Hospital-Level, Risk-Standardized Payment Associated with a 30-Day Episode of Care for Heart Failure (Version 1.0)

2013 Measure Methodology Report

Submitted By

Yale New Haven Health Services Corporation /Center for Outcomes Research & Evaluation (YNHHSC/CORE):

Nancy Kim, M.D., Ph.D.*– Project Lead
Angela Hsieh, Ph.D. – Lead Analyst
Lesli S. Ott, M.A., M.A. – Supporting Analyst
Steven Spivack, M.P.H. – Project Coordinator
Xiao Xu, M.A., Ph.D.* – Consulting Health Economist
Mark Volpe, B.S. – Research Assistant
Alex Liu, B.S. – Research Assistant
Meechen Okai, B.A. – Research Assistant
Susannah M. Bernheim, M.D., M.H.S.* – Project Director
Harlan M. Krumholz, M.D., S.M.* – Principal Investigator

*Yale School of Medicine

Prepared For:

Centers for Medicare & Medicaid Services (CMS)

September 2013

ACKNOWLEDGEMENTS

This study is a collaborative effort, and the study authors gratefully acknowledge and thank Zhenqiu Lin, Elizabeth Drye, Kanchana Bhat, and Lori Geary from Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation; Sharon-Lise Normand from Harvard School of Public Health; and Lein Han, Karen Nakano, Michael Rapp, and Kate Goodrich at the Centers for Medicare & Medicaid Services for their contributions to this work.

We also thank the Technical Expert Panel members, who provided helpful insight on key measure decisions. These members include:

Amanda Kowalski, PhD - Assistant Professor of Economics, Yale University

Anne-Marie Audet, MD, MSc, SM - Vice President, Health System Quality and Efficiency, Commonwealth Fund

David S. P. Hopkins, PhD - Senior Advisor, Pacific Business Group on Health

Donald Casey MD, MPH, MBA - Vice President and Medical Director, NYU Langone Medical Center

Kavita Patel, MD, MS - Managing Director for Clinical Transformation and Delivery, Engelberg Center for Healthcare Reform, Brookings Institution

Lesley Curtis, PhD, MS - Associate Professor in Medicine, Duke University

Peter Bach, MD, MAPP - Director, Center for Health Policy and Outcomes, Memorial Sloan-Kettering Cancer Center

Peter Lindenauer, MD, MSc - Associate Professor of Medicine, Tufts University; Medical Director, Clinical and Quality Informatics, Baystate Medical Center; Director, Center for Quality of Care Research

Scott Flanders, MD - Professor of Internal Medicine; Director of the Hospitalist Program, University of Michigan

Stephen Schmaltz, PhD, MS, MPH - Associate Director, Center for Database Management and Analysis, Joint Commission

Terry Golash, MD - Senior Medical Director, Aetna

Vivian Ho, PhD - James A. Baker III Institute Chair in Health Economics and Professor of Economics, Rice University

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This technical report describes the development of a hospital-level, risk-standardized 30-day episode-of-care payment measure for heart failure (HF) developed by Yale New Haven Health Services Corporation/ Center for Outcomes Research & Evaluation (YNHHSC/CORE) under contract with the Centers for Medicare & Medicaid Services (CMS). A risk-standardized payment measure for a HF episode of care that spans from admission through 30 days post-admission provides information that will support hospital and national efforts to optimize and coordinate care.

Context of Medicare Spending and Value Assessments

In 2012 total Medicare expenditures were $574.2 billion, representing 3.6% of gross domestic product (GDP). Current estimates suggest that Medicare spending will increase to 5.6% of GDP by 2035.[1] The growth in Medicare spending highlights the need to incentivize high value care. A critical first step in moving toward high value care is to provide transparency of costs of care that is comparable across providers. In this report, we describe the development of a "cost" measure that evaluates the cost of care for Medicare patients from the CMS perspective. We developed this measure to include a 30-day episode of care to provide insight into the cost of practice patterns that occur during inpatient admission and immediately thereafter. The measure specifications are aligned with current quality of care measures so that the costs of care can be interpreted in the context of the health outcomes they deliver. In this way, the measure can facilitate the profiling of hospital value and encourage the most efficient delivery of high quality care.

Using Payments for Medicare Patients

Costs are often approximated using hospital charges, converting hospital charges to costs based on cost-to-charge ratios, or estimating Medicare payments. Because we are interested in measuring costs from Medicare's perspective, we focused on payments made for Medicare patients for a 30-day episode of care for HF. Payments for Medicare patients are calculated using both Medicare claims and CMS data. Using CMS's clearly defined Prospective Payment Systems and Fee Schedules in combination with Medicare claims allows for the removal of payment adjustments that are not directly related to care (for example, geographic factors and policy adjustments) across all care settings, services, and supplies.

Measuring HF

By focusing on one specific condition, value assessments may provide actionable feedback to hospitals and incentivize targeted improvements in care. HF is a common condition among the elderly with substantial variability in payments due to different practice patterns. Quality measures for HF, such as 30-day HF risk-standardized mortality rate (RSMR), are already publicly reported. In the context of its publicly reported quality measures, HF is an ideal condition in which to assess payments for Medicare patients and relative hospital value.

30-Day Episode of Care

When considering hospital payments, we focused on an "episode of care" triggered by admission for several key reasons. First, hospitalizations represent brief periods of illness that require ongoing management post-discharge. Second, decisions made at the admitting hospital affect payments for care in the immediate post-discharge period. Third, assigning payments for a continuