined in step 1, this suggests the beneficiary developed the condition prior to the "index date," the date of the first claim containing a condition-relevant code during the period of analysis. Since this study aims to analyze the costs of incident acute conditions, beneficiaries with claims violating the clean period requirement are excluded from the acute condition cohorts and the incident cancer cohorts. For example, if claims with diagnosis, procedure or prescription drug codes associated with acute myocardial infarction (AMI) are observed for a given beneficiary on March 1, 2008 and March 20, 2008, the clean period approach assumes that these claims are related to the same episode of care since the AMI clean period is 60 days. The clean period requirement ensures these claims are grouped together in the same episode of care if both claims are submitted during the period of analysis. If claims for AMI are observed for a given beneficiary on March 1, 2008 and subsequently on August 1, 2008, it is assumed that these claims are related to separate episodes of care and the clean period requirement ensures they are analyzed separately. Appendix A.1lists the clean period requirement, if any, for each cohort. For cohorts with clean periods, beneficiaries are not required to be continuously enrolled during the clean period to be eligible for the cohort.

There are several advantages to the use of a clean period requirement. First, the clean period requirement is straightforward to implement using the Medicare claims data. Implementing the clean period approach requires a list of diagnostic and procedural codes for inclusion in the cohort and a choice of the length of the clean period for each cohort. For this project, the IOM Committee selected the length of the clean period using a consensus-based approach. In addition, the use of a clean period has widespread use in both commercial and governmental applications. Commercial grouping software developed by Ingenix and Thomson Reuters uses a clean period as does the medical spending per beneficiary measure CMS uses within Hospital Compare.[13]

Although imposing a clean period restriction has several advantages, meeting this requirement is imperfectly correlated with having an incident rather than prevalent condition. Beneficiaries with no evidence of a given condition during the clean period may have a prevalent condition with past treatment of the condition occurring outside of the clean period or they may simply have not sought treatment for their condition. In this case, the methodology incorrectly assigns these beneficiaries to the given condition cohort. Beneficiaries with evidence of a given condition during the clean period may have multiple incident cases of that condition, each

[13] T. MaCurdy et al., "Optimal Pay-for-Performance Scores: How to Incentivize Physicians to Behave Efficiently," http://www.cms.gov/reports/downloads/MaCurdy_Incentivize_Physicians_Optimal_P4P_Scores_Feb_2011.pdf.

requiring its own episode of care. In this case, the methodology incorrectly eliminates these beneficiary episodes from the given condition cohort.

To determine the beginning of a new episode of care for cohorts without a clean period requirement, the date of the first claim containing a condition-relevant code is used as the "index date." Clean periods are not required for the acute condition cohorts cholecystectomy and cataracts because these cohorts represent procedures, and the majority of costs related to these conditions will be incurred in the immediate period before (pre-operative costs) and after (post-operative costs) the procedure. For example, the costs related to cataracts surgery include a physician's consultation and examination prior to surgery, the costs of the surgery, prescription eye drops to prevent infection after surgery, physician visits post-surgery to monitor complications such as infection, persistent inflammation, or changes in eye pressure, and the costs of treating any complications that may occur. In addition, because chronic conditions recur and subside on a frequent basis, a clean period is not required for the chronic condition cohorts.

2.2.3 Defining the Observation Period

Once the start of an episode is identified, this study implements an observation period for each condition cohort to capture the relevant costs associated with an episode of care. The observation period is the length of the period of analysis, which begins on the "index date." IOM Committee clinicians selected the observation period for each cohort using a consensus process. All the beneficiary's claims during the observation period are included in the episode regardless of the diagnosis or procedure information on the claim.

The methodology implements different observation periods for each condition cohort to reflect differences in the expected length of the disease episode. For example, most cases of pneumonia resolve within a matter of months whereas diabetes – a chronic condition – is often a lifelong condition.[14] Appendix A.2 lists the observation period for each of the fifteen condition cohorts. The observation period for the acute conditions analyzed ranges from 3 months (pneumonia) to 12 months (acute/ischemic stroke and acute myocardial infarction). The observation period for the cholecystectomy cohort, which represents a procedure, is 90 days prior to and 90 days after the index date because a patient receiving a cholecystectomy likely incurs related costs prior to surgery (e.g., physician consultation, diagnosis of symptomatic gallstones, lab tests). The length of the observation period for all chronic conditions is one year. Furthermore, once a beneficiary meets the requirements for membership in a chronic condition

[14] According to a study published in the Journal of General Internal Medicine, while the majority of patients rated symptoms of fatigue (79%) and cough (80%) as moderate to severe at the time of diagnosis, a minority of patients rated symptoms as moderate or severe at the day 30 or day 90 follow-ups. J. P. Metlay et al., "Measuring symptomatic and functional recovery in patients with community-acquired pneumonia," *J Gen Intern Med* 12, no. 7 (1997).

cohort, the study methodology then assigns that beneficiary to that cohort in all future years of the analysis, based on the assumption that chronic conditions—by definition—rarely resolve themselves quickly.

2.2.4 Challenges to Condition Cohort-Based Approach

Conducting the analysis at the condition cohort level allows for examination of the regional variation in costs, utilization, and quality for individuals with similar health profiles; however, this approach presents several challenges. First, diagnosis and procedure codes may be reported differently across regions. The same patient may receive a different diagnosis depending on which physician he or she sees, and if physicians in certain regions diagnose patients in systematically different ways than physicians in other regions, the results of a cohort-based analysis of regional variation in health care may be biased. For example, if "upcoding" diabetes diagnoses is common in the Northeast, then beneficiaries included in the diabetes cohort residing in the Northeast will be relatively healthy since some of these individuals may not meet the criteria for a diabetes diagnosis in other regions. If upcoding occurs, these beneficiaries' costs and utilization will be relatively low compared to other regions not due to treatment choice, but due to the cohort to which this study classifies them. Second, regions may also differ in the propensity to screen for certain conditions. If some regions are more likely to identify certain conditions at an earlier stage, these conditions may be less expensive to treat and treatment may be more likely to result in a successful outcome in these regions. Although risk adjustment can control for various beneficiary level characteristics including comorbidities, it is not possible to perfectly control for the severity of a beneficiary's condition. Third, using diagnosis codes to define condition cohorts may lead to an endogeneity problem: the lowest cost beneficiaries are less likely to visit a physician, and therefore the methodology will assign fewer low cost beneficiaries to a given condition cohort. If low cost beneficiaries are more common in certain regions, the methodology will overstate costs in these regions. Finally, this study does not have access to beneficiary medical records, and thus it is not possible to independently verify diagnostic information. Previous research, however, has compared diagnosis codes on Medicare claims against diagnosis codes included in medical records and found a high positive predictive value (PPV).[15,16,17]

There are two possible methods of calculating beneficiary outcomes using the cohort-based approach: including all claims within the observation window of the cohort and including

[15]Yuka Kiyota et al., "Accuracy of Medicare Claims-Based Diagnosis of Acute Myocardial Infarction: Estimating Positive Predictive Value on the Basis of Review of Hospital Records," *American Heart Journal* 148(2004).
[16] Wolfgang C Winkelmayer et al., "Identification of Individuals with CKD from Medicare Claims Data: A Validation Study," *American Journal of Kidney Diseases* 46(2005).
[17] Elena Birman-Deych et al., "Accuracy of ICD-9-CM Codes for Identifying Cardiovascular and Stroke Risk Factors," *Medical Care* 43.

only claims that are related to each condition. Using all claims captures all health costs of a beneficiary in a given cohort during the observation window. Including only claims that are related to a condition requires the use of an "episode grouper." Episode groupers use complex algorithms to create clinically cohesive episodes of care that group treatment associated with a single condition during the observation window. Because beneficiaries may have multiple concurrent conditions, episode groupers must either divide claims among multiple episodes or allocate claims to more than one episode.

This analysis includes all of a beneficiary's claims in the observation window. Using all claims takes a holistic view by assuming that beneficiaries' conditions affect all aspects of their health, which may be particularly appropriate for chronic conditions. Though the all-claims approach creates a single measure of a beneficiary's health, it produces "false positives" when used with cohorts by including claims that are not necessarily related to each cohort. This analysis attenuates the number of false positives by shortening the observation period for several of the acute cohorts. Including claims unrelated to a given condition can be thought of as a source of noise, but the large number of cases in each region ensures that it is unlikely that one region will have more unrelated claims than another. The all-claims approach also double-counts claims across cohorts when beneficiaries have concurrent conditions. Although double-counting claims can overestimate total beneficiary outcomes, this analysis also creates an aggregate cohort in which claims are not double-counted. Episode grouping, on the other hand, will produce fewer false positives than including all claims but may produce more false negatives by excluding claims that are related to a condition from the analysis. If the episode grouper divides claim cost among episodes, for instance, costs that are related to more than one condition can be misallocated. For example, a beneficiary with diabetes may be treated for a stroke; in this case, it is difficult to determine whether the costs for the stroke treatment should be included in a stroke episode or a diabetes episode. Because episode grouping algorithms affect which claims are counted during the observation window in addition to which beneficiaries are included in each cohort, episode grouping will exacerbate the effects of regional differences in coding. For example, a region that tends to "upcode" diagnoses to a diabetes diagnosis will include more beneficiaries in the diabetes cohort and will count more of those beneficiaries' claims during the observation period. Finally, implementation of the all-claims approach is simpler and more direct than implementation of the episode grouping approach.

2.2.5 Exclusion Restrictions

Although the aim of this study is to be as inclusive as possible, the Medicare and Medicaid studies do implement several eligibility restrictions. In general, the beneficiaries who

are excluded from the analytic file are those for whom there is not complete data.[18] For both the Medicare and Medicaid analysis, some beneficiaries have ZIP codes on their claims that are missing, or are outside of the United States or are likely miscoded, and as such do not map to the regional definitions described in Section 3.4. Because one cannot identify the region in which the beneficiary is located, these beneficiaries are excluded from the analysis. Both the Medicare and Medicaid analyses also exclude episodes that have third party payer costs on any claims during the observation window. Beneficiaries with third party payer costs may have additional claims outside of their Medicare or Medicaid claims, so their health care data is likely to be incomplete. Beneficiaries that are dual-enrolled in Medicare and Medicaid are included in the Medicare study but excluded from the Medicaid study. Beneficiaries are considered to be dual-enrolled if they are enrolled in both Medicare and Medicaid in any of the twelve months after the index date. The reasons dual-eligibles are included only in the Medicare study are: 1) to avoid double-counting, and 2) Medicare is the primary payer for dual-eligibles for all medically necessary Medicare-covered services. The two sections below provide additional information on exclusion restrictions specific to the Medicare and Medicaid analytic samples.

Medicare Study Exclusion Restrictions

The Medicare analysis includes only claims for Fee for Service (FFS) beneficiaries in the months that they are enrolled. To limit the sample in this manner, this study excludes beneficiaries only enrolled in Medicare Advantage (also known as Part C or Medicare Managed Care) throughout the observation period from the analysis because information on utilization of and payment for medical services rendered is not available in the MA data.[19] A Medicare beneficiary is considered to be enrolled in FFS for a given month if the Medicare Enrollment Database shows enrollment in Part A or B and not in Part C during that month. When a beneficiary switches between Medicare FFS and Medicare Advantage, only the months with FFS enrollment are included in the episode. Months where a beneficiary is not enrolled in FFS but has FFS Part D claims are excluded from the observation window as the beneficiary is not enrolled in Medicare FFS Parts A or B. Beneficiaries must be enrolled in Medicare Part A or Part B during the first month of the observation window. In addition to excluding episodes with third party payer costs on claims, the Medicare analysis also excludes episodes with the beneficiary listed as having a third-party primary payer in the observation window in the EDB. Appendix A.5 illustrates the number and percent of Medicare beneficiaries who are excluded from the analysis due to each restriction criteria.

[18] A very small number (less than 0.00001 percent) of beneficiaries who are missing sex or date of birth in the enrollment files (EDB/EL) due to coding errors are excluded from this analysis.
[19] Beginning in 2012, CMS will collect encounter claims data from MA plans. These data, however, are not available for this study's time frame.

Although the Medicare study includes beneficiaries who are simultaneously enrolled in Medicaid, the Medicare study only uses dual-eligibles' Medicare claims. The Medicare study includes dual-enrollees because Medicare is the primary payer for dual-eligibles' medical services while Medicaid is the "payer of last resort," which means that providers must seek payment from Medicare first and then bill Medicaid for any remaining balance.[20] The Medicare analysis excludes all additional Medicaid claims for these dual-enrolled beneficiaries because Medicaid identification numbers frequently change over time, which precludes a reliable linkage of beneficiary histories across programs. As described below, dual-eligible Medicaid beneficiaries are completely excluded from the Medicaid study to prevent double counting.

Medicaid Study Exclusion Restrictions

The Medicaid study applies three additional restrictions to the cohorts. First, most Medicaid MC beneficiaries are excluded because the encounter and capitation claims submitted on their behalf are not reliably reported, and encounter claims do not report an amount paid.[21] MC beneficiaries are only included if they are enrolled in Primary Care Case Management (PCCM) or in "partial" managed care. PCCM programs charge a small capitated fee but cover all services on a FFS basis, so beneficiaries enrolled in PCCM programs are included in the investigation. Beneficiaries enrolled in partial managed care have some services, such as psychiatric services or dental work, covered through a MC organization, but all other services are covered through FFS. As a result, the analysis includes beneficiaries in partial managed care as well. Table 2.4 indicates which beneficiaries are excluded or included based on enrollment status. Excluding MC beneficiaries who are not enrolled in PCCM or partial MC programs reduces the number of beneficiaries available for the 2008 analysis by 46 percent. Excluding these MC beneficiaries may bias the analysis and limit national generalizability because healthy children and families make up the majority of Medicaid's MC enrollees.[22]

Second, beneficiaries who are not covered for the full set of Medicaid services are excluded because their claims record likely contains an incomplete picture of their healthcare spending and utilization levels. The MSIS data identifies these beneficiaries using a benefit restrictions indicator variable. For example, the Family Planning Access Care and Treatment (PACT) waiver in California provided comprehensive family planning services through Medicaid to 2.6 million beneficiaries in 2009 not otherwise eligible for Medicaid. Because these

[20]Stephanie E. Anthony et al., "Medicaid Managed Care for Dual Eligibles: State Profiles," *The Kaiser Commission on Medicaid and the Uninsured* 14(2000), http://www.kff.org/medicaid/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=13759.

[21] Daniel R. Levinson, Inspector General, "Medicaid Managed Care Encounter Data: Collection and Use," 12, no. OEI-04-07-00240 (2009), http://oig.hhs.gov/oei/reports/oei-07-06-00540.pdf.

[22] "Medicaid - A Primer: Key information on Our Nation's Health Coverage Program for Low-Income People," The Kaiser Commission on Medicaid and the Uninsured, http://www.kff.org/medicaid/upload/7334-04.pdf.

beneficiaries only received coverage for family planning services through Medicaid, they are indicated with benefit restriction flags and excluded from the analysis as each may have an incomplete health history. Third, the Medicaid study excludes all dual-enrolled beneficiaries because their costs are first covered by Medicare then by Medicaid. Thus, to avoid double-counting, only the Medicare analysis includes dual-enrolled beneficiaries.

Table 2.4: Medicaid Enrollment Type Restrictions

Enrollment Type	Included in Medicaid Cohort	Excluded from Medicaid Cohort
FFS	X	
Partial MC – Behavioral	X	
Partial MC – Prenatal/Delivery	X	
Partial MC – Long-Term	X	
Partial MC – Dental	X	
PCCM	X	
Comprehensive MC		X
PACE		X
Other MC		X

3 MEASURES OF REGIONAL VARIATION IN HEALTH CARE SERVICE PROVISION

To quantify the amount of geographic variation in the provision of health care services, this study examines regional variation in health care expenditures, utilization, and quality of care. Expenditures give a measure of the actual costs of health care incurred by each beneficiary, which includes payments by insurers and beneficiaries. Expenditures, however, depend on regional variation in both price and quantity. To more narrowly evaluate regional differences in utilization patterns, this study measures regional variation in utilization as well. Utilization is measured alternatively as a price-standardized spending levels (i.e., spending statistics that control for regional differences in prices) or as a series count variables that measure differences in the number of events per person (e.g., physician visits per capita) across regions. Areas where beneficiaries incur high medical costs or use a large amount of services, however, may not necessarily be inefficient, however, if the increased use of medical services produces better health outcomes. To determine whether or not this is the case, this study also uses a variety of quality measures to assess the relationship between utilization of medical services and quality.

The following discussion presents the approach this study uses to measure regional variation in these three outcome variables of interest. Sections 3.1, 3.2, and 3.3 describe how this study defines health care spending, utilization and quality outcomes respectively. To determine how the average values of these outcome measures varies across regions, the study uses three definitions of a "region". These definitions include Hospital Service Area (HSA), Hospital Referral Region (HRR), and Metropolitan Statistical Area (MSA). Section 3.4 describes how these regions are constructed in detail.

3.1 Measurement of Health Care Expenditures

The expenditure analysis examines regional variation in the costs of health care. With health expenditures comprising 17.9 percent of the national Gross Domestic Product in 2010, rising healthcare costs are a significant issue.[23] Identifying areas that are high cost or low cost may help policymakers implement initiatives to encourage low cost practice patterns. Regional differences in healthcare spending per capita are due to two factors: differences in the price of medical care and differences in the utilization of medical services. The expenditures analysis investigates the overall change in spending but does not assess which of these two reasons is the driving factor. The utilization analysis, described in Section 3.2, separates out these two causes of spending variation.

This study calculates all-source expenditures using three steps.

[23] "National Health Expenditure Data," Centers for Medicare & Medicaid Services, https://www.cms.gov/NationalHealthExpendData/downloads/tables.pdf.

1. Sum the expenditures included in each episodes,
2. Adjust the costs for inflation, and
3. Calculate per beneficiary, per month expenditures.

The first step calculates the total raw cost during the beneficiary episodes. The total raw cost in the Medicare analysis is calculated as the sum of the claim payment, coinsurance, and deductible from the Inpatient, Outpatient, Hospice, Home Health, Skilled Nursing, Carrier, Durable Medical Equipment, and Part D claim types. Expenditure calculations from the Inpatient claim type remove the add-on Indirect Medical Education (IME) and Disproportionate Share (DSH) payments. For Medicaid, total raw cost is calculated as the sum of the claim payment on FFS claims found in the Inpatient, Prescription Drugs, Long Term Care, and Other file types. In addition, the Medicaid analysis excludes the costs from partial capitation claims, which appear for beneficiaries in Primary Care Case Management (PCCM) programs.

Second, for all analyses, the expenditures variable adjusts raw costs for inflation between years of analysis. The IOM committee used the average Consumer Price Index to adjust for inflation, which takes into account the changing prices paid by consumers for all goods and services.[24] To inflate expenditures to costs in 2009, expenditures incurred in 2007 are multiplied by 1.032; expenditures in 2008 are multiplied by 0.995; and expenditures in 2010 are multiplied by 0.986.

Finally, the analysis calculates per beneficiary, per month expenditures by dividing the total costs for each beneficiary during his or her enrolled months by the number of months of enrollment.[25] A Medicare beneficiary is only considered enrolled during the months he or she is enrolled in Parts A or B, and a Medicaid beneficiary is only considered enrolled during the months he or she is FFS enrolled and with no benefit restrictions, as described in Section 2.2.5.

3.2 Measurement of Health Care Utilization

Examining utilization in addition to expenditures can reveal whether high cost regions are expensive because of increased utilization of services rather than higher prices for these services. This analysis measures regional variation of utilization in two ways:

- Price standardized cost
- Utilization of specific medical services

[24] "Consumer Price Index - Chained Consumer Price Index," United States Department of Labor: Bureau of Labor Statistics, http://bls.gov/data/.
[25] In addition, the beneficiary's per month expenditures are weighted by the number of months of enrollment during the risk adjustment analysis, which is described in Section 4.

Input price adjustment removes geographic variation in the price of inputs, such as labor costs, and allows for an assessment of changing patterns of utilization overall. In addition to input-price standardized cost, this study also measures the utilization of specific medical services as counts of services. Input price adjustment gives a more comprehensive assessment of utilization than the utilization counts by combining utilization from all sources and assigning appropriate relative costs to each service (i.e., inpatient stays count for more than a physician visit does). Although utilization counts are a less comprehensive measure than price-standardized cost, examining specific service counts can better reveal regional variation for specific services that are most likely to depend on patient or provider discretion. Section 3.2.1defines the input price standardized cost measure. Section 3.2.2 lists the counts of service utilization measures included in this study.

3.2.1 Price Standardized Cost

Input price standardized cost assigns a standardized price for each service, so that the price paid for each service is identical across all geographic regions. The analysis, in essence, removes regional variation in Medicare and Medicaid payment rules to determine a base rate for each service. For example, the Medicare analysis adjusts physician payments using the Geographic Practice Cost Index (GPCI). The GPCI measures the relative cost of the inputs physicians require to provide medical services against the national average input cost. The Medicare analysis closely follows the standardization methodology developed in conjunction with CMS as part of the Hospital Value-Based Purchasing (HVBP) program.[26] Price standardization occurs at the file type-year level, and prices are renormalized after standardization so that the sum of the unadjusted and standardized costs are equal for a given file type and a given year. Renormalization allows for the standardized costs to reflect the real prices paid by CMS. For a technical description of Medicare input price standardization for all file types, please refer to the attached price standardization memo. Appendix B.1 presents the technical specifications for the Medicaid input price standardization methodology.

While other subcontractors for the IOM geographic variation project calculate output adjusted prices in addition to input adjusting costs, neither the Medicare nor Medicaid analysis output-adjusts prices. Output price adjustment assigns each service the same cost regardless of where it is performed by assigning services an average payment using Diagnosis-Related Groups (DRGs) and CPTs. Medicare's geographic adjustments are budget neutral and generally adjust a standard national payment level for regional variation in the cost of providing each service. Thus, because Medicare's final prices are based on regional variation in input costs, using

[26] "Measure Methodology Reports: Medicare Spending Per Beneficiary (MSPB) Measure," QualityNet, http://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1228772057350.

separate output and input price adjustment is unnecessary. The final step renormalizes the standardized price on each claim so that the total standardized payment for all claims equals the total actual payment (excluding IME and DSH for inpatient)[27] for each claim type in each year.

Medicaid price standardization also price-standardizes using input prices only. Although Medicaid payments differ across the country because states have different payment systems, the Medicaid analysis does not output-adjust prices for several reasons. First, about one third of state Medicaid programs do not use DRGs to reimburse hospital providers, which precludes output-standardizing prices using DRGs for those states.[28] In addition, eight states do not consistently utilize CPT codes but rely on local coding systems.[29] The local coding systems do not directly map to any nationally-used coding system, which prevents the analysis from comparing specific services between geographic locations.

In addition to the overall input price adjusted expenditures, the input price adjusted expenditures are also stratified by service categories. Stratifying by service category allows analysis of different types of care, such as acute hospitalization or diagnostic services, to determine if regional variation overall is similar to regional variation for specific types of services. Appendix B.2 lists the service category specifications.

3.2.2 Counts of Service Utilization

To analyze the geographic variability of utilization, this analysis also examines the utilization counts of specific services. Price standardization can assess utilization across regions by accounting for differences in input prices. Measuring utilization with count-based variables is better able to measure regional variation in specific services that may be sensitive to supply- or demand-side factors.

This methodology relies on codes from Medicare and Medicaid claims to calculate measures such as the number of inpatient days with a surgical admission. For utilization measures that rely on CPT or HCPCS codes, Medicaid data is underreported in states with prevalent use of local coding systems, as discussed above. In addition, because of the structure of Medicaid claims data, some related utilization measures are combined. For example, the

[27] There are other special payments, such as those for Medicare Dependent Hospitals, Sole Community Hospitals, Low Volume Hospitals, etc. Since these will all be part of total actual payment, but are not part of the standardized price methodology, the renormalization will have the effect of uniformly raising the standardized price of inpatient claims. Similar payments in other claim types, such as the add-on for physicians in shortage areas, will have similar effects.

[28] "Medi-Cal DRG Project: Frequently Asked Questions," California Department of Health Care Services, http://www.dhcs.ca.gov/Documents/MCDrgProjectFAQs.pdf.

[29] This analysis calculated the percentage of each state's claims that are CPT claims and flagged eight states with consistently low percentages of CPT use from 2008 through 2010. These states are New York, Connecticut, Idaho, Maine, North Carolina, Ohio, Vermont, and Washington.

Medicaid methodology combines the number of inpatient surgical days and number of inpatient medical days measures because medical and surgical admissions are defined by DRG, and Medicaid claims in some states do not include DRGs. Appendix B.3 presents definitions of all the utilization measures.

3.3 Measurement of Health Care Quality

To analyze variation in the quality of care across geographic regions, the study utilizes a broad range of well-established quality measures. The 18 measures chosen for this analysis are all supported or developed by established institutions such as the National Committee for Quality Assurance (NCQA), the Physician Consortium for Performance Improvement (PCPI), and the Agency for Healthcare Research and Quality (AHRQ), in addition to other organizations. The quality measures apply to specific conditions to determine how the quality of care for those conditions varies. The methodology calculates separate quality measures for each cohort and for the aggregate of beneficiaries in each region. For the aggregate cohort, this analysis employs composite quality indicators from the Agency of Healthcare Research and Quality (AHRQ). Using these variables, this study can determine whether areas with high utilization levels also have high quality medical care. Appendix B.4 lists the condition-specific quality measures for the cohort analysis, and Appendix B.5 lists the composite quality measures for the aggregate analysis.

Implementing these quality measures in the Medicaid analysis presents several challenges. First, like the utilization measures, any quality measure that uses HCPCS or CPTs may be underreported for Medicaid in states with prevalent local coding system usage. Second, because the admission date on Medicaid claims is unreliable, quality measures employing the admission date must instead use the beginning date of service on claims. A final challenge is that on drug claims, the Medicaid days' supply and quantity of service variables often are not reliable. For instance, the value of the "quantity of service" variable could be recorded as the number of pills or the number of milligrams.

3.4 Defining a Region

Each of the analyses described in this report are performed using three different geographic region definitions. These include:

- Hospital Service Area (HSA)
- Hospital Referral Region (HRR)
- Metropolitan Statistical Area (MSA)

The analyses employ HSA and HRR region definitions developed by the Dartmouth Atlas of Health Care. Dartmouth defined HSAs, local health care markets for hospital care, by assigning ZIP codes to the hospital area where the greatest proportion of each ZIP code's Medicare residents were hospitalized. Most of the 3,436 nationwide HSAs contain only one hospital. HRRs represent regional health care markets for tertiary medical care that generally require the services of a major referral center. Specifically, Dartmouth defines HRRs by assigning HSAs to the region where the greatest proportion of major cardiovascular surgical procedures were performed with minor modifications to achieve geographic contiguity. Each of the 306 HRRs thus has at least one city where major cardiovascular surgical procedures are performed.[30] Finally, MSAs are relatively freestanding Metropolitan Areas, or large population nucleuses, typically surrounded by nonmetropolitan counties. Each of the 366 MSAs contains either a place with a minimum population of 50,000 or a Census Bureau-defined urbanized area and a total Metropolitan Area population of at least 100,000 (75,000 in New England).[31] All areas within each state that do not satisfy the MSA definition are aggregated into a separate category labeled "rest of state."

The analyses assign beneficiary location using the beneficiary ZIP code on each observation period index date. If the beneficiary's ZIP code changes during the observation period, all claims are assigned to the ZIP code at the beneficiaries index date because moving is considered to be within the set of treatment options for beneficiaries in the original ZIP code. Beneficiary level data is aggregated to the ZIP code level and then to each of the three geographic region levels defined above. The studies map ZIP code level data directly to HSA and HRR levels. MSAs are county-based, however, and the studies use a ZIP-to-county-to-MSA mapping despite the presence of county codes in the EDB. Some ZIP codes cross county lines, but these are mapped to the county that includes a majority of the ZIP code area using the ZIP code crosswalk provided by IOM. The studies use ZIP code when defining MSAs to enforce consistency across geographical region definitions.

[30] "Research Methods: Dartmouth Atlas of Health Care," Dartmouth Atlas of Health Care, http://www.dartmouthatlas.org/tools/faq/researchmethods.aspx.
[31] "ZIP code Database Definitions of Geographic Concepts, including Maps," ZIP-Codes.com http://www.zip-codes.com/zip_code_definitions.asp.

4 ACCOUNTING FOR DIFFERENCES IN PATIENT CASE MIX

Regional differences in healthcare spending, utilization and quality can be due to a number of factors including regional differences in patient case mix. To account for differences in beneficiary demographics and severity of illness as well as market level factors, this study applies a risk-adjustment methodology to all outcome variables described above. Risk adjustment controls for factors that can influence the dependent variables but typically are outside of providers' control. The general risk adjustment methodology uses a linear ordinary least squares (OLS) regression model to predict the value of the outcome variable given a set of observable beneficiary (and in some cases market-level) characteristics. The region-level value of the risk-adjusted outcome value equals the average difference between the observed levels of the outcome value and the values predicted by the risk adjustment model.

The remainder of this section provides a more detailed discussion of this study's risk adjustment model. Section 4.1contains a formal presentation of the risk adjustment model used. Section 4.2 describes the set of beneficiary-level and market-level variables that are used in different regression specifications.

4.1 Risk Adjustment Model Econometric Specifications

To account for geographic variation in beneficiary and market level characteristics, the methodology risk adjusts all the outcome measures described above. The outcome measures are treated as the dependent variable, and regional variation in the dependent variables is analyzed using the residuals from the risk adjustment analysis. The risk adjustment analysis relies on an average residuals approach. To implement this approach, the following specification is estimated for each year of analysis:

$$Y_i = \beta X_i + \varepsilon_i \quad (4.1)$$

In equation (4.1), Y_i, represents the dependent variable (expenditures, quality, or utilization) for beneficiary i, β represents the coefficients estimating the relationship between the dependent and the independent variables represented by X_i, and ε_i represents the error term. The dependent variable represents the outcomes described in Section 3. Equation (4.1) is estimated at the beneficiary level (or the event level for the disease cohort analysis) using the Ordinary Least Squares (OLS) regression method.

The outcome variable, Y_i, is calculated on a monthly basis. For example, in the expenditure analysis, Y_i represents average spending *per month*. Calculating average per-month costs removes the effect of increased expenditures or utilization at different points in the treatment of a condition, such as at the beginning. Weighting the outcomes gives more influence to beneficiaries who are enrolled for a longer period, in essence counting beneficiaries for each

of their months of enrollment. Although all risk adjustment models use this weighting scheme, the discussion below assumes all observations are equally weighted for expositional clarity.

After estimating β using OLS, the average residual is computed for each region in each year using the following formula:

(4.2) $$\overline{e_R} = \frac{\sum_{i=1}^{N_R} e_i}{N_R}$$

In equation (4.2), $\overline{e_R}$ represents the average residual for region *R*, e_i represents the residual for beneficiary (or event) *i*, and N_R represents the number of beneficiaries (or events) in region *R*. The residual for individual *i*, e_i, is calculated as the difference between the observed (or "actual") value of the dependent variable, Y_i, minus the predicted value of the dependent variable, $\hat{Y}_i = \hat{\beta} X_i$ where $\hat{\beta}$ denotes the OLS estimates of the coefficients, β. The sum $\sum_{i=1}^{N_R} e_i$ is calculated for all beneficiaries in region *R*.

These risk adjustment factors are added to average spending to create a risk adjusted value of spending for each region in each year, $\widetilde{Y_R}$, which can be expressed as follows:

(4.3) $$\widetilde{Y_R} = \bar{Y} + \overline{e_R}$$

In equation (4.3), $\bar{Y}$ is equal to the average predicted value of the dependent variable across all regions.

Several regression specifications ("clusters", defined below) risk-adjust dependent variables to account for the market level independent variables found in Appendix C.4. These risk adjustment analyses are calculated in the same way described above, but the following specification is estimated for each year of analysis:

(4.4) $$Y_i = \beta X_i + \gamma Z_R + \varepsilon_i$$

In equation 4.4, Y_i, represents the dependent variable (expenditures, quality, or utilization) for beneficiary *i*, β represents the coefficients estimating the relationship between the dependent and the beneficiary level independent variables represented by X_i, γ represents the coefficients for the market level independent variables represented by Z_R for the beneficiaries' region *R*, and ε_i represents the error term. Equation 4.4 is estimated at the beneficiary level and the market level independent variables (Z_R) are assigned to each beneficiary based on the region in which they reside.

To test model sensitivity and the impact of beneficiary and market level independent variables on each dependent variable, the studies separately risk adjust dependent variables for

ten unique "clusters"[32] of independent variables, which can be found in Appendix C.1 for the Medicare analysis and Appendix C.2 for the Medicaid analysis. Cluster 2, the baseline model, includes the following independent variables: beneficiary age, sex, health status (HCCs), income/pharmacy benefit, partial year enrollment, the interaction between age and sex, a new enrollee indicator, and an indicator for the year of analysis. The baseline model independent variables are chosen to be available to all subcontractors and promote consistency across analyses. The cluster analyses allow researchers flexibility to evaluate model sensitivity and answer diverse research questions when interpreting results of the aggregate analysis. For example, the choice of whether to compare the risk-adjusted dependent variables using the baseline model versus cluster 5, which includes additional race and income variables, depends on whether the impact of race and income on those dependent variables is of interest. In addition, certain independent variables are only accessible to particular IOM subcontractors as a result of differential data sources and other factors, so various clusters are constructed with a common set of variables to facilitate comparisons across subcontractor analyses while other clusters isolate variables specific to selected subcontractors. For example, cluster 9 includes all independent variables common to each subcontractor while cluster 10 includes independent variables unique to the Medicare and Medicaid analysis.

Only the quality measures that are outcome measures are risk-adjusted. Outcome measures assess the ultimate results of health care, and must be risk adjusted to take into account beneficiary factors. For example, the COPD admission rate should be adjusted for beneficiary health status to avoid penalizing regions with beneficiaries that are sicker. Process measures assess procedures that should be performed for all beneficiaries with a given condition, and thus, they should not be adjusted for beneficiary factors. For example, all beneficiaries with diabetes should have a screening for diabetic retinal disease, regardless of their gender or health status. The classifications of each quality measure can be found in Appendix B.4. All quality measures that are risk adjusted, other than the PQI measure for the aggregate cohort, using the baseline model applied to a logistic regression rather than an OLS regression because the outcomes are binary. The reported risk adjusted values for each episode are the observed measure divided by the expected measure multiplied by the measure national mean across all episodes. The HRR level mean for each quality measure is the average of these risk-adjusted quality outcomes for each measure. The PQI composite measure, on the other hand, uses OLS because the outcome is a count of events during the course of the observation window, while the IQI and PSI composite measures use logistic regression in the same manner as the cohort specific quality measures. The composite quality measures are not weighted to account for precision due to the number of

[32] The term "cluster" in this report refers to regression specifications.

events in a region (as the AHRQ software does), so that the analysis can observe all variation in quality.

4.2 Independent Variables Used in the Risk Adjustment Model

This analysis risk adjusts spending, utilization, and quality across regions to control for differences due to variation in patient case mix and in the price of medical care. Risk adjustment controls for factors that can influence spending but are outside the provider's control. The independent variables used for risk adjustment were chosen in consultation with IOM and were designed to be as consistent as possible across the Medicare and Medicaid analyses as well as the commercial analyses performed by other subcontractors to IOM. To account for patient case mix, the methodology employs a set of beneficiary-level characteristics which are described in Section 4.2.1. In addition, some factors in the market can also affect spending and quality in a region, such as the percent of people uninsured or the supply of physicians. Section 4.2.2 describes the set of market-level characteristics that this analysis uses for a separate set of regression specifications.

4.2.1 Beneficiary-Level Characteristics

The methodology gathers beneficiary-level information from Medicare and Medicaid claims to account for patient case mix. The Medicare analysis includes the following beneficiary-level characteristics:

- Age
- Sex[33]
- Age-sex interaction
- Race and ethnicity
- Income
- Health status
- Institutionalization status
- Dual enrolled status
- New enrollee indicator
- Partial year enrollment
- Supplemental Medicare insurance
- DRG and other inpatient claim information (only used for IQI and PSI quality measures)

Appendix C.3 contains a complete listing of the definitions of beneficiary-level independent variables. Several adjustments are made for the Medicaid analysis to account for the specific features of the Medicaid program and data structure. First, the Medicaid analysis does

[33] The prostate cancer cohort is not risk adjusted for beneficiary sex.

not risk-adjust using the beneficiary's income because this information is not available in the enrollment or claims files. Second, because all dual-enrolled beneficiaries are included only in the Medicare analysis, the Medicaid analysis does not risk-adjust for dual-enrolled status. Third, the Medicaid analysis does not risk-adjust using supplemental Medicare insurance because enrollment in Medicaid is considered supplemental Medicare insurance; thus, all Medicaid beneficiaries would have the same value for this indicator. Finally, the Medicaid analysis additionally includes a state indicator for each beneficiary for certain levels of the analysis.

Risk adjusting for health status allows the methodology to account for the change in cost associated with beneficiaries' varying levels of health. The analysis utilizes CMS' 2008 definition of Hierarchical Condition Categories (HCCs) as an indicator of health status. CMS uses HCCs within its risk adjustment model used to determine capitation payments to Medicare Advantage plans.[34] HCCs aggregate ICD-9 diagnosis codes into clinical categories to determine beneficiaries' health status and comorbidities. Like the CMS-HCC model, this analysis examines beneficiaries' claims for the 12-month period prior to their observation start date to identify their health status. Areas with higher utilization levels will also have more HCCs, as beneficiaries in those areas have diagnoses recorded more often. Thus, beneficiaries in high-use areas will appear somewhat sicker, and risk adjustment may bias the regression estimates toward a better (i.e., lower cost, higher quality) result.[35] The Medicare analysis does not include the HCC interaction terms that use dual-enrollment status. Though dual-enrollment status may be predictive of health status, it is not, in itself, a health status indicator. Thus, the Medicare analysis includes a dual-enrollment indicator in certain clusters but does not tie it to the health status indicators.

Finally, to account for other factors that influence the price of medical care, the commercial subcontractors to the IOM utilize beneficiary-level employer and insurer characteristics. However, because the Medicare and Medicaid claims data do not have information regarding employer characteristics, the risk adjustment approach does not include employer information.

4.2.2 Market-Level Characteristics

To account for differences in spending, utilization, and quality due to the differing prices of care across regions, the risk adjustment employs a set of market-level variables. These market-level characteristics include:

- Hospital competition

[34] Gregory C. Pope et al., "Evaluation of the CMS-HCC Risk Adjustment Model," *RTI International and the Centers for Medicare & Medicaid Services*(March 2011), https://www.cms.gov/MedicareAdvtgSpecRateStats/downloads/Evaluation_Risk_Adj_Model_2011.pdf.
[35] Medicare Payment Advisory Commission, "Regional Variation in Medicare Service Use: Report to Congress," (January 2011), http://www.medpac.gov/documents/Jan11_RegionalVariation_report.pdf.

- Percent of population uninsured
- Supply of medical services per capita
- Malpractice environment risk
- Physician composition per capita
- Access to care
- Payer mix
- Medicaid penetration
- Health professional mix per capita
- Percent of beneficiaries with supplemental Medicare insurance

These variables are meant to capture the underlying causes of the variation in prices of care. The market-level characteristics are listed in Appendix C.4. The market-level variables are drawn from the following data sources:

- Medicare Enrollment Database (EDB)
- Area Resource File (ARF)[36]
- Medicare Physician Fee Schedule (MPFS)[37]
- InterStudy Health[38]
- American Hospital Association (AHA)[39]
- National Association of County and City Health Officials (NACCHO).[40]

This analysis uses an adjustment factor to calculate the per-capita health professional mix variable from the ARF. Though the ARF includes a population estimate for most counties for each year, some counties do not have a population estimate for a given year. For counties with no population estimate for a year of analysis, the methodology inflates the county's 2000 United States Census population count (which can be found in the ARF) assuming a growth rate equal to the average national population growth rate:

$$Adj.Pop_{j,t} = Pop_{j,2000} \times \frac{\sum_j Pop_{j,t}}{\sum_j Pop_{j,2000}} \quad (4.5)$$

[36] "Area Resource File (ARF)," US Department of Health and Human Services, Health Resources and Services Administration, Bureau of Health Professions, http://arf.hrsa.gov.
[37] "Medicare Physician Fee Schedule (MPFS)," Centers for Medicare & Medicaid Services, https://www.cms.gov/apps/physician-fee-schedule/overview.aspx.
[38] HealthLeaders-InterStudy, http://hl-isy.com/.

In equation 4.5, $Adj.\ Pop_{j,t}$ represents the adjusted population for county j in year t. $Pop_{j,t}$ represents the population estimate for county j as found in the ARF for year t, and $\sum_j Pop_{j,t}$ indicates the sum of the ARF population estimates for all counties, or the national population estimate in the ARF, for year t. For example, for a county with no population estimate in 2007, the analysis would calculate the adjusted population for that county as that county's population in 2000 multiplied by the national population in 2007 and divided by the national population in 2000. This adjustment avoids underestimating the population of counties that do not have a population estimate for a given year of analysis. In addition, if a county does not have data for a given year for any market-level variable, the methodology uses the most recent data available. As a result, an area's market-level variable could be the same for multiple years of analysis. For example, if a county has data for 2008 but not for 2009 for a given market-level variable, the 2009 analysis will assign that variable the same value as the 2008 analysis.

5 GEOGRAPHIC VARIATION IN MEDICARE SPENDING AND UTILIZATION

Using the methodology described in the previous three chapters, this section aims to answer the six research questions posed at the start of these report.

1. How much variation is there in per capita volume of healthcare services across the nation?
2. What are the potential savings from adopting the best practices of regions with the lowest utilization levels?
3. Are regions with high utilization levels likely to have high utilization rates in the future?
4. Is the variation in the volume of medical services greater within or across regions?
5. Do regions that provide a high volume of medical services when treating beneficiaries for a given disease also provide a high volume of medical services when treating all other diseases?
6. What types of services are the primary drivers of regional variation in the utilization of medical services?

Although the empirical analyses define regions alternatively as HRRs, MSAs and HSAs, for brevity this section only discusses analysis of regional variation at the HRR level. The following six sections answer each of these research questions in turn.

5.1 Variation in Spending Across the Nation

Medicare spending exhibits many of the defining characteristics of healthcare spending distributions across payers. Table 5.1 presents per capita monthly spending levels before price-standardization or risk adjustment by beneficiary criteria for the aggregate cohort in the 2007 through 2009 analysis period.[41] The distribution is heavily right-skewed as the median cost ($310) is far below the mean cost ($964). In addition, there exist a large number of beneficiaries that do not incur any Medicare expenditures over the year. In fact, over ten percent of all beneficiaries have $0 spending per month. The large number of beneficiaries with $0 spending

[41] Expenditures are calculated for each episode as average monthly expenditures. Each beneficiary may have more than one episode per period of analysis. All analyses use expenditures weighted by the number of months the beneficiary is enrolled during the observation window. For simplicity, the remainder of this report refers to the episode-month as the beneficiary.

and the right-skewed distribution of Medicare spending levels are similar to findings of previous studies of Medicare spending and of healthcare spending in other settings.[42,43]

Table 5.1: Medicare Average Monthly Cost by Beneficiary Characteristic

Category	# Episodes (millions)	Avg.	Std. Dev.	Min	Percentile			Max	90-10 Difference
					10th	50th	90th		
All	104.7	$964	$6,791	$0	$0	$310	$2,565	$1,624,496	$2,565
Female	58.2	$991	$6,452	$0	$16	$351	$2,619	$538,869	$2,604
Male	46.6	$931	$7,191	$0	$0	$257	$2,490	$1,624,496	$2,490
White	87.5	$940	$6,512	$0	$2	$312	$2,501	$1,624,496	$2,499
Black	10.7	$1,190	$8,569	$0	$0	$304	$3,333	$491,706	$3,333
Asian	2	$828	$6,343	$0	$0	$299	$1,883	$260,717	$1,883
Hispanic	2.3	$1,153	$7,915	$0	$0	$353	$3,133	$403,307	$3,133
Other	2.1	$818	$6,606	$0	$0	$214	$2,070	$336,245	$2,070
Unknown	0.2	$833	$7,964	$0	$0	$109	$2,302	$448,033	$2,302
Dual	21.7	$1,594	$9,034	$0	$48	$689	$4,174	$1,597,797	$4,125
Non-Dual	83.1	$803	$5,953	$0	$0	$252	$2,100	$1,624,496	$2,100
Alive During Entire Episode	100.2	$857	$5,780	$0	$0	$297	$2,273	$1,624,496	$2,273
Died During Episode	4.6	$5,214	$14,413	$0	$442	$3,742	$11,394	$1,320,817	$10,952

The right-skewed nature of the Medicare per capita spending levels persists even after removing variation due to regional differences in prices, patient demographics, and observed beneficiary severity of illness. Table 5.2 displays per capita spending levels after price-standardization and risk adjustment. Because this analysis applies an OLS regression, risk adjustment standardizes the average monthly cost across beneficiaries types identified as explanatory variables in the model; this modeling produces an average monthly risk-adjusted cost that is equal for all beneficiary criteria (except death/non-death, as this methodology did not risk-adjust for episode outcome as a beneficiary-level variable). For the aggregate cohort, the average price-standardized monthly cost is $958, while the median is $729, showing that spending levels are still heavily right-skewed, but not as much as the unadjusted figures. The skewness of the distribution can also be seen in the difference between the most extreme values and the top and bottom 10th percentile; the difference between the 10th percentile and the minimum is between

[42] Amy Finkelstein and Robin McKnight, "What did Medicare do? The initial impact of Medicare on mortality and out of pocket medical spending," *Journal of Public Economics* 92, no. 7 (2008).
[43] Naihua Duan et al., "A Comparison of Alternative Models for the Demand of Medical Care," *Journal of Business & Economic Statistics* 1, no. April 1983, http://www.jstor.org/stable/1391852.

$12,000 and $17,000 for all criteria, while the difference between the 90th percentile and the maximum ranges from $250,000 to $1,630,000. Similar results can be found for the AMI, CHD, diabetes, and stroke episode cost distributions, which are presented in Appendix D.

Table 5.2: Medicare Average Price-Standardized Risk Adjusted Monthly Cost

Category	# Episodes (millions)	Avg.	Std. Dev.	Min	Percentile			Max	90-10 Difference
					10th	50th	90th		
All	104.7	$958	$5,666	-$16,821	-$28	$729	$2,089	$1,631,068	$2,117
Female	58.2	$958	$5,354	-$15,433	-$26	$718	$2,138	$525,144	$2,164
Male	46.6	$958	$6,033	-$16,821	-$31	$750	$2,026	$1,631,068	$2,057
White	87.5	$958	$5,537	-$16,821	-$12	$727	$2,096	$1,631,068	$2,108
Black	10.7	$958	$6,672	-$16,780	-$213	$716	$2,208	$487,355	$2,421
Asian	2	$958	$4,909	-$12,952	$140	$843	$1,648	$255,445	$1,509
Hispanic	2.3	$958	$6,269	-$15,032	-$150	$727	$2,163	$404,324	$2,312
Other	2.1	$958	$5,212	-$13,126	$101	$851	$1,707	$290,940	$1,605
Unknown	0.2	$958	$6,883	-$12,098	$99	$707	$1,792	$516,429	$1,692
Dual	21.7	$958	$7,492	-$16,821	-$414	$486	$2,823	$1,595,705	$3,237
Non-Dual	83.1	$958	$5,083	-$16,780	$96	$754	$1,919	$1,631,068	$1,823
Alive During Entire Episode	100.2	$923	$5,008	-$13,706	$6	$727	$1,969	$1,631,068	$1,963
Died During Episode	4.6	$2,336	$13,157	-$16,821	-$1,932	$1,134	$7,811	$1,317,830	$9,743

Although the effect of death on episode costs is inherently uncertain, this analysis concludes that death episodes are among the most expensive Medicare episodes. Episodes ending in death are truncated and thus Medicare may avoid paying for services that the beneficiary would have otherwise incurred had they lived through the entire year; on the other hand, beneficiaries who die during the year may experience an increase in the utilization of intensive, high-cost treatments may be performed in an attempt to prolong the beneficiary's life. On average, however, death episodes are high cost; although only 4.4 percent of beneficiaries die each year, over half of these beneficiaries fall into the top decile of Medicare spending. Although controlling for patient case mix decreases the share of death episodes in the top decile of overall episode costs, death episodes still cost much more on average ($2,336) than non-death episodes ($923).

The variability in the aggregate cost distribution across beneficiary criteria, measured using the standard deviation and 90-10 difference, is highest among beneficiaries who died during their

episodes and—to a lesser extent—among dual-eligible beneficiaries. While the standard deviation in costs for all beneficiaries is $5,666, the standard deviation for beneficiaries whose episodes ended in death is $13,157. Similarly, the 90-10 difference—which is defined as the difference in spending levels for beneficiaries at the 90th and 10th percentiles of the episode cost distribution—is $2,117, while the 90-10 differences for beneficiaries whose episodes ended in death are $9,743,. Dual-eligible beneficiaries who are enrolled in Medicare and Medicaid also have higher variability in costs, but the variability is not as large as for patients that die during the episode. The standard deviation of average Medicare spending for dual-eligibles is $7,492 and the 90-10 difference is $3,237. These figures are 47 percent and 76 percent higher than the corresponding variability statistics for non-dual beneficiaries.

Although not shown, this study reveals that the average monthly cost and variability for beneficiaries with acute conditions generally is higher than for beneficiaries who have chronic conditions. The average monthly cost in the year after a beneficiary has an AMI or stroke are $5,591 and $5,047, respectively, and the average monthly costs for beneficiaries with CHD and diabetes are $1,960 and $1,632, respectively, as presented in Appendix D. The standard deviations of AMI and stroke are $13,980 and $11,959, and the standard deviation of CHD and diabetes are considerably lower, at $8,570 and $7,664. Though the acute cohorts have higher averages and more variability, the chronic cohorts have more high-cost outliers. These high-cost outliers are more likely to occur for chronic episodes because the number of chronic episodes is almost 18 times the number of acute episodes. In addition, though chronic conditions that are well-managed can be low-cost, chronic conditions that are not well-managed can result in extremely high costs.

5.2 Potential Cost Savings

According to the United States Government Accountability Office, rising health care costs is a "fundamental driver" of the federal government's future fiscal imbalances.[44] To the extent that provider practice patterns drive costs, if all providers could mirror best practices the result might fundamentally alter our fiscal trajectory. This section explores the potential cost savings Medicare could realize if all beneficiaries utilized the same amount of medical services as beneficiaries living in the lowest-volume regions.

To answer this question, Figure 5.1 presents potential costs savings if each HRR's average unadjusted monthly cost per beneficiary is applied to all other HRRs. Figure 5.2 presents the potential cost savings when controlling for regional variation in prices, and Figure 5.3

[44] "The Federal Government's Long-Term Fiscal Outlook," United States Government Accountability Office, http://www.gao.gov/assets/590/589835.pdf.

contains the potential cost savings after price standardization and risk adjustment.[45] In these three figures, '0' on the horizontal axis corresponds to the HRR with the lowest average costs per beneficiary-event, and the dollar value on the vertical axis indicates the total potential cost savings if all HRRs had identical average monthly costs per beneficiary. Appendix E displays cost savings information using the price-standardized risk adjusted costs for Medicare beneficiaries in the AMI, stroke, diabetes, and CHD cohorts. Negative cost savings indicate that the HRR has an average monthly cost that is above the national average and that switching beneficiary utilization levels to that HRR would increase total Medicare spending. The ordering of the HRRs in the three graphs is not necessarily the same.

Figure 5.1: Annual Savings from Reducing Spending to Lower Cost HRR

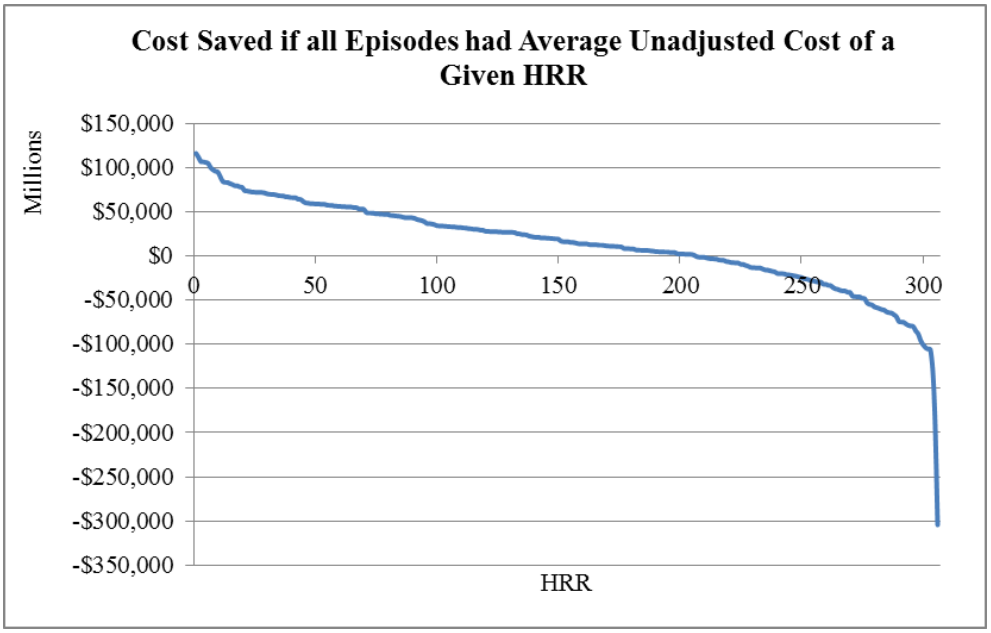


Figure 5.2: Annual Savings from Reducing Utilization to Lower Cost HRR

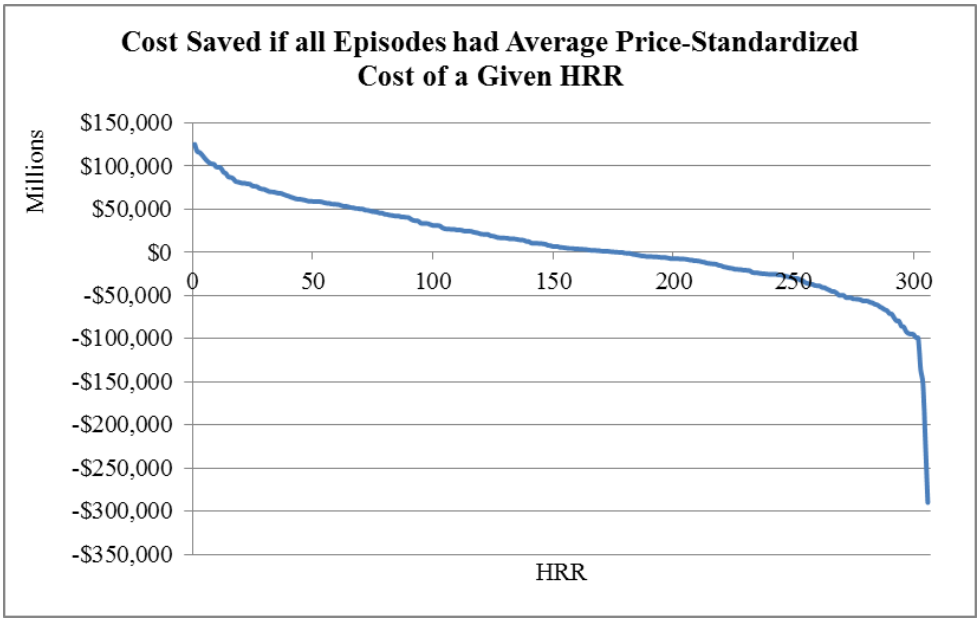
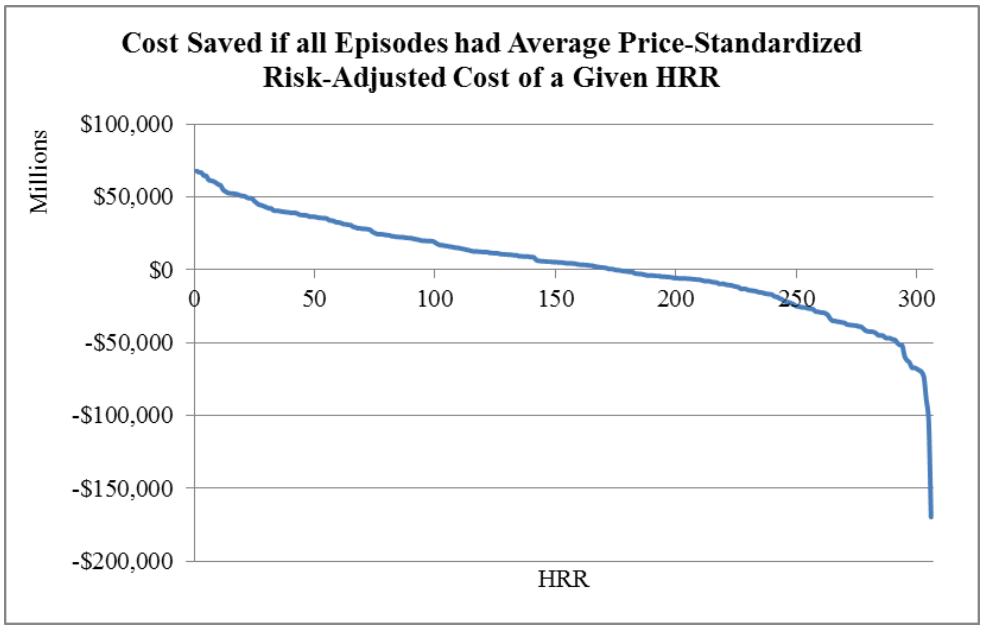


Figure 5.3: Annual Savings from Reducing Utilization to Lower Cost HRR, Risk Adjusted



This analysis shows that if all Medicare beneficiaries used the same amount of services as beneficiaries in the lowest cost region, Medicare could potentially save hundreds of billions of dollars. Grand Junction, CO only spends an average of $666 per beneficiary per month whereas the average Medicare HRR spends $964 per month on the average beneficiary. If Medicare could move all fee-for-service beneficiaries to spending levels similar to those in Grand Junction, total costs would decrease by 31 percent. A 31 percent reduction in Medicare costs is equivalent

to $116 billion of annual savings (as shown in Figure 5.1). After adjusting for geographic variation in prices and in the health status of beneficiaries, Rochester, NY is the lowest cost HRR with an average beneficiary spending level 18 percent below the adjusted national average. If all Medicare beneficiaries had the same utilization levels as beneficiaries in Rochester (controlling for case mix), Medicare's potential cost savings is still $68 billion yearly (shown in Figure 5.3). Medicare could achieve significant costs savings even it could reduce utilization levels to HRRs at the 10th percentile (11 percent savings) or even the 25th percentile (7 percent saving). All regions will certainly not achieve uniform efficiency, and the regional cost differences that remain after controlling for price and patient health status are almost certainly not completely due to discretionary provider practices, but these findings illustrate the theoretical total cost savings.

Even if Medicare cannot move all beneficiaries towards utilization levels of the lowest cost HRRs, if Medicare could accomplish this feat for certain beneficiary cohorts it could still save billions of dollars. Figure 5.3 presents the maximum possible savings for four disease cohorts if all beneficiaries in these cohorts had the same average costs as beneficiaries in the lowest cost HRR (after price standardization and risk adjustment). As shown in the second column of the table, potential cost savings per beneficiary are over twice as high for the acute conditions as for the chronic conditions. However, because many more Medicare beneficiaries have a chronic disease than an acute disease in a given year, the total cost savings are over six times as high for the chronic conditions than for acute conditions (as shown in the third column of the table). Although these figures indicate that potential cost savings from reducing regional variation in per capita utilization levels are large, the following sections provide additional analysis to evaluate whether these potential cost savings could feasibly be realized.

Table 5.3: Potential Monthly and Yearly Savings by Cohort

Cohort	Per-Beneficiary Monthly Savings	Yearly Savings (billions)
Aggregate	$174	$67.8
AMI	$1,060	$3.2
Stroke	$1,110	$2.1
CHD	$392	$27.9
Diabetes	$373	$26.4

5.3 Stability of Medical Service Volume over Time

Although the previous section describes the billions of dollars that could be saved if beneficiary utilization fell to the utilization levels of the lowest volume HRR, these savings may only be realizable if HRRs that have low utilization rates one year also have low utilization rates

in subsequent years. If the same HRRs remain low volume regions across years, this finding suggests that there exist persistent differences in provider practice patterns, beneficiary treatment preferences or other time-invariant factors. On the other hand, if the lowest volume regions in one year are high-volume the next, then variation in utilization rates may be the result of random noise rather than any time-invariant cultural or institutional characteristics. To determine whether or not medical service utilization is constant over time, the following analysis measures the correlation of HRR average expenditures and rankings over time.

Within the years 2007 through 2009, relative utilization levels across HRRs are stable over time. Figure 5.4 provides a scatterplot of each HRRs rank by price-standardized risk adjusted cost for the aggregate cohort in 2007 and 2008. The figure indicates a strong persistence of HRR utilization levels across time. Figure 5.4 and Figure 5.5quantify the strength of this relationship. Figure 5.4 shows that the unweighted Pearson correlation coefficients are above 0.95 for all mean price-standardized, risk adjusted cost year-to-year comparisons. Although not shown, the Pearson correlations are above 0.92 when using the median cost. The unweighted Spearman rank correlation coefficients presented in Figure 5.5 are similarly high. For all mean year-to-year comparisons of the aggregate cohort the Spearman rank correlation coefficients are above 0.94. Using median HRR cost, the Spearman rank correlation is 0.91. This evidence indicates that relative medical service volume across HRRs is stable over time; random variation is unlikely to be generating outlier HRR utilization levels.

Figure 5.4: HRR Utilization Rank 2007-2008

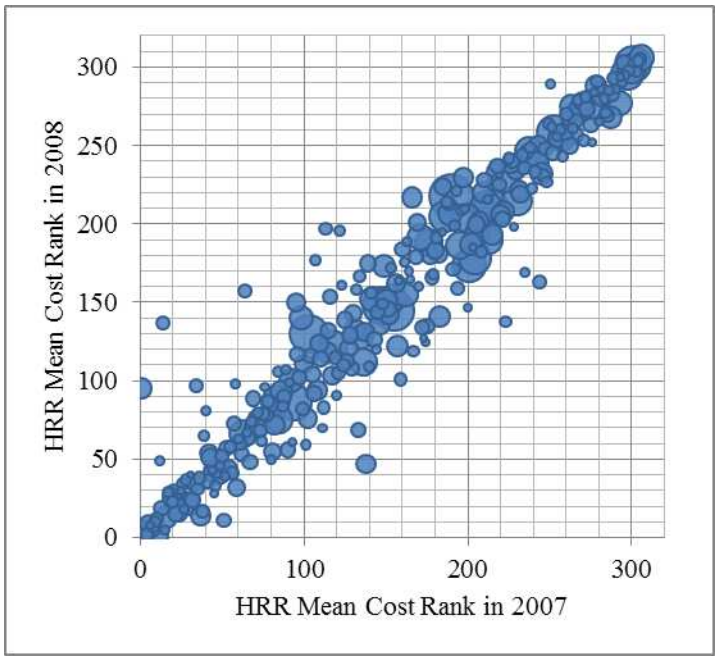


Table 5.4: Pearson Correlation for Standardized Risk-Adjusted Costs

	2007	2008	2009
2007	1.000	0.967	0.953
2008	0.967	1.000	0.971
2009	0.953	0.971	1.000

Table 5.5: Spearman Rank Correlation for Standardized Risk-Adjusted Costs

	2007	2008	2009
2007	1.000	0.963	0.942
2008	0.963	1.000	0.965
2009	0.942	0.965	1.000

The average HRR-level volume of services used by Medicare beneficiaries in specific cohorts also is highly persistent over time, but beneficiaries with chronic conditions have higher correlations over time than beneficiaries with acute conditions. Figure 5.5 presents the 2007 HRR's relative ranking based on utilization compared to its relative ranking in 2008 measuring utilization as monthly price-standardized risk adjusted cost. This figure indicates a high level of persistence for the diabetes cohort, which has a weighted Pearson correlation score of 0.971, and Figure 5.6 presents the same figure for the cholecystectomy cohort, which has one of the lowest Pearson correlation scores, at 0.457. While the diabetes graph shows a near-linear relationship between 2007 rank and 2008 rank, the cholecystectomy graph appears much more scattered and shows a weaker relationship, especially for HRRs with fewer episodes. Appendix F presents the weighted Pearson and Spearman rank correlation coefficients for the AMI, stroke, CHD, and diabetes cohorts.

Figure 5.5: HRR Utilization Rank 2007-2008 (Diabetes Cohort)

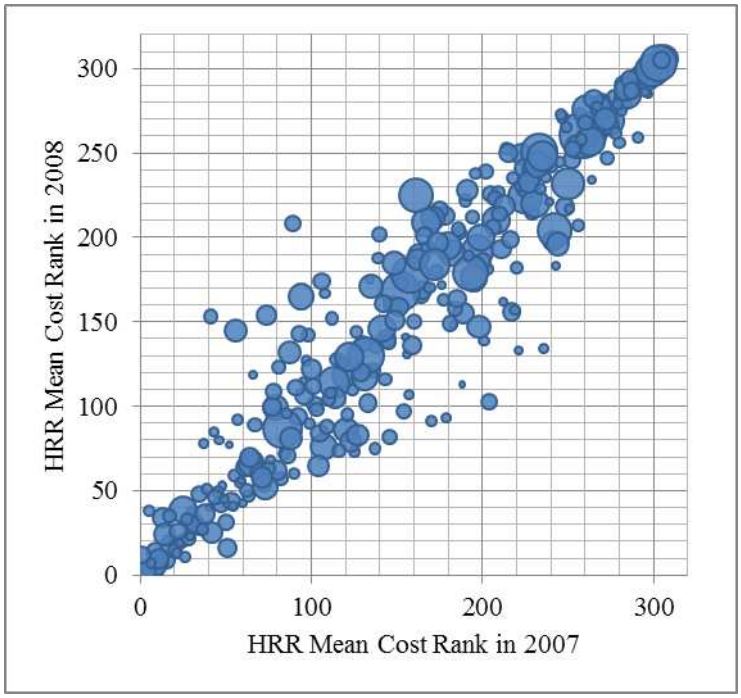
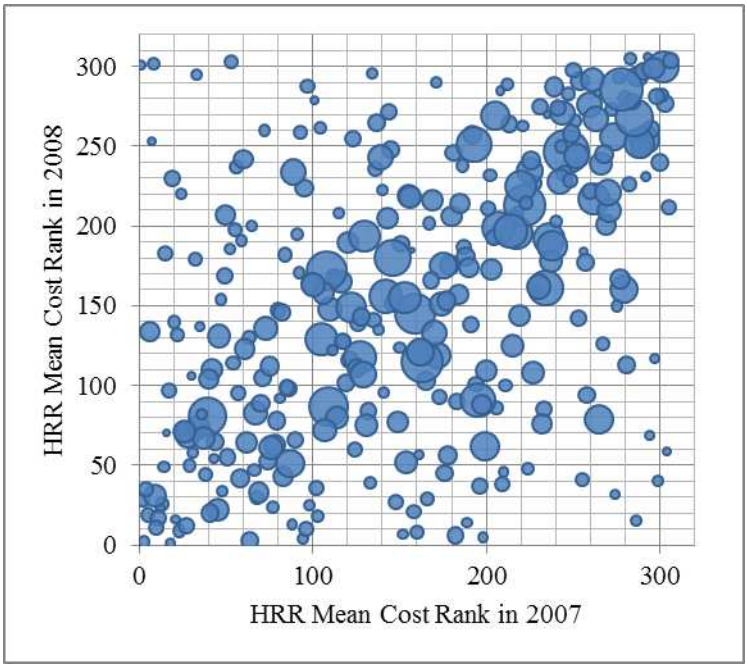


Figure 5.6: HRR Utilization Ranks 2007-2008 (Cholecystectomy Cohort)



Though the correlation of costs and ranks over time is high for some cohorts, this analysis cannot determine whether the correlation is due to provider culture, beneficiary preferences, or other factors. Further, for the chronic cohort, the high levels of correlation may be due in part to

the fact that the same beneficiaries may appear in multiple chronic cohorts. Beneficiaries with chronic conditions will have chronic conditions for life. Thus, the beneficiaries who have a chronic condition in one year are largely the same beneficiaries who had the condition the year before, while for acute conditions the cohorts are largely different sets of beneficiaries each year. Although HRR utilization rankings are stable across the time period of this study, 2007 through 2009, further study is needed to identify whether these patterns persist over a longer time frame.

5.4 Variation in Volume of Medical Services Within and Across Regions

Although the relative rankings of average HRR medical service utilization are persistent over time, there exists substantial variation in health care expenditures and utilization within regions. Specifically, health care expenditures and utilization differ *across* regions on average, but regional differences in average spending and utilization are significantly smaller than variation in beneficiary utilization levels *within* a given region. Throughout this section, variation in spending and utilization calculated using data for beneficiaries residing in a given region is referred to as "within-HRR" variation whereas "across-HRR" variation refers to dispersion in average HRR spending and utilization across the nation. Average HRR spending and utilization refers to the average over all beneficiaries residing in an HRR. The finding that within-HRR variation is significantly larger than across-HRR variation indicates that it may be more productive to target high-cost beneficiaries regardless of location rather than focus efforts on reducing utilization for the average beneficiary in a high cost region.

To measure within- and across-HRR variation, this analysis employs two measures of dispersion: standard deviation and the 90-10 difference. To determine within-HRR variation, this analysis calculates the standard deviation and 90-10 difference using beneficiary observations for beneficiaries residing in a given HRR. The standard deviations and 90-10 differences for each HRR are then averaged over all HRRs to generate two measures of within-HRR dispersion. To determine across-HRR variation, this analysis calculates average spending and utilization within each region using beneficiary observations for beneficiaries residing in that region and measures the standard deviation and 90-10 difference of these HRR averages. Table 5.6 presents several measures of within- and across-HRR variation for unadjusted, price-standardized, and price-standardized risk-adjusted expenditures. Unadjusted measures of dispersion are misleading because they do not adjust for important differences across regions, including differences in Medicare payment levels and in beneficiary characteristics. Risk adjustment reduces variation due to beneficiary characteristics, resulting in lower within- and across-region variation for the risk-adjusted costs.

Within-HRR variation in spending and utilization is an order of magnitude larger than the across-HRR variation. The average standard deviation within HRRs of price-standardized risk-

adjusted expenditures is $5,421, whereas the standard deviation of average costs across HRRs is $84. Similarly, the average 90-10 difference within HRRs is $2,094, while the 90-10 difference across HRRs of the average HRR cost is $208. The weighted averages of the standard deviation and 90-10 differences (which weight HRRs based on the count of beneficiary-months contained in the HRR rather than treating each HRR equally) are even higher than the unweighted averages. Within-region variation is also higher than across-region variation for unadjusted and price-standardized expenditures.

The qualitative relationship between within-HRR and across-HRR variation also holds for all condition cohorts; in particular, the AMI, stroke, CHD, and diabetes cohorts have considerably higher within-HRR variation than across-HRR variation. Appendix G presents within- and across-HRR variation for each of these condition cohorts. Of the condition cohorts, the acute conditions tend to have both larger within-region variation and larger across-region variation, though the cataract cohort, an acute procedure cohort, has the lowest within- and across-region variation of all cohorts. The cholecystectomy, cataract, and pneumonia cohorts have shorter observation periods, which may result in more variability in monthly episode costs.

Table 5.6: Dispersion of Medical Service Utilization Within and Across Regions

	Unadjusted	Price-Standardized	Price-Standardized Risk-Adjusted
Average of HRR Standard Deviations	$6,364	$6,354	$5,421
Standard Deviation of HRR Means	$129	$135	$84
Average of HRR 90-10 Differences	$2,479	$2,498	$2,094
90-10 Difference of HRR Means	$304	$322	$208

To reconcile the observations that i) there exists significant stability in HRR rank across years and ii) within-HRR variation is an order of magnitude larger than the across-HRR variation, one can examine whether the "typical" or "outlier" beneficiaries are causing the persistence in HRR utilization levels across time.

Figure 5.7 and Figure 5.8 present the rank of the HRRs by mean price-standardized risk adjusted cost versus the rank by median and by the 90th percentile cost, respectively, for the aggregate cohort for three years of analysis. While there is a moderate level of correlation between an HRR's mean and median utilization levels, and mean and median rank is somewhat high for the highest- and lowest-ranked HRRs, the relationship is weak in general. The relationship between the mean and the 90th percentile rank, however, is strong for all HRRs. These figures illustrate that stability of average HRR utilization levels across years is due to the persistence in the cost of treating the highest-cost beneficiaries rather than the cost of treating beneficiaries at the median.

Figure 5.7: HRR Utilization Levels 2007-2008, Mean vs. Median

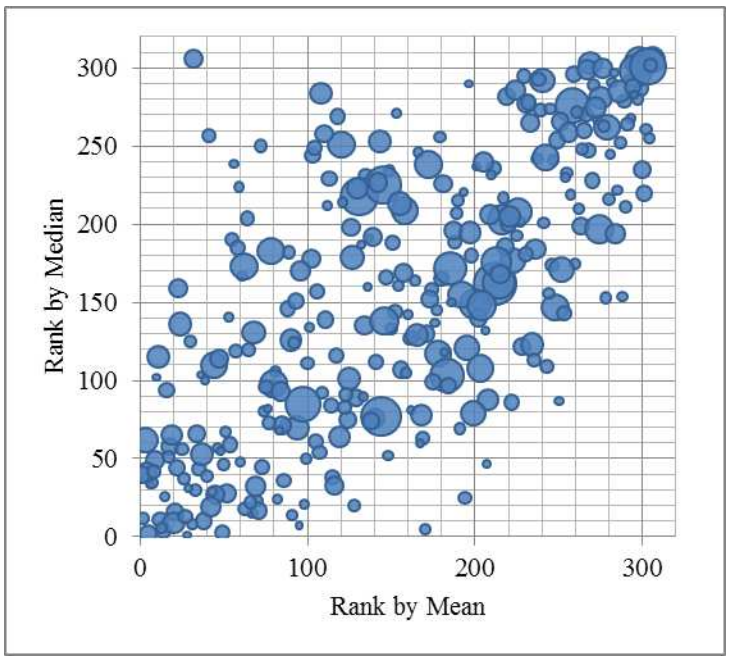
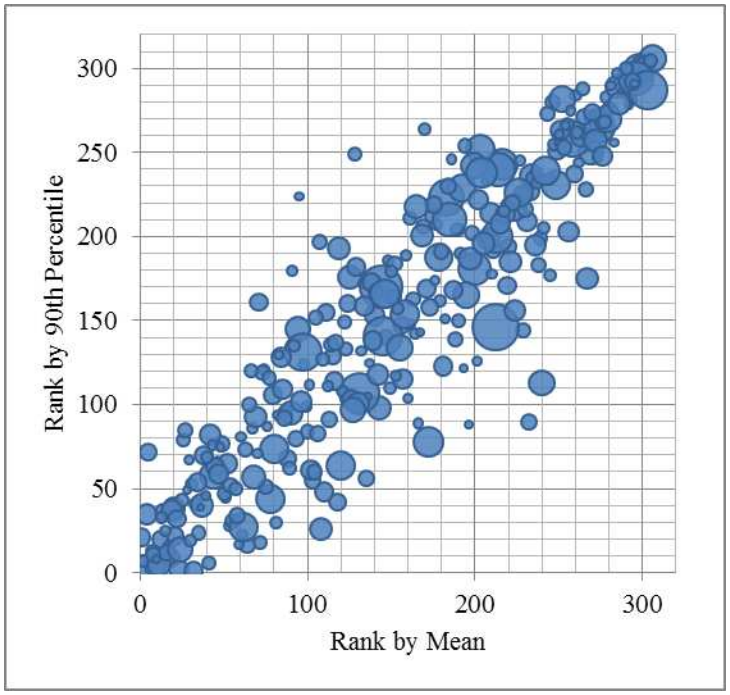


Figure 5.8: HRR Utilization Levels 2007-2008, Mean vs. 90th Percentile



5.5 Variation in Volume of Medical Services Across Condition Cohorts

To determine whether regions that have high utilization levels when treating beneficiaries with a certain condition also have high utilization levels for treating beneficiaries with other conditions, the following analysis measures the correlation of utilization across beneficiary cohorts. The correlation across cohorts can be measured using a Pearson correlation or Spearman rank correlation. The unweighted correlations give all HRRs the same weight, regardless of the number of episodes in the HRR, which allows the correlations to be influenced by all HRRs equally and allows observation of the full range of variability.

Overall, the highest unweighted Pearson correlation across HRRs of the average monthly price-standardized risk-adjusted cost is between the low back pain and aggregate cohorts, at 0.958; the lowest correlation is between the prostate cancer and cataract cohorts, at 0.230.

Figure 5.7 shows the Pearson correlation coefficients across HRRs of the average monthly price-standardized residual costs for the aggregate, AMI, stroke, CHD, and diabetes cohorts. The highest correlation is between diabetes and the aggregate cohort, at 0.957, and the lowest is between the AMI and aggregate cohorts, at 0.712. The correlations between CHD, diabetes, and the aggregate cohort are higher than the correlations between the AMI and stroke cohorts. Figure 5.8 displays the unweighted Spearman rank correlations for the same cohorts across HRRs, ranked by the average monthly price-standardized residual cost, which show similar results. The full comparison of unweighted Pearson correlations between all cohorts is presented in Appendix H.

Table 5.7: Correlation (Pearson) of Utilization Levels across Cohorts

	Aggregate	AMI	Stroke	CHD	Diabetes
Aggregate	1.000	0.712	0.803	0.915	0.957
AMI	0.712	1.000	0.781	0.731	0.739
Stroke	0.803	0.781	1.000	0.773	0.804
CHD	0.915	0.731	0.773	1.000	0.916
Diabetes	0.957	0.739	0.804	0.916	1.000

Table 5.8: Correlation (Spearman) of Utilization Levels across Cohorts

	Aggregate	AMI	Stroke	CHD	Diabetes
Aggregate	1.000	0.720	0.782	0.894	0.962
AMI	0.720	1.000	0.794	0.721	0.775
Stroke	0.782	0.794	1.000	0.746	0.827
CHD	0.894	0.721	0.746	1.000	0.923
Diabetes	0.962	0.775	0.827	0.923	1.000

The results indicate a higher correlation between beneficiaries with different chronic conditions compared to beneficiaries with different acute conditions. The highest unweighted Pearson correlation between chronic conditions is 0.948, between the COPD and CHF cohorts, while the lowest correlation is 0.767, between the CHF and arthritis cohorts. Medicare beneficiaries often have multiple chronic conditions, and the costs associated with each chronic illness will be counted toward all chronic episodes that are triggered. Beneficiaries with chronic conditions also have them for multiple years, so the same beneficiaries are often included across years. In addition, a single provider may care for a beneficiary's multiple chronic conditions, or a beneficiary may see the same type of provider for his or her chronic conditions, such as a general practitioner.

The HRR-level correlation of utilization levels for beneficiaries with acute conditions, however, is typically much lower than the HRR-level correlation for chronic condition cohorts. The lowest acute-condition correlation is 0.340, between the AMI and cataract cohorts. Certain acute conditions do have higher correlations between HRRs; for instance the HRR-level correlation between the AMI and pneumonia cohorts is 0.842. In general, the highest correlations occur between conditions that are cared for by similar providers; for example, beneficiaries with AMI and CHF are often treated by emergency room inpatient or outpatient physicians and show a high correlation of 0.824. Although AMI and CHD are both diseases of the heart, and the correlation between AMI and CHD is lower, at 0.731. This lower correlation for these two heart-related diseases may occur because AMI and CHF are treated in the inpatient setting whereas CHD is typically treated in the outpatient setting. This trend suggests that the persistence in region spending is due, in part, to the high utilization levels of beneficiaries with particular diseases who are cared for by the same types of providers.

5.6 Service Categories Driving Results

To determine whether regional differences in expenditures are driven by spending on particular services, this analysis stratifies price-standardized, risk adjusted expenditures by

service categories. Section 5.4 presents results implying that the costs of various conditions are correlated within regions. This section expands the results of Section 5.4 by examining the correlation between the costs of particular service categories and total costs within regions. This section proceeds as follows. Section 5.6.1 describes how risk-adjusted service categories are created, Section 5.6.2 analyzes the relationship between total average monthly risk-adjusted costs and the monthly risk-adjusted costs of each of the service categories, and Section 5.6.3 presents the correlations between the service categories.

5.6.1 Creating Risk-Adjusted Service Categories

This analysis examines seven service categories, which include:

- Acute care
- Post-acute care
- Prescription drugs
- Diagnostic
- Procedures
- Emergency department/ambulance
- Other

Acute care includes care provided in an inpatient setting, excluding inpatient psychiatric and rehabilitation facilities; the post-acute care category is mostly home health, skilled nursing and hospice care; and prescription drugs include drugs purchased under both the Medicare Part B and Part D programs. The diagnostic service category includes physician visits to evaluate the patient condition as well as medical test and imaging procedures. The procedures and emergency department/ambulance categories are fairly self-explanatory and the "other" category contains any claim not included in the first six groups. Appendix B.2 provides further details about these groupings, which impose a hierarchy to create mutually exclusive classifications.

To create risk adjusted costs for each service category, this study re-estimates the OLS risk model separately for each service category. The service-specific risk adjustment model uses the same explanatory variables as the cross-service model. The risk adjusted costs for each service category obtained from the risk model are weighted by the number of beneficiary-months enrolled in the HRR. These weights allow HRRs with a greater number of observations to have a larger impact on the results.

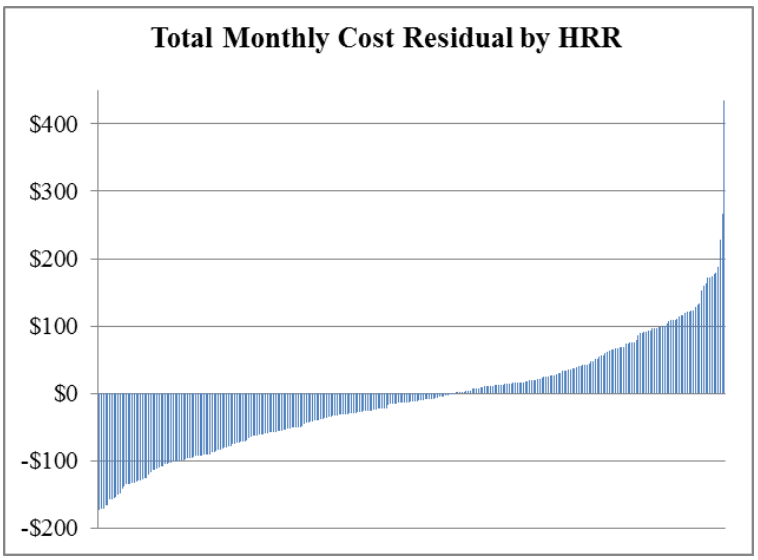
5.6.2 Relationship between Overall and Service-Specific Utilization Levels

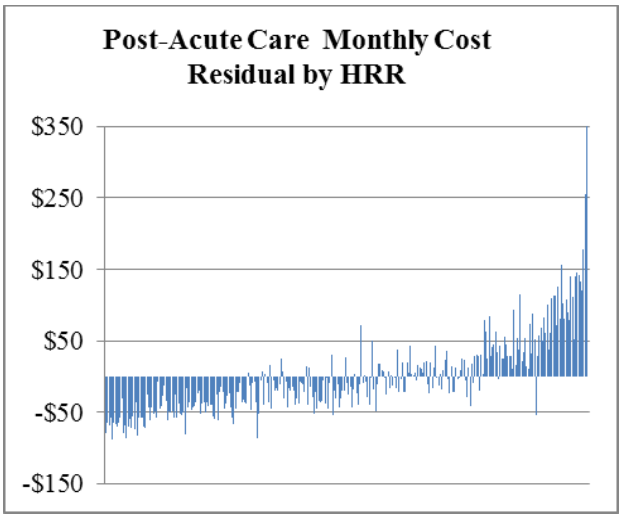
The post-acute and acute care risk adjusted costs have the strongest relationship with the total average monthly risk adjusted costs.

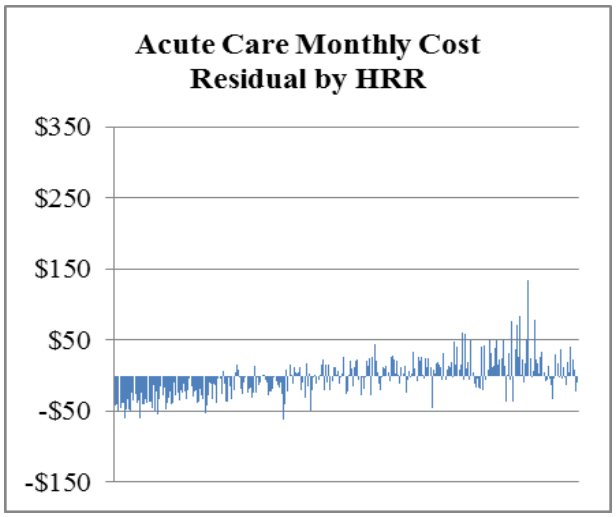
Figure 5.9 presents a series of charts of the average monthly price-standardized cost residuals for each service category for the aggregate cohort. The horizontal axis represents the HRRs sorted by their total average residual cost, with HRRs furthest left being the lowest cost and HRRs furthest right being the highest cost. The vertical axis shows the average monthly cost residual for the service category. If service utilization is positively correlated with overall utilization, then it is expected that the graph will show a near-linear relationship with a positive slope.

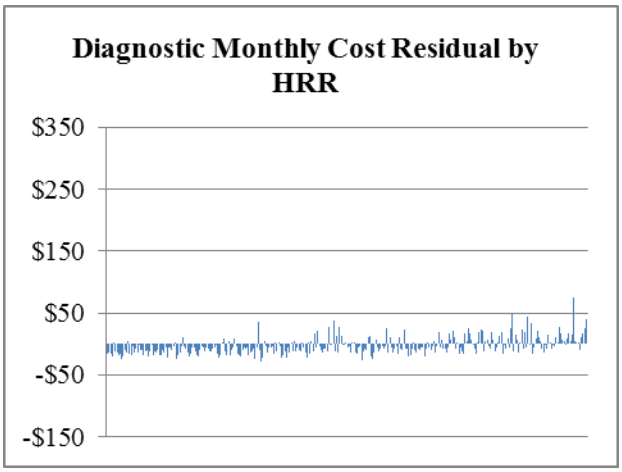
The results indicate that the utilization of post-acute care services is main driver of HRR-level variation in utilization levels. Post-acute residual costs are closely related to total average monthly residual costs; HRRs that have the lowest total cost residuals (on the left) also have the lowest post-acute cost residuals, and HRRs that have the highest total cost residuals (on the right) also have the highest post-acute cost residuals. The post-acute care service category also makes up the largest share of the total cost residual, followed by the acute care service category. The other categories make up small portions of the total cost residual and show little relationship with total residual cost. Regional variation in the utilization of acute services also contributes to HRR-level variation in utilization levels, but regional variation in diagnostic, prescription drug, procedure, ER/ambulance, and other monthly residual costs have little effect on HRR utilization rankings.

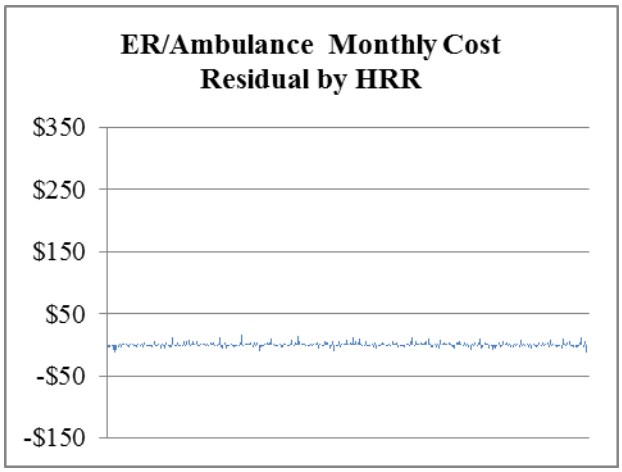
Figure 5.9: Service Category Average Price-Standardized Residual

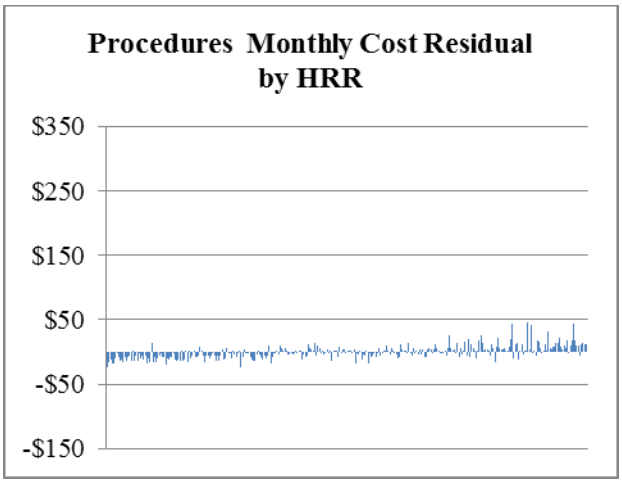


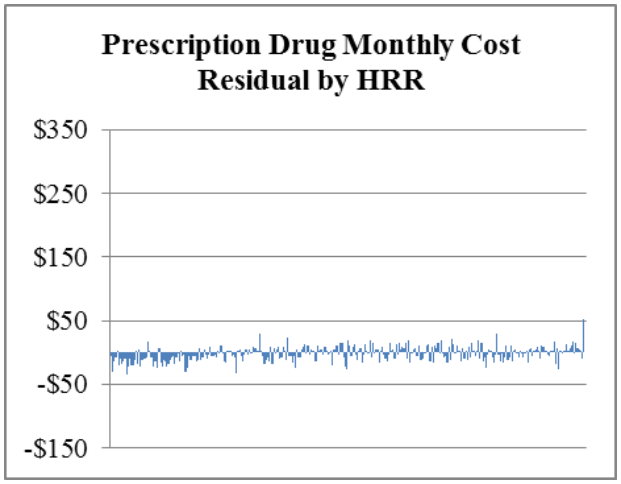

Post-Acute Care Monthly Cost Residual by HRR
$350
$250
$150
$50
-$50
-$150

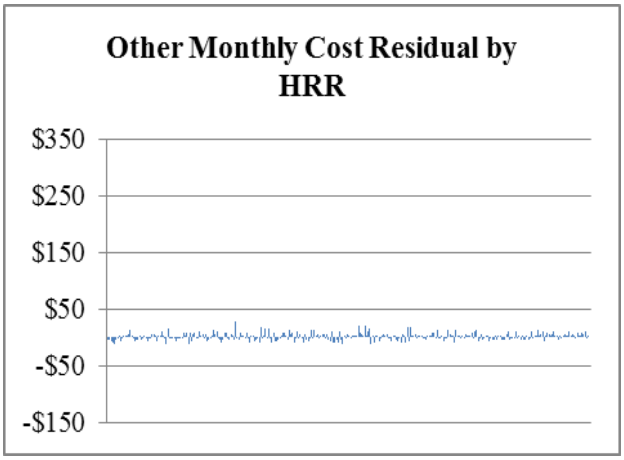

Acute Care Monthly Cost Residual by HRR
$350
$250
$150
$50
-$50
-$150


Diagnostic Monthly Cost Residual by HRR
$350
$250
$150
$50
-$50
-$150


ER/Ambulance Monthly Cost Residual by HRR
$350
$250
$150
$50
-$50
-$150


Procedures Monthly Cost Residual by HRR
$350
$250
$150
$50
-$50
-$150


Prescription Drug Monthly Cost Residual by HRR
$350
$250
$150
$50
-$50
-$150



5.6.3 Regional Variation in the Utilization of Specific Healthcare Services

HRRs with high utilization levels in one service category do not necessarily have high utilization levels in other service categories. Although the correlation between the seven types of service categories is positive, it is fairly low. In fact, correlations between service category costs are generally below 0.35.

Figure 5.9 presents the unweighted Pearson correlation of the average price-adjusted residuals between each service category for the aggregate cohort in 2007. In Table 5.9, the correlation between each category and all other costs (the "Remaining Costs" category) is reported. The "Remaining Costs" category is the total costs minus the costs of the service category with which the correlation is reported in the cell. For example, the correlation between acute care costs and "remaining costs" is defined as the correlation between acute care costs and total costs net of acute care costs. If the "Remaining Costs" category had been reported as simply the total cost, its correlation with the categories that are high-cost and make up a large share of the total cost would appear artificially high. For the aggregate cohort, the other cost and prescription drug cost categories tend to have lower correlation with other categories, while the acute care and ER/ambulance categories tend to have higher correlations. Appendix I presents the unweighted Pearson correlations for AMI, stroke, CHD, and diabetes. The chronic cohorts tend to have higher correlations overall than the acute cohorts. The chronic cohorts also have patterns of correlation similar to the aggregate cohort, which is related to the high correlation between chronic cohorts and the aggregate cohort described above.

Table 5.9: Service Category Utilization Levels across HRRs, Pearson Correlation (2007)

	Remaining Costs	Acute Care	Prescription Drugs	Diagnostic	Post-Acute Care	Procedures	ER/Ambulance	Other
Remaining Costs	.	0.28	0.06	0.21	0.24	0.12	0.31	0.08
Acute Care	0.28	1.00	0.03	0.13	0.27	0.04	0.29	0.05
Prescription Drugs	0.06	0.03	1.00	0.19	-0.01	0.16	0.02	0.05
Diagnostic	0.21	0.13	0.19	1.00	0.01	0.38	0.12	0.10
Post-Acute Care	0.24	0.27	-0.01	0.01	1.00	0.01	0.19	0.03
Procedures	0.12	0.04	0.16	0.38	0.01	1.00	0.05	0.08
ER/Ambulance	0.31	0.29	0.02	0.12	0.19	0.05	1.00	0.04
Other	0.08	0.05	0.05	0.10	0.03	0.08	0.04	1.00

6 SUMMARY OF FINDINGS

The aim of this report is to examine variation in health care expenditures, utilization and quality across geographic regions. The report's major findings are the following.

1. Average monthly costs are significantly right-skewed for all beneficiary categories due the presence of high-cost outliers. Further, the standard deviation of annual beneficiary costs is highest for beneficiaries who die during their observation period.

2. After adjusting for geographic price variation, if Medicare could reduce utilization levels of all fee-for-service beneficiaries to those of the most efficient HRR (Honolulu), it would reduce cost by $116 billion per year. This reduction represents a 31 percent decrease in total Medicare spending. After adjusting for both price variation and beneficiary health status, if Medicare could reduce utilization levels to those of the most efficient HRR (Rochester), it would reduce cost by $68 billion per year. Reducing average beneficiary utilization levels to those of the HRR at the 25th percentile (St. Cloud, MN) would save Medicare $24.5 billion (7 percent decrease) per year.

3. Regions that are high- or low-cost in one year tend to be similarly high- or low-cost in the next. The correlation of HRR-level utilization rank between 2007 and 2008 is 0.95.

4. Although health care expenditures vary across geographic regions, the variation within regions is an order of magnitude greater than the variation across regions. Further, the stability of relative HRR utilization levels across years is in large part due to the persistence in the cost of treating the highest-cost beneficiaries rather than the cost of treating beneficiaries at the median.

5. HRRs with high utilization levels for beneficiaries with a particular condition do not necessarily have high utilization levels for beneficiaries in the same HRR with other conditions. HRRs are more likely to have highly correlated utilization levels for conditions treated by the same set of providers (e.g., AMI and CHF) compared to conditions treated by a different set of providers (e.g., cataract and cholecystectomy).

6. Post-acute care is the major category driver of variation in Medicare utilization levels.

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APPENDIX A: COHORT DEFINITIONS

A.1 Clean Period Requirements

The table below classifies each condition as chronic or acute and lists the clean period requirement. Section A.2 lists the source of the codes used to identify beneficiaries in each cohort and describes the definition of the index date, the length of the observation period, and the length of the clean period if there is a clean period requirement. Section A.3 lists all codes relevant to each condition cohort definition.

Condition	Condition Type	Clean Period Requirement
Acute/ Ischemic Stroke	Acute	60 days
Diabetes	Chronic	None
Pneumonia	Acute	90 days
Rheumatoid Arthritis	Chronic	None
Depression	Chronic	None
Congestive Heart Failure	Chronic	None
Acute Myocardial Infarction	Acute	60 days
Coronary Heart Disease	Chronic	None
COPD	Chronic	None
Cataract	Acute (Procedure)	None
Low Back Pain	Chronic	None
Cholecystectomy	Acute (Procedure)	None
Breast Cancer	Incident Cancer	6 months
Lung Cancer	Incident Cancer	2 years
Prostate Cancer	Incident Cancer	6 months

A.2 Condition Algorithms

The table below contains the algorithms for specifying the condition cohorts for the Medicare study. The Medicaid study utilizes identical algorithms in most cases, however certain CPT and HCPCS codes are not reported using uniform coding across states, and cohort definitions utilizing these codes may underreport the number of beneficiary members of these cohorts in the Medicaid analysis.

Condition	Code Source	Medicare Study Cohort Algorithm
Acute/ Ischemic Stroke	ICD-9 Dx	**Index date:** At least 1 hospital inpatient admission with Dx code. Need 60 day clean period prior to index date. **Observation period:** 12 months after index date. **Position:** 1 **Age:** 18+
Diabetes	ICD-9 Dx, NDCs	**Index date:** 1 inpatient or 2 outpatient with Dx code OR 1 outpatient and drugs **Observation period:** 12 months after index date. **Position:** 1 **Age:** 18+
Pneumonia	ICD-9 Dx	**Index date:** 1 inpatient or 2 outpatient Dx codes; 90 day clean period prior to incident. **Observation period:** 90 days after index date. **Position:** 1 **Age:** 18+
Rheumatoid Arthritis	ICD-9 Dx, DRG	**Index date:** 1 inpatient or 2 outpatient with Dx code **Observation period:** 12 months after index date **Position:** 1-3 **Age:** 18+
Depression	ICD-9 Dx	**Index date:** 1 inpatient or 2 outpatient with Dx code **Observation period:** 12 months. **Position:** 1-3 **Age:** 18+
Congestive Heart Failure	ICD-9 Dx	**Index date:** Inpatient or 2 outpatient Dx code **Observation period:** 12 months **Position:** 1-3 **Age:** 18+
Acute Myocardial Infarction	ICD-9 Dx	**Index date:** 1 inpatient with Dx code. Need 60 day clean period prior to index date. **Observation period:** 12 months **Position:** 1-3 **Age:** 18+
Coronary Heart Disease	ICD-9 Dx	**Index date:** 1 inpatient or 2 outpatient with Dx code **Observation period:** 12 months. **Position:** 1-3 **Age:** 18+
COPD	ICD-9 Dx, CPT Codes, & HCPCS	**Index date:** 1 inpatient or 2 outpatient with Dx code or HCPCs **Observation period:** 12 months **Position:** 1-3 **Age:** 18+

Condition	Code Source	Medicare Study Cohort Algorithm
Cataract	ICD-9 Procedure, CPT, ICD-9 Dx	**Index date:** First occurrence of procedure code **Observation period:** 3 months after the first (or second) procedure code. Thus, the observation period could range anywhere from 3 to 6 months. **Position:** 1-3 **Age:** 18+
Low Back Pain	ICD-9 Dx, ICD-9 Procedure codes	**Index date:** 1 inpatient or 2 outpatient Dx codes **Observation period:** 12 months **Position:** 1-3 **Age:** 18+
Chole-cystectomy	ICD-9 Procedure, CPT Codes, DRG	**Index date:** 1 inpatient procedure code **Observation period:** 90 days prior to and after the index date. **Position:** 1-3 **Age:** 18+
Breast Cancer	ICD-9 Dx, ICD-9 Procedure, CPT Codes, & HCPCS	**Index date:** 1 Medpar, Outpatient, or Carrier Claim Dx code and 1 procedure code from Medpar, Outpatient, or Carrier Claims within a window of 90 days before or after the first Dx (Diagnosis) date. **Observation period:** 12 months **Position:** 1-3 **Age:** 18+
Prostate Cancer	ICD-9 Dx, HCPCS, & CPT Codes	**Index date:** 2 Medpar, Outpatient, or Carrier Claim Dx code with different dates of service and 1 procedure code from Medpar, Outpatient, or Carrier Claims within a window of 30 days before or after the first Dx (Diagnosis) date. **Observation period:** 12 months **Position:** 1-3 **Age:** 18+ Female beneficiaries are excluded from this cohort.[46]
Lung Cancer	ICD-9 Dx	**Index date:** At least one Dx code on at least two claims with different dates of services, at least one of which is primary, within the index year anywhere on the Medpar. **Observation period**: 12 months **Position**: 1-3 **Age**: 18+

A.3 Condition Codes

Condition	Included Codes
Acute/ Ischemic Stroke	**433.01** Occlusion and stenosis of basilar artery with cerebral infarction (CI) **433.11** Occlusion and stenosis of carotid artery w/ CI **433.21** Occlusion and stenosis of vertebral artery w/ CI **433.31** Occlusion and stenosis of multiple and bilateral precerebral arteries w/ CI **433.81** Occlusion and stenosis of other specified precerebral artery w/ CI **433.91** Occlusion and stenosis of unspecified precerebral artery w/CI **434.01** Occlusion of cerebral arteries w/ CI **434.11** Embolic cerebrovascular accident

[46] Out of 224,580 Medicare beneficiaries in the aggregate prostate cancer cohort, 10 female beneficiaries were removed from the cohort due to this restriction. Out of 3,510 Medicaid beneficiaries in the prostate cancer cohort, 2 female beneficiaries were removed.

Condition	Included Codes
	434.91 Stroke (ischemic) **436** Acute but ill-defined cerebrovascular disease
Diabetes	**Diagnosis Codes:** **250.00-03** DM without mention of complication **250.10** Diabetes w/ ketoacidosis, type II or unspecified type, not stated as uncontrolled **250.11** Diabetes w/ ketoacidosis, type I, not stated as uncontrolled **250.12** DM w/ ketoacidosis type II or unspecified, uncontrolled **250.13** Diabetes with ketoacidosis, type I, uncontrolled **250.20-.23** Diabetes with hyperosmolarity (same designations as above) **250.30-.33** Diabetes with other coma (same designations as above) **250.40-.43** Diabetes w/ retinal manifestations (same designations as above) **250.50-.53** Diabetes w/ ophthlamic manifestations (same designations as above) **250.60-.63** Diabetes w/ neurological manifestations (same designations as above) **250.70-.73** Diabetes w/ peripheral circulatory disorders (same designations as above) **250.80-.83** Diabetes w/ other specified manifestations (same designations as above) **250.90-.93** Diabetes w/ unspecified complication (same designations as above) **NDC Codes**[47]
Pneumonia	**480.0** Pneumonia (Pn) due to adenovirus **480.1** Pn due to respiratory syncytial virus **480.2** Pn due to parainfluenza virus **480.3** Pn due to SARS-associated coronavirus **480.8** Pn due to other virus not elsewhere classified **480.9** Viral Pn unspecified **481** Pneumococcal Pn **482.0** Pneumonia due to klebsiella pneumoniae **482.1** Pn due to pseudomonas **482.2** Pn doe to haemophilus influenzae **482.3x** Pn due to streptococcus (excludes 481) **482.4x** Pn due to staphylococcus **482.8x** Pn due to other specified bacteria **482.9** Pn due to Bacterial pneumonia unspecified **483.0** Pn due to Mycoplasma pneumoniae **483.1** Pn due to chlamydia **483.8** Pn due to other specified organism **485** Bronchopneumonia organism unspecified **486** Pn organism unspecified **487.0** Influenza with Pn
Depression	**296.20** Major depressive disorder single episode unspecified degree **296.21** Major depressive affective disorder single episode mild degree **296.22** Major depressive affective disorder single episode moderate **296.23** Major depressive affective disorder single episode severe degree without psychotic behavior **296.24** Major depressive affective disorder single episode severe degree specified as with psychotic behavior **296.25** Major depressive affective disorder single episode in partial or unspecified remission **296.26** Major depressive affective disorder single episode in full remission **296.30** Major depressive disorder recurrent episode unspecified degree

[47]HEDIS 2010 Final NDC Lists, "Table CDC-A: Prescriptions to Identify Members with Diabetes," National Committee for Quality Assurance, http://www.ncqa.org/tabid/1091/Default.aspx.

Condition	Included Codes	
	296.31	Major depressive affective disorder recurrent episode mild degree
	296.32	Major depressive affective disorder recurrent episode moderate degree
	296.33	Major depressive affective disorder recurrent episode severe degree without psychotic behavior
	296.34	Major depressive affective disorder recurrent episode severe degree specified as with psychotic behavior
	296.35	Major depressive affective disorder recurrent episode in partial or unspecified remission
	296.36	Major depressive affective disorder recurrent episode in full remission
	300.4	Dysthymic disorder
	309.1	Adjustment reaction with prolonged depressive reaction
	311.xx	Depressive disorder not elsewhere classified
Congestive Heart Failure	**402.01**	Malignant hypertensive heart disease with heart failure
	402.11	Benign hypertensive heart disease with heart failure
	402.91	Unspecified hypertensive heart disease with heart failure
	404.01	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney stage i-iv, or unspecified
	404.03	Hypertensive heart and chronic kidney disease, malignant, with heart failure and chronic kidney disease state v or end state renal disease
	404.13	Hypertensive heart and chronic kidney disease, benign, ...
	404.93	Hypertensive heart and chronic kidney disease, unspecified,
	404.11	Hypertensive heart and chronic kidney disease, benign, with heart failure and with chronic kidney stage i-iv, or unspecified
	404.91	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and with chronic kidney stage i-iv, or unspecified
	425.1	Hypertrophic obstructive cardiomyopathy
	425.4	Other primary cardiomyopathies
	425.5	Alcoholic cardiomyopathy
	425.7	Nutritional and metabolic cardiomyopathy
	425.8	Cardiomyopathy in other diseases classified elsewhere
	425.9	Secondary cardiomyopathy unspecified
	428.0	Congestive heart failure unspecified
	428.1	Left heart failure
	428.20	Unspecified systolic heart failure
	428.21	Acute systolic heart failure
	428.22	Chronic systolic heart failure
Acute Myocardial Infarction	**410.00**	AMI of anterolateral wall EOC unspecified
	410.01	AMI of anterolateral wall initial episode of care (IEOC)
	410.10	AMI of other anterior wall EOC unspecified
	410.11	AMI of other anterior wall IEOC
	410.20	AMI of inferolateral wall EOC unspecified
	410.21	AMI of inferolateral wall IEOC
	410.30	AMI of inferoposterior wall EOC unspecified
	410.31	AMI of inferoposterior wall IEOC
	410.40	AMI of other inferior wall EOC unspecified
	410.41	AMI of other inferior wall IEOC
	410.50	AMI of other lateral wall episode of care unspecified
	410.51	AMI of other lateral wall IEOC
	410.60	True posterior wall infarction EOC unspecified
	410.61	True posterior wall infarction IEOC
	410.70	Subendocardial infarction EOC unspecified
	410.71	Subendocardial infarction IEOC
	410.80	AMI of other specified sites EOC unspecified
	410.81	AMI of other specified sites IEOC

Condition	Included Codes
	410.90 AMI of unspecified site EOC unspecified **410.91** AMI of unspecified site IEOC
Coronary Heart Disease	**410.xx** Acute myocardial infarction **411.x** Ischemic heart disease **412** Old myocardial infarction **413.x** Angina **414.x** Other ischemic heart disease
COPD	**DX codes:** **491.0** Simple chronic bronchitis **491.1** Mucopurulent chronic bronchitis **491.20** Obstructive chronic bronchitis without exacerbation **491.21** Obstructive chronic bronchitis with (acute) exacerbation **491.22** Obstructive chronic bronchitis with acute bronchitis **491.8** Other chronic bronchitis **491.9** Unspecified chronic bronchitis **492.0** Emphysematous bleb **492.8** Other emphysema **496** Chronic airway obstruction not elsewhere classified **HCPCS codes:** **G8093** Newly diagnosed chronic obstructive pulmonary disease (COPD) patient documented to have received smoking cessation intervention, within 3 months of diagnosis **G8094** Newly diagnosed chronic obstructive pulmonary disease (COPD) patient not documented to have received smoking cessation intervention, within 3 months of diagnosis
Cataract	**Procedure Codes:** **13.19** Other intracapsular extraction of lens. Surgical removal of a cataractous lens. (Dorland, 28th ed) **13.64** Discission of secondary membrane [after cataract] **13.41** Phacoemulsification and aspiration of cataract **13.42** Mechanical phacofragmentation and aspiration of cataract by posterior route **13.43** Mechanical phacofragmentation and other aspiration of cataract **13.61, 13.62, 13.63, 13.65** Excision of secondary membrane [after cataract] **13.66** Mechanical fragmentation of secondary membrane [after cataract] **13.69** Other cataract extraction **CPT Codes:** **66982** Extracapsular cataract removal with insertion of intraocular lens prosthesis, (1-stage procedure), manual or mechanical technique (eg, irrigation and aspiration or phacoemulsification), complex, requiring devices or techniques not generally used in routine cataract surgery (eg, iris expansion device, suture support for intraocular lens, or primary posterior capsulorhexis) or performed on patients in the amblyogenic developmental stage. **66983** Intracapsular cataract extraction with insertion of intraocular lens prosthesis (1

Condition	Included Codes
	stage procedure), **66984** Extracapsular cataract removal with insertion of intraocular lens prosthesis (1 stage procedure), manual or mechanical technique (eg, irrigation and aspiration or phacoemulsification) **66840** Removal of lens material; aspiration technique, 1 or more stages **66850** Removal of lens material; phacofragmentation technique (mechanical or ultrasonic) (eg, phacoemulsification), with aspiration **66852** Removal of lens material; pars plana approach, w/ or wo vitrectomy **66920** Removal of lens material; intracapsular **66930** Removal of lens material; intracapsular, for dislocated lens **66940** Removal of lens material; extracapsular (not 66840, 66850, 66852)
Rheumatoid Arthritis	**714.0** Rheumatoid Arthritis (RA) - does not include juvenile (714.30) **714.1** Felty's syndrome - RA with splenoadenomegaly and leukopenia **714.2** Other RA with visceral or systemic involvement **714.30** Chronic or unspecified polyarticular juvenile RA **714.31** Acute polyarticular juvenile RA **714.32** Pauciarticular juvenile RA **714.33** Monoarticular juvenile RA **714.89** Other specified inflammatory polyarthropathies
Low Back Pain	**353.1, 353.4** Nerve root and plexus disorders **355.0** Lesion of sciatic nerve **720.0 - 720.9** Spondylitis **721.3-721.91** Spondylosis and allied disorders **722.10** Intervertebral disc disorders **722.32** **722.52** **722.73** **722.83** **722.93** **724.02-03** Other and unspecified disorders of back. Excludes: collapsed vertebra **724.2-.9** **733.13** Pathological fracture of vertebrae **737.20-737.29** Lordosis (acquired), (postural), postlaminectomy, Other postsurgical lordosis, Other lordosis acquired **737.40** Unspecified curvature of spine assoc. w/ other conditions **737.42** Lordosis associated with other conditions **738.4** Acquired spondylolisthesis, Degenerative spondylolisthesis **738.5** Other acquired deformity of back or spine **739.3-739.4** Nonallopathic lesions of lumbar region, sacral region, pelvic region not elsewhere classified **756.11** Congenital spondylolysis lumbosacral region **756.12** Spondylolisthesis congenital **805.4** Closed fracture of lumbar vertebra w/o spinal cord injury **805.5** Open fracture of lumbar vertebra w/o spinal cord injury **805.6** Closed fracture of sacrum and coccyx w/o spinal cord injury **805.7** Open fracture of sacrum and coccyx w/o spinal cord injury **805.8** Closed fract. of unspecified vertebral column w/o spinal cord injury **805.9** Open fracture ... (same as above) **806.4-806.9** Closed fracture of lumbar spine with spinal cord injury, Open fracture of lumbar spine with spinal cord injury, Closed fracture of sacrum and coccyx with spinal cord injury, Open fracture of sacrum and coccyx with spinal cord injury, Closed fracture of unspecified vertebra with spinal cord injury, Open fracture of unspecified

Condition	Included Codes
	vertebra with spinal cord injury **839.20** Closed dislocation lumbar vertebra **839.30** Open dislocation lumbar vertebra **839.40-839.49** Closed dislocation vertebra unspecified site, coccyx, sacrum, other vertebra **839.50-839.59** Open dislocation vertebra unspecified site, coccyx, sacrum, other vertebra **846.x** Sprains and strains of sacroiliac region **847.2** Lumbar sprain **847.3** Sprain of sacrum **847.4** Sprain of coccyx **847.9** Sprain of unspecified site of back, Back NOS **952.2-952.9** Lumbar, Sacral, Cauda equine, Multiple. Unspecified site (respectively) of spinal cord injury without spinal bone injury **953.2-953.3** Injury to lumbar and sacral (respectively) nerve root **953.5-953.9** Injury to lumbosacral plexus, multiple sites (unspecified) of nerve roots and spinal plexus
Cholecystectomy	**Procedure Codes:** **51.2** Cholecystectomy **51.21** Other partial cholecystectomy **51.22** Cholecystectomy **51.23** Laparoscopic cholecystectomy **51.24** Laparoscopic partial cholecystectomy **CPT Codes:** **47562** Laparoscopy, surgical; cholecystectomy **47563** Laparoscopy, surgical; cholecystectomy with cholangiography **47564** Laparoscopy, surgical; cholecystectomy with exploration of common duct **47570** Laparoscopy, surgical; cholecystoenterostomy **47579** Unlisted laparoscopy procedure, biliary tract, **47600** Cholecystectomy **47605** Cholecystectomy with cholangiography **47610** Cholecystectomy with exploration of common duct **47612** Cholecystectomy with exploration of common duct; with choledochoenterostomy **47620** Cholecystectomy with exploration of common duct; with transduodenal sphincterotomy or sphincteroplasty, with or without cholangiography
Breast Cancer	**DX Codes:** **174** Breast Cancer **174.1-174.9** Breast Cancer **233.0** Breast Cancer **Procedure Codes** **85.1-85.19** Biopsy **85.20-85.21** Lumpectomy **85.22-85.23** partial mastectomy **40.3** Lymph node dissection **85.33-85.48** Mastectomy **CPT Codes:**

Condition	Included Codes
	19000, 19001, 19100, 19101, 19110, 19112 Biopsy **19120, 19125, 19126** Lumpectomy **19160, 19162, 19301, 19302** Partial mastectomy **38740, 38745, 38525** Lymph node dissection **19180-19255, 19303-19307** Mastectomy
Prostate Cancer	**Diagnosis Codes:** **185** Prostate Cancer **Procedure Codes:** **60.11** Closed (percutaneous) (needle) biopsy of prostate **60.12** Open biopsy of prostate **CPT Codes:** **G0416** Surgical pathology, gross and microscopic examination for prostate needle saturation biopsy sampling, 1-20 specimens **G0417** Surgical pathology, gross and microscopic examination for prostate needle saturation biopsy sampling, 21-40 specimens **G0418** Surgical pathology, gross and microscopic examination for prostate needle saturation biopsy sampling, 41-60 specimens **G0419** Surgical pathology, gross and microscopic examination for prostate needle saturation biopsy sampling, greater than 60 specimens **55700** Biopsy, prostate; needle or punch, single or multiple, any approach **55705** Biopsy, prostate; incisional, any approach **55706** Biopsies, prostate, needle, transperineal, stereotactic template guided saturation sampling, including imaging guidance **0137T** Biopsy, prostate, needle, saturation sampling for prostate mapping
Lung Cancer	**DX Codes:** **162.2** Malignant neoplasm of main bronchus **162.3** Malignant neoplasm of upper lobe, bronchus, or lung **162.4** Malignant neoplasm of middle lobe, bronchus, or lung **162.5** Malignant neoplasm of lower lobe, bronchus, or lung **162.8** Malignant neoplasm of other parts of bronchus or lung **162.9** Malignant neoplasm of bronchus and lung, unspecified site

A.4 Cancer Cohort Methodology

The analysis examines three incident cancer cohorts: breast cancer, lung cancer and prostate cancer. It is difficult to identify beneficiaries with incident cancer from Medicare claims data because cancer diagnosis codes appear in claims data both due to cancer screening and cancer treatment procedures. Since periods of remission and recurrence are common, it is difficult to distinguish between new and prevalent cancer cases. Furthermore, defining membership in a condition cohort through procedures claims leads to an endogeneity problem: high cost areas are more likely to perform more procedures, and therefore to diagnose an incident cancer at an earlier, and less expensive, stage, biasing observed costs downwards.

This methodology links the Surveillance, Epidemiology, and End Results (SEER) registry data with Medicare claims data to validate the incident cancer cohort definitions used in the analysis. The SEER program of the National Cancer Institute (NCI) collects data from hospitals, physicians, laboratory reports and death certificates to determine cancer status in the United States, including diagnosis date. The SEER registry is recognized as one of most accurate sources of cancer incidence statistics: The seventeen SEER registries capture approximately 98 percent of breast cancer cases within the SEER domain[48] It is not possible to use the SEER-Medicare linked data for the purposes of this analysis because the registry covers only 28 percent of the U.S. population and the goal of the analysis is to examine regional variation in costs, utilization and quality across the U.S.

To determine beneficiary membership in each cancer cohort using Medicare or Medicaid claims data, the methodology develops an algorithm for each cohort. The prediction power of these algorithms is tested by comparing the results of each algorithm applied to the subsample of beneficiaries surveyed by SEER to the actual cancer status of these beneficiaries reported in SEER.

The general algorithm for determining membership in the cancer cohorts based on the claims data involves three basic steps: 1) Screen valid claims for the appropriate diagnosis and procedure codes, and if a specified code combination is present, define the index date as the date of the claim containing the first condition relevant code, 2) Require continuous enrollment in Medicare Parts A and B or in Medicaid without benefits restrictions for the duration of the "clean period," and 3) Remove prevalent cases, or beneficiaries with claims dating from the "clean period" that contain procedure and diagnosis codes indicating preexisting cancer. Since the analysis aims to assess the costs in the first year after a cancer diagnosis, membership in all three cancer cohorts requires a clean period ranging from 6 months to 2 years. Because Medicaid beneficiaries tend to enroll and disenroll frequently, a substantial number of beneficiaries are lost as a result of the continuous enrollment requirement. More specifics about the "screening" requirement (step 1) can be found in Appendix A. The cancer cohort algorithms were developed based on the academic literature and refined under the guidance of the IOM committee member Peter Bach of the Memorial Sloan-Kettering Cancer Center.

The cancer cohort algorithms are assessed using Medicare data based on four criteria: positive predictive value, negative predictive value, sensitivity and specificity. Positive predictive value measures the percentage of beneficiaries assigned by the algorithm to a given incident cancer cohort that are registered for that cancer incident to the index date defined in step 1 in the SEER registry. Negative predictive value measures the percentage of beneficiaries not

[48] H. T. Gold and H. T. Do, "Evaluation of three algorithms to identify incident breast cancer in Medicare claims data," *Health Serv Res* 42, no. 5 (2007), http://www.ncbi.nlm.nih.gov/pubmed/17850533.

assigned by the algorithm to a given incident cancer cohort that are not registered for that condition incident to the index date in the SEER registry. Sensitivity measures the probability an individual is assigned to a given incident cancer cohort given the individual is registered for the condition incident for the index date in the SEER registry. Specificity measures the probability an individual is not assigned to a given incident cancer cohort given the individual is not registered for the condition incident to the index date in the SEER registry. The table below provides these metrics for the final breast, prostate, and lung cancer algorithms.

Table A.1: Cancer Cohort Algorithm Results

Condition Cohort	Positive Predictive Value	Negative Predictive Value	Sensitivity	Specificity
Breast Cancer	92.11	99.87	71.22	99.97
Prostate Cancer	83.82	99.84	71.57	99.92
Lung Cancer	72.82	99.86	76.75	99.82

A.5 Medicare Exclusion Restrictions

The table below shows the result of imposing exclusion restrictions for the Medicare analysis. Beneficiaries' episodes will be excluded from the final analysis if:

- They do not have enrollment data in the EDB (column B)
- They are not enrolled in Medicare Part A or Part B during the first month of the observation period (column C)
- They have an invalid ZIP code that is missing or does not map to a HRR, HSA, and MSA (column D)
- They are listed in the EDB as the primary payer for their health care costs (column E)
- They have claims with third party payer costs in the observation window (column F)
- For acute cohorts, they have $0 total cost on all Part A and B claims in the observation window.

Column A presents the total number of Medicare episodes created in the 2007-2009 period for each condition cohort and for the aggregate sample. The aggregate sample includes over 114 million episodes, and the condition cohorts range from 151,000 episodes (for breast cancer) to over 22.8 million episodes (for low back pain). Each of the remaining columns shows the percent of episodes which satisfy each criterion. Because these exclusions need not be applied in any order, some episodes will be excluded based on more than one restriction. As a result, the total percent of episodes excluded is not necessarily equal to the sum of the episodes lost to each restriction.

Column B presents the percent of episodes with beneficiaries whose enrollment information is not available in the EDB. Column C shows the percent of episodes with beneficiaries that are not enrolled in Medicare A or B in the first month of the observation window, which results in the largest loss of episodes. The remaining beneficiaries are beneficiaries who are only enrolled in Part C; these beneficiaries are excluded from the analysis because not all Part C claims are available. For the condition cohorts, the percent of episodes excluded due to this restriction varies from 1 percent (for prostate cancer) to 22 percent (for CHF). Column D shows the percent of episodes with an invalid ZIP code. Valid ZIP codes are not missing and map to a HRR, HSA, and MSA. A majority of the episodes that are lost due to this restriction have international ZIP codes or are the result of coding errors. Columns E and F ensure that all of the beneficiary's claims will be available in the Medicare claims database. Column E shows the percent of episodes with beneficiaries who do not have a payer primary to

Medicare listed in the EDB. The start and end date of the beneficiary's enrollment with a primary payer must not overlap the observation period. Column F shows the percent of episodes that do not have any claims with third party payer costs. In general, columns E and F are comparable, which suggests that about 2 percent of episodes are excluded due to Medicare not being the primary payer. Column G presents, for acute cohorts, the percent of episodes with $0 total cost on Parts A and B during the observation window. Acute episodes with $0 total cost are likely miscoded or otherwise not valid episodes of care. Column H presents the final results of applying these restrictions. The percent of episodes from the total that are ultimately excluded from the analysis ranges from 4 percent (for prostate cancer) to 25 percent (for CHF).

	A	B	C	D	E	F	G	H
	Total Number of Episodes	**Not Found in EDB**	**Not A or B Enrolled in First Month of Observation**	**Invalid ZIP Code**	**Enrolled as Primary Payer (EDB)**	**Medicare is Not Primary Payer for all Claims**	**Acute Claims with $0 Total Cost on A and B**	**Total Episodes Lost**
Aggregate	114,778,863	0.0%	0.0%	1.9%	5.8%	2.8%	*N/A*	8.8%
AMI	1,221,791	0.0%	14.1%	0.8%	1.1%	0.8%	0.0%	16.2%
Arthritis	1,911,765	0.0%	8.5%	0.7%	2.6%	2.9%	*N/A*	12.9%
Breast Cancer	151,390	0.0%	6.0%	0.5%	1.9%	2.1%	0.0%	9.2%
Cataract	4,082,817	0.0%	1.9%	0.5%	1.8%	1.9%	0.1%	5.0%
CHD	22,667,833	0.0%	13.7%	0.7%	1.9%	1.9%	*N/A*	16.8%
CHF	13,152,055	0.0%	22.3%	0.6%	1.3%	1.2%	*N/A*	24.5%
Cholecystect-omy	409,482	0.0%	11.8%	0.9%	1.7%	1.3%	0.0%	14.6%
COPD	13,147,737	0.0%	16.7%	0.5%	1.6%	1.5%	*N/A*	19.2%
Depression	8,685,355	0.0%	9.4%	0.6%	2.2%	2.1%	*N/A*	13.1%
Diabetes	21,478,295	0.0%	10.2%	0.7%	2.2%	2.1%	*N/A*	13.7%
Low Back Pain	22,819,996	0.0%	7.2%	0.5%	2.4%	2.3%	*N/A*	11.0%
Lung Cancer	335,482	0.0%	3.5%	0.3%	2.4%	2.7%	0.0%	7.3%
Pneumonia	2,628,307	0.0%	6.2%	0.6%	1.3%	1.1%	0.0%	8.4%
Prostate Cancer	224,580	0.0%	0.6%	0.6%	2.2%	2.6%	0.0%	4.4%
Stroke	730,743	0.0%	13.4%	1.0%	1.0%	0.8%	0.0%	15.4%

APPENDIX B: OUTCOME MEASURE SPECIFICATION

B.1 Medicaid Input Price Standardization Methodology

Although other subcontractors will utilize both input and output price standardization methods, the Medicaid analysis will only use input price adjustments. For Medicare, input price-adjustment is based on payment rules, but in Medicaid payment rules vary by state, so this study uses proxies for the cost of living adjustments. For the Medicaid methodology, the adjustments vary by file type. The following sections describe the methodology used in the Medicaid analysis to input price-standardize inpatient, long-term, drug, and other expenditures to measure utilization.

B.1.1 Inpatient and Long Term Care Files

For inpatient (IP) and long-term (LT) claims, the Medicaid study standardizes spending to account for regional variation in labor costs. The study uses the Hospital Wage Index (HWI) to estimate regional variation in labor costs. The methodology employs CMS's assumption that labor costs explain 69.7 percent of hospital costs from 2006 to September 31, 2008 and 68.8 percent from October 1, 2008 through 2010.[49] Medicaid IP and LT claim costs are standardized using equations B.1 and B.2:

(B.1) For claims before October 1, 2008:

$$Standardized\_Cost = Medicaid\_Amount\_Paid \ * \ 1/(0.697 * HWI + 0.303)$$

(B.2) For claims on or after October 1, 2008:

$$Standardized\_Cost = Medicaid\_Amount\_Paid \ * \ 1/(0.688 * HWI + 0.312)$$

B.1.2 Other Therapy File

For Other Therapy (OT) claims, the analysis uses two distinct methodologies to standardize costs. If an OT claim has a valid HCPCS code, the analysis standardizes costs using Geographic Practice Cost Index (GPCI) and Relative Value Units (RVUs). GPCIs vary by geographic region (i.e., Medicare locality), while RVUs vary by HCPCS. Both GPCIs and RVUs can be broken down into three major components: physician work (W), practice expense (PE), and professional liability insurance (L). For OT claims with a valid HCPCS, the study standardizes costs using equation B.3:

(B.3)
$$Standardized\_Cost = Medicaid\_Amount\_Paid \ / \ Adj_{GPCI}$$

$$Adj_{GPCI} = \frac{(RVU_W * GPCI_W + RVU_{PE} * GPCI_{PE} + RVU_L * GPCI_L)}{(RVU_W + RVU_{PE} + RVU_L)}$$

[49] "IPPS Annual Proposed and Final Rules," Centers for Medicare & Medicaid Services, http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/.

For OT claims without a valid HCPCS, the Medicaid study adjusts costs with the Geographic Adjustment Factor (GAF). The GAF is a weighted average of the three GPCIs where the cost share weights are determined by the Medicare Economic Index (MEI) 2006 base year weights as shown in equation B.4.[50] The methodology uses equation B.5 to standardize costs on OT claims with no valid HCPCS code.

(B.4) $GAF =$

(B.5) $Standardized\_Cost = Medicaid\_Amount\_Paid / GAF$

B.1.3 Prescription Drug File

For prescription drugs (RX), the methodology does not adjust costs for input prices. Because the quantity of service and days' supply variables are not reliable on Medicaid claims, actual expenditures are used.

[50] "Medicare Economic Index Web Table," Centers for Medicare & Medicaid Services, http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/MedicareProgramRatesStats/downloads//mktbskt-economic-index.pdf.

B.2 Service Categories

As part of the input price adjustment analysis, this methodology also stratifies costs by service category to examine the specific drivers of cost. For example, an area with higher than average costs may be found to have higher acute care costs but lower diagnostic costs than other areas. The service cost stratifications are defined by claim type and code. For the Medicare analysis, for OP and PB claims that qualify under multiple categories, the hierarchy of assignment is as follows: Acute, ER/Ambulance, Post-acute, Procedures, Diagnostic, and Rx. The same hierarchy is followed for Medicaid OT claims that qualify under multiple categories, except no OT claims are included in the acute category; so for Medicaid, the hierarchy has the same order but no acute category.

Service Category	Medicare / Medicaid Claim Types	Medicare Specification	Medicaid Specification
Acute Care	IP, PB / IP, OT	• IP claims: third digit of Provider Number = "0" or third-fourth digits of "13" (inpatient hospital) • PB claims: Place of Service = 21 (inpatient hospital)	• All IP claims • OT claims: Place of Service = 21 (inpatient hospital)
Prescription Drugs	OP, PB, DME, PD / OT, RX	• OP, PB, DME claims: BETOS[51] IN ("D1G" (drugs administered through DME), "O1E" (other drugs), "O1D" (chemotherapy)) • all PD claims	• OT claims: BETOS IN ("D1G" (drugs administered through DME), "O1E" (other drugs), "O1D" (chemotherapy)) • all RX claims
Diagnostic	OP, PB / OT	• OP and PB claims: first digit of BETOS IN ("M" (evaluation and management), "I" (imaging), "T" (tests))	• OT claims: first digit of BETOS IN ("M" (evaluation and management), "I" (imaging), "T" (tests))

Post-Acute Care	SNF, HH, HS, OP, IP, PB / LT, OT	• All SNF, HH, HS claims
		• OP claims: Type of Service IN (4,5, 6) AND Facility Type="7" (outpatient rehabilitation);
		• IP claims: last four digits of Provider Number:
		  • 2000-2299 (long term care)
		  • 4000-4499 OR third digit of "M" OR third digit of "S" (psychiatric)
		  • 3025-3099 OR third digit of "R" or "T" (rehab)
		• PB claims: Place of Service IN (31 (skilled nursing), 32 (nursing facility), 34 (hospice), 51 (inpatient psychiatric), 52 (psychiatric facility), 53 (community mental health center),
			• All LT claims
			• OT claims:
			  • Place of Service IN (31 (skilled nursing), 32 (nursing facility), 34 (hospice), 51 (inpatient psychiatric), 52 (psychiatric facility), 53 (community mental health center), 56 (psychiatric residential treatment center), 61 (inpatient rehab), 62 (outpatient rehab))
			  • Type of Service in (7 (nursing facility), 13 (home health), 33 (rehab), 35 (hospice))

[51] "Berenson-Eggers Type of Service (BETOS)," Centers for Medicare & Medicaid Services, https://www.cms.gov/Medicare/Coding/HCPCSReleaseCodeSets/BETOS.html.

		56 (psychiatric residential treatment center), 61 (inpatient rehab), 62 (outpatient rehab))	
Procedures	OP, PB / OT	• OP and PB claims: first digit of BETOS="P" (procedures)	• OT claims: first digit of BETOS="P" (procedures)
Emergency Room / Ambulance	OP, PB / OT, IP	• OP claims: BETOS = "O1A" (ambulance) OR Revenue Center code 0450-0459 or 0981 (emergency room) • PB claims: BETOS = "O1A" (ambulance) OR Place of Service IN (23 (emergency room), 41 (land ambulance), 42 (air or water ambulance))	• OT claims: BETOS = "O1A" (ambulance) OR Revenue Center code 0450-0459, or 0981 (emergency room) OR Place-of-Service = 23 (ambulance) • IP claims: Revenue Center code 0450-0459 or 0981 (emergency room)
Other	All claim types	• Any claim not previously categorized	• Any claim not previously categorized

B.3 Utilization Counts

Utilization Count Measure	Medicare Method				Medicaid Method
	Code	Code type	Description	Notes	
Number of Inpatient Surgical Admissions	All valid DRGs	DRG	Count of observed inpatient surgical admissions. No more than 1 per day.	IP claims (non-interim) with admission date in episode window and an acute short-term/CAH provider number and surgical MSDRG	Combine categories using IP claims; does not differentiate between medical and surgical admissions. Count of inpatient admissions. No more than 1 per day.
Number of Inpatient Medical Admissions	All valid DRGs	DRG	Count of observed inpatient medical admissions. No more than 1 per day.	IP claims (non-interim) with admission date in episode window and an acute short-term/CAH provider number and medical MSDRG	
Number of Inpatient Surgical	All valid DRGs	DRG	Count of inpatient surgical days	Same specification as	Combine categories using

Utilization Count Measure	Medicare Method				Medicaid Method
	Code	Code type	Description	Notes	
Days				Number of Inpatient Surgical Admissions	IP claims; does not differentiate between medical and surgical days. Count of inpatient days.
Number of Inpatient Medical Days	All valid DRGs	DRG	Count of inpatient medical days	Same specification as Number of Inpatient Medical Admissions	
Number of days with an outpatient office visit	99201	CPT	Office visit, E&M, new pt., minimal	OP and PB claims. Can have only 1 outpatient office visit per day	OT claims. (Under-reported in states with prevalent local code system usage)
	99202	CPT	Office visit, E&M, new pt., minor		
	99203	CPT	Office visit, E&M, new pt., low complexity		
	99204	CPT	Office visit, E&M, new pt., moderate complexity		
	99205	CPT	Office visit, E&M, new pt., high complexity		
	99211	CPT	Office visit, E&M, established pt., minimal		
	99212	CPT	Office visit, E&M, established pt., minor		
	99213	CPT	Office visit, E&M, established pt., low complexity		
	99214	CPT	Office visit, E&M, established pt., moderate complexity		
	99215	CPT	Office visit, E&M, established pt., high complexity		
	99241	CPT	E&M, Consultation, minimal		
	99242	CPT	E&M, Consultation, minor		
	99243	CPT	E&M, Consultation, low		
	99244	CPT	E&M, Consultation, moderate		
	99245	CPT	E&M, Consultation, high		
Number of RX drug fills	All valid NDC claims	NDC	For each person/NDC/Day: =1 if days' supply <=30; =days' supply/30 if days' supply >30	OP, PB, or DM claims with HCPCs with BETOS in (D1G, O1E, or O1D), and all Part D claims	OT claims. (Under-reported in states with prevalent local code system usage)
Number of Emergency Department Visit Days	99281	CPT	Emergency dept visit, minimal	OP claims with Revenue Center code 0450-0459 or 0981; and IP claims with	OT claims with Revenue Center code 0450-0459 or 0981, or Place-of-Service = 23; and IP claims with
	99282	CPT	Emergency dept visit, minor		
	99283	CPT	Emergency dept visit, low		
	99284	CPT	Emergency dept visit, moderate		

Utilization Count Measure	Medicare Method				Medicaid Method
	Code	Code type	Description	Notes	
	99285	CPT	Emergency dept visit, high	Revenue Center code 0450-0459 or 0981 and restricting to Source of Admission =7. Max 1 per person per day.	Revenue Center code 0450-0459 or 0981. Max 1 per person per day.
Number of Imaging Encounters	Diagnostic Imaging Codes	CPT		Maximum of 1 procedure of each type on any given day. OP and PB claims.	OT claims (Under-reported in states with prevalent local code system usage.)
Sentinel Services	Cardiac Stress Test	ICD-9 and CPT	Nuclear stress tests	No more than 1 test per enrollee day. IP, OP, and PB claims.	OT and IP claims (Under-reported in states with prevalent local code system usage.)
Sentinel Services	Bilateral Cardiac Catheterization	ICD-9 and CPT	Bilateral cardiac catheterization	No more than 1 procedure per enrollee day. IP, OP, and PB claims.	OT and IP claims (Under-reported in states with prevalent local code system usage.)
Discretionary Services	Hip and Knee Replacement	CPT	Hip and knee replacement	No more than 1 procedure per enrollee day. IP, OP, and PB claims.	OT and IP claims (Under-reported in states with prevalent local code system usage.)
Discretionary Services	Cholecystectomy	CPT	Laparoscopic cholecystectomy as percent of all cholecystectomy (in cohort analyses, calculated only for the cholecystectomy cohort.) This measure is not risk-adjusted because it is a process of care quality measure.)	No more than 1 procedure per enrollee day. IP claims.	IP claims (Under-reported in states with prevalent local code system usage.)
Discretionary Services	Hysterectomy	CPT	Hysterectomy	No more than 1 procedure per enrollee day. IP, OP, and PB claims.	OT and IP claims (Under-reported in states with prevalent local code system usage.)

Utilization Count Measure	Medicare Method				Medicaid Method
	Code	Code type	Description	Notes	
Discretionary Services	Lower Back Surgery	CPT	Lower back surgery	No more than 1 procedure per enrollee day. IP, OP, and PB claims.	OT and IP claims (Under-reported in states with prevalent local code system usage.)
Specialist encounters	See Outpatient Visits	CPT	Same specifications as number of days with an outpatient office visit, but restrict to visits to a physician specialist[52] except those to a primary care physician (01=General practice, 08=Family practice, 11=Internal medicine, 37=Pediatric medicine, and 38=Geriatric medicine) and to 65=Physical therapist.		Not included in analysis as Medicaid claims do not include specialty codes.

B.4 Condition-Specific Quality Measures

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
Acute/ Ischemic Stroke	Discharged on Antiplatelet Therapy: Patients aged 18 and older with diagnosis of ischemic stroke or TIA who were prescribed antiplatelet therapy at discharge.	Process	Programmed to align with AAN/ACR/PCPI/ NCQA Performance Measure #2 specifications	American Academy of Neurology, American College of Radiology, Physician Consortium for Performance Improvement®, National Committee for Quality Assurance. Stroke and stroke rehabilitation physician performance measurement set. Chicago (IL): American Medical Association (AMA), National Committee for Quality Assurance (NCQA); 2009 Feb. 20 p.	Measure 2 (Page 7): http://www.ama-assn.org/ama1/pub/upload/mm/pcpi/stroke-worksheets.pdf

[52] The analysis uses CMS' definition of physician specialty code found in the Medicare claims processing manual: "Medicare Claims Processing Manual: Chapter 26 - Completing and Processing Form CMS-1500 Data Set. Section 10.8.2: Physician Specialty Codes," The Centers for Medicare & Medicaid Services, http://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/Downloads/clm104c26.pdf.

[53] At the recommendation of the team clinician, the chosen approach enforces all optional exclusions in the quality measures in order to give providers the benefit of the doubt in cases where certain services may not be appropriate for beneficiaries with certain characteristics.

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
Diabetes	Rate of Lower-extremity Amputation among Patients with Diabetes: Discharges of age 18 and older with ICD-9-CM procedure code for lower extremity amputation and diagnosis of diabetes in any field.	Outcome	Programmed in accordance with AHRQ Prevention Quality Indicator (PQI) #16 specifications	AHRQ quality indicators. Guide to prevention quality indicators: hospital admission for ambulatory care sensitive conditions [version 3.1]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2007 Mar 12. 59 p. (AHRQ Pub; no. 02-R0203). AHRQ quality indicators. Prevention quality indicators appendices [version 4.2]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 1 p. AHRQ quality indicators. Prevention quality indicators: technical specifications [version 4.2]. PQI #16 rate of lower-extremity amputation among patients with diabetes. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 2 p.	http://www.qualityindicators.ahrq.gov/Downloads/Software/SAS/V41A/TechSpecs/PQI%2016%20Rate%20of%20Lower-extremity%20Amputation.pdf
	Comprehensive diabetes care: percentage of members 18 through 75 years of age with diabetes mellitus (type 1 and type 2) who had an eye screening for diabetic retinal disease.	Process	Programmed to align with HEDIS specifications.	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various p.	See HEDIS measure: Comprehensive diabetes care: percentage of members 18 through 75 years of age with diabetes mellitus (type 1 and type 2) who had an eye screening for diabetic retinal disease.
	Comprehensive diabetes care: percentage of members 18 through 75 years of age with diabetes mellitus (type 1 and type 2) who had a hemoglobin A1c (HbA1c) test during the measurement year.	Process	Programmed to align with HEDIS specifications.	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Comprehensive diabetes care: percentage of members 18 through 75 years of age with diabetes mellitus (type 1 and type 2) who had a hemoglobin A1c (HbA1c) test during the measurement year.

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
Pneumonia	Bacterial Pneumonia Admission Rate: All discharges of age 18 years and older with ICD-9-CM principal diagnosis code for bacterial pneumonia.	Outcome	Programmed to align with AHRQ PQI #11 specifications	AHRQ quality indicators. Guide to prevention quality indicators: hospital admission for ambulatory care sensitive conditions [version 3.1]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2007 Mar 12. 59 p. (AHRQ Pub; no. 02-R0203). AHRQ quality indicators. Prevention quality indicators appendices [version 4.2]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 1 p. AHRQ quality indicators. Prevention quality indicators: technical specifications [version 4.2]. PQI #11 bacterial pneumonia admission rate. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 3 p.	http://www.qualityindicators.ahrq.gov/Downloads/Software/SAS/V41A/TechSpecs/PQI%2011%20Bacterial%20Pneumonia%20Admission%20Rate.pdf
Rheumatoid Arthritis	Rheumatoid arthritis: Percentage of members who were diagnosed with rheumatoid arthritis and who were dispensed at least one ambulatory prescription for a disease modifying anti-rheumatic drug (DMARD).	Process	Programmed to align with HEDIS specifications	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages. National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 2, technical specifications. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Rheumatoid arthritis: percentage of members who were diagnosed with rheumatoid arthritis and who were dispensed at least one ambulatory prescription for a disease modifying anti-rheumatic drug (DMARD).
Depression	Antidepressant medication management (effective acute phase treatment): Percentage of members 18 years of age and older who were diagnosed with a new episode of major depression,	Process	Programmed to align with HEDIS specifications	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages. National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 2, technical specifications. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Antidepressant medication management (effective acute phase treatment): percentage of members 18 years of age and older who were diagnosed with a new episode of major depression, and treated with antidepressant

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
	and treated with antidepressant medication, and who remained on an antidepressant medication for at least 84 days (12 weeks)				medication, and who remained on an antidepressant medication for at least 84 days (12 weeks)
	Antidepressant medication management (effective continuation phase treatment): Percentage of members 18 years of age and older who were diagnosed with a new episode of major depression, and treated with antidepressant medication, and who remained on an antidepressant medication for at least 180 days (6 months)	Process	Programmed to align with HEDIS specifications	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages. National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 2, technical specifications. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Antidepressant medication management (effective continuation phase treatment): percentage of members 18 years of age and older who were diagnosed with a new episode of major depression, and treated with antidepressant medication, and who remained on an antidepressant medication for at least 180 days (6 months)
Congestive Heart Failure	Congestive Heart Failure (CHF) Admission Rate	Outcome	Programmed in accordance with AHRQ PQI #8 specifications	AHRQ quality indicators. Prevention quality indicators: technical specifications [version 4.2]. PQI #8 congestive heart failure (CHF) admission rate. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 3 p.	http://www.qualityindicators.ahrq.gov/Downloads/Software/SAS/V41A/TechSpecs/PQI%2008%20CHF%20Admission%20Rate.pdf

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
Acute Myocardial Infarction	Acute myocardial infarction (AMI): Percentage of members 18 years of age and older during the measurement year who were hospitalized and discharged alive from July 1 of the year prior to the measurement year to June 30 of the measurement year with a diagnosis of AMI and who received persistent beta-blocker treatment for six months after discharge	Process	Programmed to align with HEDIS specifications	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages. National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 2, technical specifications. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Acute myocardial infarction (AMI): percentage of members 18 years of age and older during the measurement year who were hospitalized and discharged alive from July 1 of the year prior to the measurement year to June 30 of the measurement year with a diagnosis of AMI and who received persistent beta-blocker treatment for six months after discharge
Coronary Heart Disease	Antiplatelet Therapy: Percentage of patients aged 18 and older with a diagnosis of coronary artery disease seen within a 12 month period who were prescribed aspirin or clopidogrel	Process	Programmed to align with ACC/AHA/ PCPI Chronic Stable Coronary Artery Disease Performance Measure #6 specifications	American College of Cardiology, American Heart Association, Physician Consortium for Performance Improvement®. Clinical performance measures: chronic stable coronary artery disease. Tools developed by physicians for physicians. Chicago (IL): American Medical Association (AMA); 2005. 8 p.	Measure 6 (Page 55): http://www.ama-assn.org/ama1/pub/upload/mm/pcpi/cadminisetjune06.pdf

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
COPD	Chronic Obstructive Pulmonary Disease (COPD) Admission Rate	Outcome	Programmed in accordance with AHRQ's PQI #5 specifications	AHRQ quality indicators. Guide to prevention quality indicators: hospital admission for ambulatory care sensitive conditions [version 3.1]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2007 Mar 12. 59 p. (AHRQ Pub; no. 02-R0203). AHRQ quality indicators. Prevention quality indicators appendices [version 4.2]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 1 p. AHRQ quality indicators. Prevention quality indicators: technical specifications [version 4.2]. PQI #5 chronic obstructive pulmonary disease (COPD) admission rate. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 2 p.	http://www.qualityindicators.ahrq.gov/Downloads/Software/SAS/V41A/TechSpecs/PQI%2005%20Chronic%20Obstructive%20Pulmonary%20Disease%20%28COPD%29%20Admission%20Rate.pdf
	Pharmacotherapy management of chronic obstructive pulmonary disease (COPD) exacerbation: Percentage of COPD exacerbations for members 40 years of age and older who had an acute inpatient discharge or ED encounter between January 1 to November 30 of the measurement year and who were dispensed a bronchodilator within 30 days of the event	Process	Programmed to align with HEDIS specifications	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages. National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 2, technical specifications. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Pharmacotherapy management of chronic obstructive pulmonary disease (COPD) exacerbation: percentage of COPD exacerbations for members 40 years of age and older who had an acute inpatient discharge or ED encounter between January 1 to November 30 of the measurement year and who were dispensed a bronchodilator within 30 days of the event

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
Cataract	Cataracts: Complications within 30 Days Following Cataract Surgery Requiring Additional Surgical Procedures	Outcome	Programmed to align with AAO/PCPI/NCQA Performance Measure #3 specifications	American Academy of Ophthalmology, Physician Consortium for Performance Improvement®, National Committee for Quality Assurance. Eye care physician performance measurement set. Chicago (IL): American Medical Association, National Committee for Quality Assurance; 2007 Oct. 36 p. [42 references]	Measure 3 (Page 17): http://www.ama-assn.org/ama1/pub/upload/mm/pcpi/eye-care-two-worksheets.pdf
Low Back Pain	Use of imaging studies for low back pain: Percentage of members with a primary diagnosis of low back pain who did not have an imaging study (plain x-ray, MRI, CT scan) within 28 days of the diagnosis	Process	Programmed to align with HEDIS specifications	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages. National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 2, technical specifications. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Use of imaging studies for low back pain: percentage of members with a primary diagnosis of low back pain who did not have an imaging study (plain x-ray, MRI, CT scan) within 28 days of the diagnosis
Cholecystectomy	Laparoscopic Cholecystectomy Rate	Process	Programmed to align with AHRQ Inpatient Quality Indicator (IQI) Measure #23 specifications	AHRQ quality indicators. Guide to inpatient quality indicators: quality of care in hospitals - volume, mortality, and utilization [version 3.1]. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2007 Mar 12. 91 p. AHRQ quality indicators. Inpatient quality indicators: technical specifications [version 4.2]. IQI #23 laparoscopic cholecystectomy rate. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2010 Sep. 1 p.	http://www.qualityindicators.ahrq.gov/Downloads/Software/SAS/v41A/TechSpecs/IQI%2023%20Laparoscopic%20Cholecystectomy%20Rate.pdf
Breast Cancer	Percentage of women 42 to 69 years of age who had one or more mammograms during the measurement year or the year prior to the measurement year.	Process	Programmed to align with HEDIS specifications, modifying age range as defined for measure.	National Committee for Quality Assurance (NCQA). HEDIS® 2011: Healthcare Effectiveness Data and Information Set. Vol. 1, narrative. Washington (DC): National Committee for Quality Assurance (NCQA); 2010. various pages.	See HEDIS measure: Breast cancer screening: percentage of women 40 to 69 years of age who had one or more mammograms during the measurement year or the year prior to the measurement year.

Condition	Quality Measure[53]	Type	Specification	External Source	Link to measure
	Radiation therapy is administered within 1 year (365 days) of diagnosis for women 18 to 69 years of age receiving breast conserving surgery for breast cancer.	Process	Programmed to align with ASCO/NCCN measure specifications, modifying age rage as defined for measure.	American Society of Clinical Oncology (ASCO) National Comprehensive Cancer Network (NCCN)ASCO/NCCN quality measures, endorsed by NQF. ASCO/NCCN quality measures: breast and colorectal cancers. Alexandria (VA): American Society of Clinical Oncology, National Comprehensive Cancer Network, Inc.; 2007 Apr. 5 p.	Table 1 (Page 2): http://www.asco.org/ASCO/Downloads/cancer%20Policy%20and%20Clinical%20Affairs/NCCN/ASCO%20NCCN%20Quality%20Measures%20table%20web%20posting%20with%20CoC%200507.pdf

B.5 Composite Quality Measures

Quality Measure	Components
Patient Safety Indicator Composite: Patient Safety for Selected Indicators (PSI #90)[54]	PSI #03 Pressure Ulcer Rate
	PSI #06 Iatrogenic Pneumothorax Rate
	PSI #07 Central Venous Catheter-Related Blood Stream Infection Rate
	PSI #08 Postoperative Hip Fracture Rate
	PSI #12 Postoperative Pulmonary Embolism or Deep Vein Thrombosis Rate
	PSI #13 Postoperative Sepsis Rate
	PSI #14 Postoperative Wound Dehiscence Rate
	PSI #15 Accidental Puncture or Laceration Rate
Inpatient Quality Indicator Composite: Mortality for Selected Conditions (IQI #91)[55]	IQI #15 Acute Myocardial Infarction (AMI) Mortality Rate
	IQI #16 Congestive Heart Failure (CHF) Mortality Rate
	IQI #17 Acute Stroke Mortality Rate
	IQI #18 Gastrointestinal Hemorrhage Mortality Rate
	IQI #19 Hip Fracture Mortality Rate
	IQI #20 Pneumonia Mortality Rate

[54] "Quality Indicator User Guide: Patient Safety Indicators (PSI) Composite Measures, Version 4.4," The Agency for Healthcare Research and Quality, http://qualityindicators.ahrq.gov/Downloads/Modules/PSI/V44/Composite_User_Technical_Specification_PSI%20V4.4.pdf.
[55] "Quality Indicator User Guide: Inpatient Quality Indicators (IQI) Composite Measures, Version 4.4," The Agency for Healthcare Research and Quality, http://qualityindicators.ahrq.gov/Downloads/Modules/IQI/V44/Composite_User_Technical_Specification_IQI%20V4.4.pdf.

Quality Measure	Components
Prevention Quality Indicator Composite (PQI #90)[56]	PQI #01 Diabetes Short-Term Complications Admission Rate
	PQI #03 Diabetes Long-Term Complications Admission Rate
	PQI #05 Chronic Obstructive Pulmonary Disease (COPD) or Asthma in Older Adults
	PQI #07 Hypertension Admission Rate
	PQI #08 Congestive Heart Failure (CHF) Admission Rate
	PQI #10 Dehydration Admission Rate
	PQI #11 Bacterial Pneumonia Admission Rate
	PQI #12 Urinary Tract Infection Admission Rate
	PQI #13 Angina without Procedure Admission Rate
	PQI #14 Uncontrolled Diabetes Admission Rate
	PQI #15 Asthma in Younger Adults Admission Rate
	PQI #16 Rate of Lower-Extremity Amputation Among Patients with Diabetes

[56] "Quality Indicator User Guide: Prevention Quality Indicators (PQI) Composite Measures, Version 4.4," The Agency for Healthcare Research and Quality, http://qualityindicators.ahrq.gov/Downloads/Modules/PQI/V44/Composite_User_Technical_Specification_PQI%20V4.4.pdf.

APPENDIX C: RISK ADJUSTMENT SPECIFICATIONS

C.1 Composition of Risk Adjustment Clusters for Medicare Analysis

Independent Variable		Cluster										
		Control	1	2 (Baseline)	3	4	5	6[57]	7	8	9	10
Beneficiary-Level Variables	Year[58]	X	X	X	X	X	X		X	X	X	X
	Partial Year Enrollment	X	X	X	X	X	X		X	X	X	X
	Age		X	X	X	X	X		X	X	X	X
	Sex		X	X	X	X	X		X	X	X	X
	Age-Sex Interaction		X	X	X	X	X		X	X	X	X
	Health Status			X			X			X	X	X
	Race				X		X			X	X	X
	Income					X	X			[59]	X	
	Institutionalization Status									X		X
	New Enrollee Indicator			X			X			X	X	X
	Dual Enrollment Status									X		X
	Supplemental Medicare Insurance								X	X		X
Market-Level Variables	Hospital Competition								X	X	X	
	Percent of Population Uninsured								X	X	X	
	Supply of Medical Services								X	X	X	
	Malpractice Environmental Risk								X	X	X	
	Physician Composition								X	X	X	
	Access To Care								X	X	X	
	Payer Mix								X	X		
	Medicaid Penetration								X	X		
	Health Professional Mix								X	X		
	Supplemental Medicare Insurance								X	X		

[57] Cluster 6 is not applicable to the Medicare or Medicaid analysis.
[58] The indicator variable for year of analysis is only used in the analysis of the full 2007 through 2009 data.
[59] Cluster 8 does not include the income indicator because the income indicator is highly collinear with the dual enrollment status indicator.

C.2 Composition of Risk Adjustment Clusters for Medicaid Analysis

Independent Variable		Cluster										
		Control	1	2 (Baseline)	3	4[60]	5	6[61]	7	8	9	10
Beneficiary-Level Variables	Year[62]	X	X	X	X		X		X	X	X	X
	Partial Year Enrollment	X	X	X	X		X		X	X	X	X
	Age		X	X	X		X		X	X	X	X
	Sex		X	X	X		X		X	X	X	X
	Age-Sex Interaction		X	X	X		X		X	X	X	X
	Health Status			X			X			X	X	X
	Race				X		X			X	X	X
	Institutionalization Status			X			X			X	X	X
	New Enrollee Indicator			X			X			X	X	X
	State Indicator											X
Market-Level Variables	Hospital Competition								X	X	X	
	Percent of Population Uninsured								X	X	X	
	Supply of Medical Services								X	X	X	
	Malpractice Environmental Risk								X	X	X	
	Physician Composition								X	X	X	
	Access To Care								X	X	X	
	Payer Mix								X	X		
	Medicaid Penetration								X	X		
	Health Professional Mix								X	X		

[60] Cluster 4 is the same as cluster 1 for the Medicaid analysis.
[61] Cluster 6 is not applicable to the Medicare or Medicaid analysis.
[62] The indicator variable for year of analysis is only used in the analysis on the full 2007 through 2009 data.

C.3 Beneficiary-Level Characteristics

Beneficiary-Level Variable	Data Source: Medicare/Medicaid	Medicare Measure	Medicaid Measure
Age	EDB/EL	5-year age bands tied to 65 (e.g., 65-69), one age band for under 65, and one age band for over 90, indicating beneficiary age as of index date.	5-year age bands tied to 20 (e.g., 20-24), one age band for 18-19, and one age band for over 90, indicating beneficiary age as of index date.
Sex	EDB/EL	Male/Female	Same as Medicare
Age*Sex Interaction	EDB/EL	Age* Sex interaction (e.g., 65-69 and Female, 65-69 and Male, etc.)	Same as Medicare
Race and Ethnicity	EDB/EL	White, Black, Hispanic, Asian, Other (includes North American Native category), Unknown.	White, Black, Hispanic, Asian, Other, Unknown (includes Missing category)
Income	EDB	Low Income Subsidy (LIS). Flag as LIS if beneficiary submits any LIS copay or subsidy during the observation period. LIS information is available for Part D beneficiaries only, so any beneficiary who is counted as LIS is also enrolled in Part D.	Not included because this information is not available on Medicaid claims.
Health Status	CWF/MSIS	CMS 2008 HCC health status and enrollment indicators during look-back period of 365 days from the index date. HCCs include one originally disabled indicator and an ESRD indicator. HCC interactions do not include interactions with Medicaid status.[63]	CMS 2008 HCC health status indicators during look-back period of 365 days from the index date. HCC interactions do not include interactions with Medicaid status or disability status.
New Enrollee Indicator	CWF/MSIS	Indicator for whether beneficiary has a full year of claims history (enrollment in A AND B) prior to the observation start date.	Indicator for whether beneficiary has a full year of claims history (FFS enrolled with no benefits restriction) prior to the observation start

[63] When risk-adjusting the composite quality measures for the aggregate analysis, the regression uses the HCCs from the prior calendar year instead of the HCCs from the year prior to the inpatient event to assure consistency across the components of the quality measures.

Beneficiary-Level Variable	Data Source: Medicare/Medicaid	Medicare Measure	Medicaid Measure
			date.
Institutionalization Status	RAPS/LT	Indicator variable for being in long-term care for at least 90 consecutive days in the calendar year prior to the year of analysis.[64]	Indicator variable for being in long-term care for at least 90 cumulative days in the calendar year prior to the year of analysis.
Dual Eligibility Status	EDB	Indicator variable for enrollment in both Medicare and Medicaid at any time during the observation period.	Not included because dual-enrolled beneficiaries are dropped from the Medicaid analysis.
Partial Year Enrollment	EDB/EL	Cohort Analysis: Three sets of indicator variables for enrollment during the observation window,[65] indicating if the beneficiary is enrolled in the first month, second month, third month, etc.: 1. Order of months alive and enrolled in Medicare Part A 2. Order of months alive and enrolled in Medicare Part B 3. Order of months alive and enrolled in Medicare (Part A OR B) AND Part D	Cohort Analysis: One set of indicator variables for order of months enrolled in Medicaid during the observation window. To be considered enrolled, beneficiary must be alive, FFS enrolled and have no benefits restriction.
		Aggregate Analysis: Two indicator variables for continuous enrollment from the first month of enrollment through the calendar year: 1. Continuously enrolled and alive in Medicare Part A or B 2. Continuously enrolled and alive in Medicare (Part A OR B) AND Part D	Aggregate Analysis: One indicator variable for continuously enrolled in FFS, alive, and without benefits restriction.
Supplemental Medicare	EDB	Indicator for the presence of supplemental Medicare insurance. This	Not included.

[64] For beneficiaries in the cholecystectomy cohort whose observation period overlaps 2006, because 2006 is the earliest year of data available for this analysis, the institutionalization status indicator for both the Medicare and the Medicaid analysis examines the entire 2006 time period.

[65] Because the observation window for the cataract cohort can vary between three and six months, the fourth through sixth indicators of the partial year enrollment variable for cataracts are zero if either the beneficiary is not enrolled in the relevant part of Medicare for that month or the observation window has ended.

Beneficiary-Level Variable	Data Source: Medicare/Medicaid	Medicare Measure	Medicaid Measure
Insurance		indicator as defined in the EDB includes Medicaid enrollment. However, because this analysis includes a dual-enrollment indicator, beneficiaries enrolled in Medicaid are not counted as having supplemental insurance.	

C.4 Market-Level Characteristics

Market-Level Variable	Data Source	Variables
Hospital Competition	AHA	Herfindahl index (HHI) of competition based on the distribution of beds in each market
		=1 if there is at least 1 teaching hospital in the HRR
		=1 if there is at least 1 specialty hospital in the HRR
		=1 if there is at least 1 government owned hospital in the HRR
Percent of Population Uninsured	InterStudy	Population uninsured
Supply of Medical Services	ARF	Number of hospitals per 1,000
		Number of hospital beds per 1,000
Malpractice Environment Risk	MPFS	Medicare malpractice GPCI
Physician Composition	ARF	Active MDs per 1,000
		Active general practitioners per 1,000
		Active primary care physicians per 1,000
		Active specialists per 1,000
Access to Care	ARF	Indicator for population shortage areas, weighted by county population.
Payer Mix	InterStudy	Medicare analysis only: percent of Medicare population covered by managed care plans
		Medicaid analysis only: percent of Medicaid population covered by managed care plans
Medicaid Penetration	InterStudy	= (# Medicaid beneficiaries / total population in HRR)
Health Professional Mix	ARF	Six variables for non-physicians per capita. These variables are not included in Harvard's market-level file. This analysis has created these variables from ARF data.

Market-Level Variable	Data Source	Variables
		Physician's Assistants
		Active Nurse Practitioners
		Nurse Anesthetists
		Active Certified Nurse Midwives
		Registered Nurses
		Licensed Practical Nurses and Licensed Vocational Nurses
Percent of Medicare Beneficiaries with Supplemental Insurance	EDB	Medicare analysis only: Percent of beneficiaries with supplemental Medicare insurance: (Number of beneficiary-months enrolled in supplementary Medicare insurance) / (Number of beneficiary-months alive and enrolled in Medicare Part A or B but not C). Beneficiaries are counted for each month. This indicator as defined on claims includes Medicaid enrollment. However, because this analysis includes a dual-enrollment indicator, beneficiaries enrolled in Medicaid are not counted as having supplemental insurance.

APPENDIX D: VARIATION IN SPENDING ACROSS THE NATION

Table D.1: AMI Price-Standardized Risk-Adjusted Average Monthly Cost Distribution

Beneficiary Criteria	# Episodes	Avg.	Std. Dev.	Minimum	10th Percentile	50th Percentile	90th Percentile	Maximum	90-10 Difference
All Beneficiaries	1,024,431	$5,591	$13,980	-$20,837	$2,140	$4,696	$9,867	$258,338	$7,727
Female	512,902	$5,591	$13,449	-$20,837	$2,109	$4,743	$9,896	$229,883	$7,787
Male	511,529	$5,591	$14,493	-$16,946	$2,171	$4,649	$9,836	$258,338	$7,665
White	881,250	$5,591	$13,487	-$16,946	$2,290	$4,733	$9,717	$251,455	$7,427
Black	96,324	$5,591	$16,732	-$20,837	$1,246	$4,366	$11,150	$258,338	$9,904
Asian	12,223	$5,591	$17,262	-$12,478	$1,573	$4,282	$10,739	$132,730	$9,166
Hispanic	17,881	$5,591	$16,923	-$14,882	$1,417	$4,348	$10,896	$175,674	$9,479
Other	15,383	$5,591	$15,898	-$15,335	$1,916	$4,616	$10,022	$136,022	$8,107
Unknown	1,370	$5,591	$14,682	-$12,925	$1,623	$4,692	$9,932	$81,370	$8,309
Dual-Eligible	267,748	$5,591	$15,456	-$17,403	$1,455	$4,555	$10,802	$219,412	$9,346
Not Dual-Eligible	756,683	$5,591	$13,419	-$20,837	$2,467	$4,729	$9,557	$258,338	$7,090
Living during Entire Episode	651,584	$5,462	$11,510	-$13,234	$2,603	$4,703	$9,227	$229,152	$6,624
Not Living during Entire Episode	372,847	$6,322	$17,413	-$20,837	-$1,601	$4,609	$15,038	$258,338	$16,639

Table D.2: Stroke Price-Standardized Risk-Adjusted Average Monthly Cost Distribution

Beneficiary Criteria	# Episodes	Avg.	Std. Dev.	Minimum	10th Percentile	50th Percentile	90th Percentile	Maximum	90-10 Difference
All Beneficiaries	618,106	$5,047	$11,959	-$15,859	$1,766	$4,139	$9,517	$161,695	$7,751
Female	359,863	$5,047	$11,458	-$13,376	$1,734	$4,229	$9,442	$124,919	$7,708
Male	258,243	$5,047	$12,625	-$15,859	$1,811	$4,024	$9,629	$161,695	$7,817
White	506,223	$5,047	$11,266	-$13,240	$1,961	$4,176	$9,389	$161,695	$7,427
Black	83,586	$5,047	$14,963	-$15,859	$1,041	$3,922	$10,319	$124,919	$9,278
Asian	8,078	$5,047	$13,937	-$10,615	$1,518	$3,914	$9,854	$61,081	$8,337
Hispanic	11,023	$5,047	$14,499	-$9,604	$1,210	$4,000	$10,166	$100,790	$8,956
Other	8,352	$5,047	$13,157	-$10,981	$1,688	$4,063	$9,554	$75,530	$7,865
Unknown	844	$5,047	$11,524	-$5,038	$1,563	$4,224	$9,563	$64,339	$8,001
Dual-Eligible	173,793	$5,047	$13,648	-$13,376	$1,087	$4,177	$10,071	$124,919	$8,984
Not Dual-Eligible	444,313	$5,047	$11,230	-$15,859	$2,181	$4,127	$9,296	$161,695	$7,115
Living during Entire Episode	422,274	$4,916	$11,194	-$13,240	$2,019	$4,086	$9,027	$147,232	$7,008
Not Living during Entire Episode	195,832	$5,908	$13,339	-$15,859	-$639	$4,796	$13,101	$161,695	$13,740

Table D.3: CHD Price-Standardized Risk-Adjusted Average Monthly Cost Distribution

Beneficiary Criteria	# Episodes	Avg.	Std. Dev.	Minimum	10th Percentile	50th Percentile	90th Percentile	Maximum	90-10 Difference
All Beneficiaries	18,856,261	$1,960	$8,570	-$18,193	$224	$889	$1,416	$2,362	$4,364
Female	8,562,970	$1,960	$8,547	-$18,193	$154	$818	$1,386	$2,427	$4,499
Male	10,293,291	$1,960	$8,589	-$17,489	$292	$948	$1,437	$2,311	$4,253
White	16,437,459	$1,960	$8,306	-$17,489	$280	$920	$1,425	$2,356	$4,313
Black	1,443,533	$1,960	$10,834	-$18,193	-$313	$533	$1,244	$2,466	$5,049
Asian	305,736	$1,960	$8,428	-$15,514	$419	$972	$1,508	$2,231	$3,938
Hispanic	364,269	$1,960	$9,914	-$16,027	-$120	$597	$1,286	$2,514	$4,920
Other	284,552	$1,960	$8,836	-$14,970	$228	$927	$1,514	$2,288	$4,165
Unknown	20,712	$1,960	$9,144	-$9,985	$56	$716	$1,365	$2,473	$4,587
Dual-Eligible	4,017,579	$1,960	$10,645	-$18,193	-$294	$436	$1,160	$2,667	$5,224
Not Dual-Eligible	14,838,682	$1,960	$7,915	-$17,489	$425	$998	$1,447	$2,304	$4,151
Living during Entire Episode	17,146,365	$1,880	$7,334	-$15,711	$294	$904	$1,407	$2,273	$4,105
Not Living during Entire Episode	1,709,896	$3,500	$15,972	-$18,193	-$1,919	-$115	$2,269	$5,472	$9,801

Table D.4: Diabetes Price-Standardized Risk-Adjusted Average Monthly Cost Distribution

Beneficiary Criteria	# Episodes	Avg.	Std. Dev.	Minimum	10th Percentile	50th Percentile	90th Percentile	Maximum	90-10 Difference
All Beneficiaries	18,533,150	$1,632	$7,664	-$15,786	$120	$1,264	$3,509	$1,686,842	$3,389
Female	10,246,929	$1,632	$7,172	-$15,589	$144	$1,261	$3,518	$215,568	$3,373
Male	8,286,221	$1,632	$8,232	-$15,786	$87	$1,268	$3,497	$1,686,842	$3,411
White	14,469,046	$1,632	$7,496	-$15,589	$156	$1,271	$3,482	$1,686,842	$3,325
Black	2,577,191	$1,632	$8,586	-$15,786	-$112	$1,196	$3,770	$401,662	$3,882
Asian	439,860	$1,632	$6,536	-$13,083	$418	$1,365	$2,915	$131,280	$2,496
Hispanic	579,711	$1,632	$8,556	-$14,386	-$72	$1,123	$3,996	$410,213	$4,068
Other	445,583	$1,632	$7,183	-$13,478	$242	$1,379	$3,141	$156,702	$2,899
Unknown	21,759	$1,632	$7,913	-$14,940	$13	$1,175	$3,720	$74,014	$3,707
Dual-Eligible	5,498,487	$1,632	$8,869	-$15,786	-$239	$1,021	$4,238	$171,513	$4,477
Not Dual-Eligible	13,034,663	$1,632	$7,094	-$15,589	$319	$1,312	$3,227	$1,686,842	$2,908
Living during Entire Episode	17,440,041	$1,567	$6,909	-$13,591	$166	$1,258	$3,289	$1,686,842	$3,123
Not Living during Entire Episode	1,093,109	$3,425	$14,550	-$15,786	-$1,526	$2,205	$9,533	$401,662	$11,059

APPENDIX E: POTENTIAL COST SAVINGS

Figure E.1: Potential Price Standardized-Risk Adjusted Yearly Cost Savings (AMI)

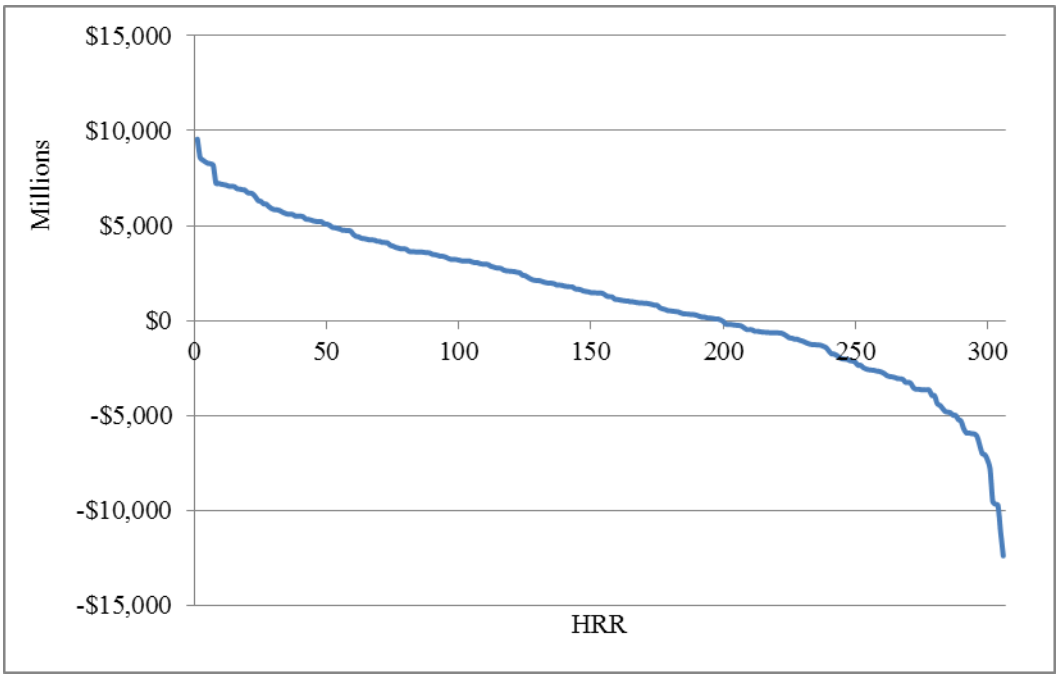


Figure E.2: Potential Price Standardized-Risk Adjusted Yearly Cost Savings (Stroke)

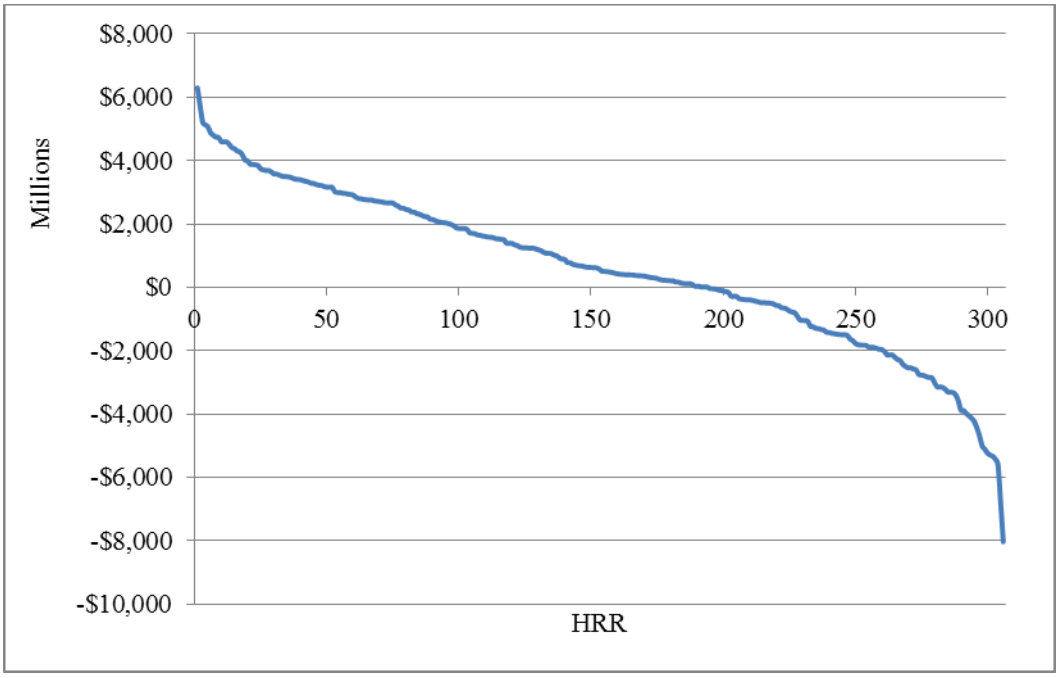


Figure E.3: Potential Price Standardized-Risk Adjusted Yearly Cost Savings (CHD)

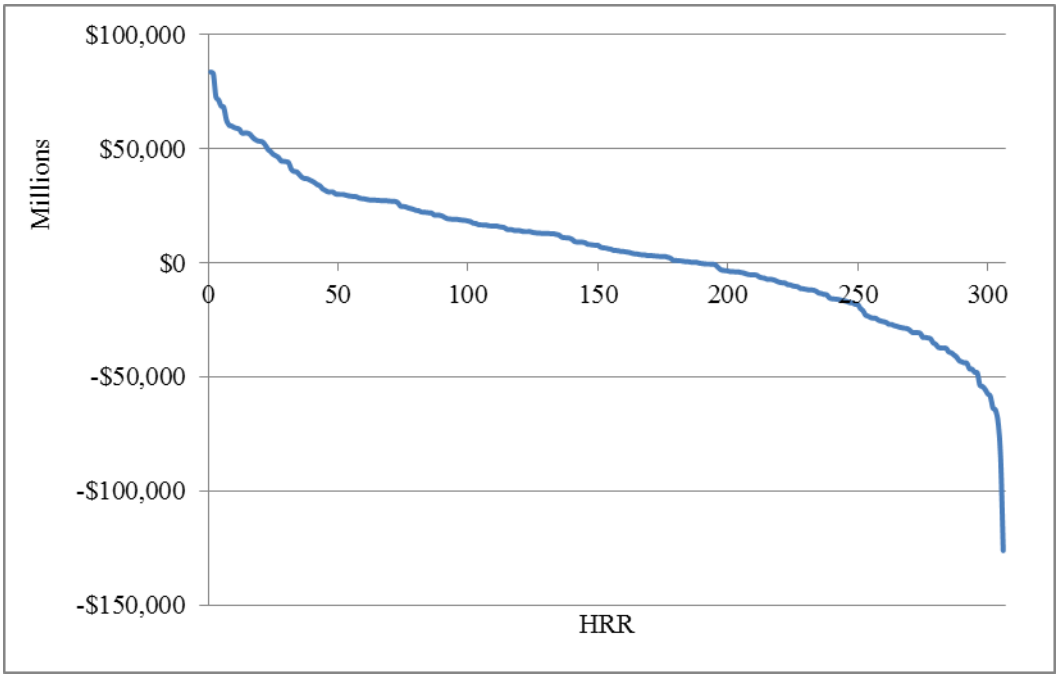
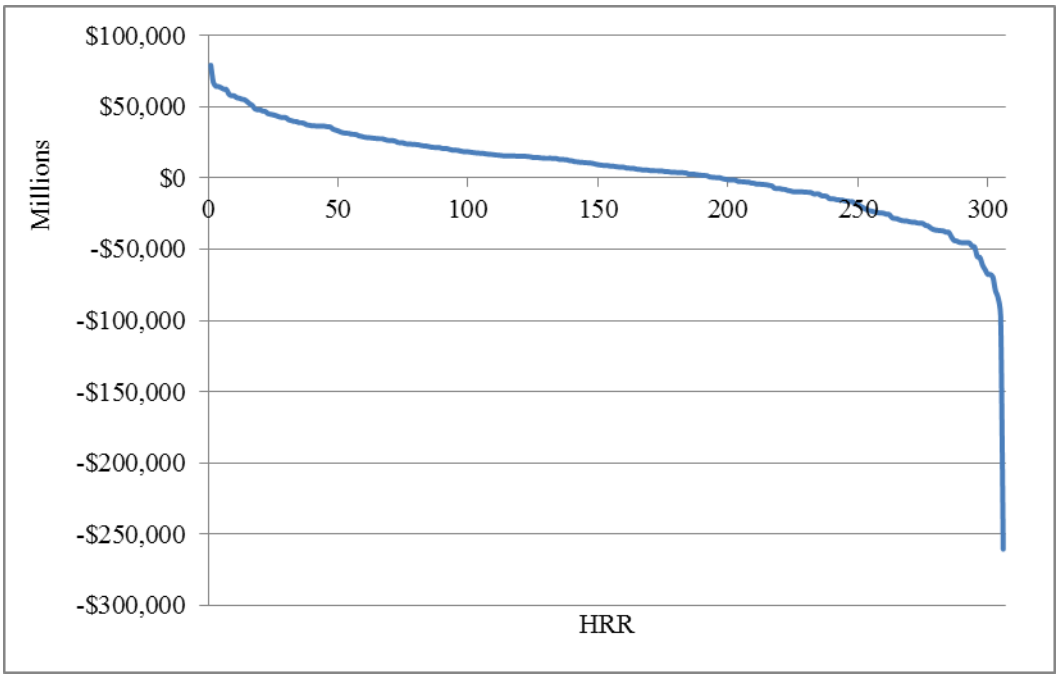


Figure E.4: Potential Price Standardized-Risk Adjusted Yearly Cost Savings (Diabetes)



APPENDIX F: STABILITY OF MEDICAL SERVICE VOLUME OVER TIME

Table F.1: Pearson Correlation of HRR-Level Utilization 2007-2009 (AMI)

	2007	2008	2009
2007	1.000	0.853	0.828
2008	0.853	1.000	0.870
2009	0.828	0.870	1.000

Table F.2: Spearman Correlation of HRR-Level Utilization 2007-2009 (AMI)

	2007	2008	2009
2007	1.000	0.836	0.813
2008	0.836	1.000	0.865
2009	0.813	0.865	1.000

Table F.3: Pearson Correlation of HRR-Level Utilization 2007-2009 (Stroke)

	2007	2008	2009
2007	1.000	0.810	0.791
2008	0.810	1.000	0.814
2009	0.791	0.814	1.000

Table F.4: Spearman Correlation of HRR-Level Utilization 2007-2009 (Stroke)

	2007	2008	2009
2007	1.000	0.804	0.807
2008	0.804	1.000	0.813
2009	0.807	0.813	1.000

Table F.5: Pearson Correlation of HRR-Level Utilization 2007-2009 (CHD)

	2007	2008	2009
2007	1.000	0.927	0.871
2008	0.927	1.000	0.928
2009	0.871	0.928	1.000

Table F.6: Spearman Correlation of HRR-Level Utilization 2007-2009 (CHD)

	2007	2008	2009
2007	1.000	0.903	0.839
2008	0.903	1.000	0.909
2009	0.839	0.909	1.000

Table F.7: Pearson Correlation of HRR-Level Utilization 2007-2009 (Diabetes)

	2007	2008	2009
2007	1.000	0.971	0.952
2008	0.971	1.000	0.958
2009	0.952	0.958	1.000

Table F.8: Spearman Correlation of HRR-Level Utilization 2007-2009 (Diabetes)

	2007	2008	2009
2007	1.000	0.947	0.926
2008	0.947	1.000	0.930
2009	0.926	0.930	1.000

APPENDIX G: VARIATION IN VOLUME OF MEDICAL SERVICES WITHIN AND ACROSS REGIONS

Table G.1: AMI Dispersion of Medical Service Utilization Within and Across Regions

	Unadjusted	Price-Standardized	Price-Standardized Risk-Adjusted
Average of HRR Standard Deviations	$16,602	$16,408	$13,322
Weighted Average of HRR Standard Deviations	$17,395	$17,034	$13,780
Standard Deviation of HRR Means	$870	$663	$424
Average of HRR 90-10 Differences	$9,582	$9,532	$7,411
Weighted Average of HRR 90-10 Differences	$10,201	$10,045	$7,723
90-10 Difference of HRR Means	$2,182	$1,618	$1,051

Table G.2: Stroke Dispersion of Medical Service Utilization Within and Across Regions

	Unadjusted	Price-Standardized	Price-Standardized Risk-Adjusted
Average of HRR Standard Deviations	$13,725	$13,678	$11,310
Weighted Average of HRR Standard Deviations	$14,503	$14,295	$11,791
Standard Deviation of HRR Means	$681	$595	$435
Average of HRR 90-10 Differences	$9,166	$9,190	$7,486
Weighted Average of HRR 90-10 Differences	$9,620	$9,542	$7,744
90-10 Difference of HRR Means	$1,593	$1,498	$1,111

Table G.3: CHD Dispersion of Medical Service Utilization Within and Across Regions

	Unadjusted	Price-Standardized	Price-Standardized Risk-Adjusted
Average of HRR Standard Deviations	$9,635	$9,582	$8,246
Weighted Average of HRR Standard Deviations	$10,125	$9,942	$8,481
Standard Deviation of HRR Means	$232	$213	$139
Average of HRR 90-10 Differences	$4,597	$4,609	$4,035
Weighted Average of HRR 90-10 Differences	$4,825	$4,775	$4,143
90-10 Difference of HRR Means	$552	$485	$358

Table G.4: Diabetes Dispersion of Medical Service Utilization Within and Across Regions

	Unadjusted	Price-Standardized	Price-Standardized Risk-Adjusted
Average of HRR Standard Deviations	$8,534	$8,503	$7,093
Weighted Average of HRR Standard Deviations	$9,108	$8,977	$7,463
Standard Deviation of HRR Means	$248	$244	$154
Average of HRR 90-10 Differences	$3,902	$3,921	$3,279
Weighted Average of HRR 90-10 Differences	$4,109	$4,084	$3,387
90-10 Difference of HRR Means	$552	$531	$348

APPENDIX H: VARIATION IN VOLUME OF MEDICAL SERVICES ACROSS CONDITION COHORTS

			Acute					Chronic							Cancer		
		Agg	AMI	Cat	Chol	Pneu	Stroke	Arthr	CHD	CHF	COPD	Depr	Diab	LBP	Breast	Lung	Prostate
	Aggregate	1.000	0.712	0.537	0.588	0.753	0.803	0.833	0.915	0.927	0.942	0.921	0.957	0.958	0.589	0.557	0.501
Acute	AMI	0.712	1.000	0.340	0.634	0.842	0.781	0.581	0.731	0.824	0.763	0.682	0.739	0.736	0.549	0.676	0.545
	Cataract	0.537	0.340	1.000	0.355	0.350	0.346	0.465	0.548	0.496	0.535	0.434	0.559	0.482	0.313	0.347	0.230
	CHOL	0.588	0.634	0.355	1.000	0.627	0.578	0.501	0.585	0.620	0.617	0.527	0.584	0.592	0.407	0.493	0.410
	Pneumonia	0.753	0.842	0.350	0.627	1.000	0.840	0.611	0.730	0.851	0.810	0.768	0.777	0.754	0.539	0.675	0.552
	Stroke	0.803	0.781	0.346	0.578	0.840	1.000	0.670	0.773	0.866	0.827	0.814	0.804	0.802	0.501	0.590	0.524
Chronic	Arthritis	0.833	0.581	0.465	0.501	0.611	0.670	1.000	0.809	0.767	0.830	0.807	0.814	0.847	0.476	0.436	0.373
	CHD	0.915	0.731	0.548	0.585	0.730	0.773	0.809	1.000	0.920	0.944	0.849	0.916	0.909	0.516	0.537	0.424
	CHF	0.927	0.824	0.496	0.620	0.851	0.866	0.767	0.920	1.000	0.948	0.891	0.921	0.910	0.585	0.621	0.499
	COPD	0.942	0.763	0.535	0.617	0.810	0.827	0.830	0.944	0.948	1.000	0.922	0.943	0.937	0.560	0.595	0.465
	Depression	0.921	0.682	0.434	0.527	0.768	0.814	0.807	0.849	0.891	0.922	1.000	0.906	0.916	0.528	0.498	0.454
	Diabetes	0.957	0.739	0.559	0.584	0.777	0.804	0.814	0.916	0.921	0.943	0.906	1.000	0.934	0.538	0.540	0.477
	LBP	0.958	0.736	0.482	0.592	0.754	0.802	0.847	0.909	0.910	0.937	0.916	0.934	1.000	0.574	0.558	0.484
Cancer	Breast	0.589	0.549	0.313	0.407	0.539	0.501	0.476	0.516	0.585	0.560	0.528	0.538	0.574	1.000	0.610	0.523
	Lung	0.557	0.676	0.347	0.493	0.675	0.590	0.436	0.537	0.621	0.595	0.498	0.540	0.558	0.610	1.000	0.518
	Prostate	0.501	0.545	0.230	0.410	0.552	0.524	0.373	0.424	0.499	0.465	0.454	0.477	0.484	0.523	0.518	1.000

APPENDIX I: SERVICE CATEGORIES DRIVING RESULTS

Table I.1: AMI Service Category Utilization across HRRs, Pearson Correlation (2007)

	Remaining Costs	Acute Care	Prescription Drugs	Diagnostic	Post-Acute Care	Procedures	ER/Ambulance	Other
Remaining Costs	.	0.15	0.02	0.05	0.13	0.04	0.16	0.05
Acute Care	0.15	1.00	0.00	0.02	0.13	0.00	0.13	0.03
Prescription Drugs	0.02	0.00	1.00	0.24	-0.04	0.29	0.08	0.08
Diagnostic	0.05	0.02	0.24	1.00	-0.05	0.29	0.20	0.13
Post-Acute Care	0.13	0.13	-0.04	-0.05	1.00	0.00	0.07	0.03
Procedures	0.04	0.00	0.29	0.29	0.00	1.00	0.07	0.09
ER/Ambulance	0.16	0.13	0.08	0.20	0.07	0.07	1.00	0.07
Other	0.05	0.03	0.08	0.13	0.03	0.09	0.07	1.00

Table I.2: Stroke Service Category Utilization across HRRs, Pearson Correlation (2007)

	Remaining Costs	Acute Care	Prescription Drugs	Diagnostic	Post-Acute Care	Procedures	ER/Ambulance	Other
Remaining Costs	.	0.19	0.01	0.05	0.17	0.07	0.22	0.11
Acute Care	0.19	1.00	0.00	0.03	0.17	0.00	0.18	0.05
Prescription Drugs	0.01	0.00	1.00	0.21	-0.04	0.24	0.07	0.07
Diagnostic	0.05	0.03	0.21	1.00	-0.04	0.30	0.16	0.10
Post-Acute Care	0.17	0.17	-0.04	-0.04	1.00	0.05	0.12	0.10
Procedures	0.07	0.00	0.24	0.30	0.05	1.00	0.08	0.09
ER/Ambulance	0.22	0.18	0.07	0.16	0.12	0.08	1.00	0.07
Other	0.11	0.05	0.07	0.10	0.10	0.09	0.07	1.00

Table I.3: CHD Service Category Utilization across HRRs, Pearson Correlation (2007)

	Remaining Costs	Acute Care	Prescription Drugs	Diagnostic	Post-Acute Care	Procedures	ER/Ambulance	Other
Remaining Costs	.	0.24	0.04	0.12	0.21	0.06	0.28	0.08
Acute Care	0.24	1.00	0.02	0.07	0.22	0.01	0.26	0.04
Prescription Drugs	0.04	0.02	1.00	0.20	-0.02	0.17	0.03	0.06
Diagnostic	0.12	0.07	0.20	1.00	-0.04	0.36	0.10	0.10
Post-Acute Care	0.21	0.22	-0.02	-0.04	1.00	-0.01	0.15	0.04
Procedures	0.06	0.01	0.17	0.36	-0.01	1.00	0.03	0.10
ER/Ambulance	0.28	0.26	0.03	0.10	0.15	0.03	1.00	0.04
Other	0.08	0.04	0.06	0.10	0.04	0.10	0.04	1.00

Table I.4: Diabetes Service Category Utilization across HRRs, Pearson Correlation (2007)

	Remaining Costs	Acute Care	Prescription Drugs	Diagnostic	Post-Acute Care	Procedures	ER/Ambulance	Other
Remaining Costs	.	0.32	0.05	0.18	0.30	0.09	0.26	0.11
Acute Care	0.32	1.00	0.02	0.11	0.32	0.02	0.23	0.06
Prescription Drugs	0.05	0.02	1.00	0.17	-0.01	0.14	0.02	0.06
Diagnostic	0.18	0.11	0.17	1.00	0.01	0.35	0.09	0.12
Post-Acute Care	0.30	0.32	-0.01	0.01	1.00	0.01	0.18	0.06
Procedures	0.09	0.02	0.14	0.35	0.01	1.00	0.05	0.09
ER/Ambulance	0.26	0.23	0.02	0.09	0.18	0.05	1.00	0.04
Other	0.11	0.06	0.06	0.12	0.06	0.09	0.04	1.00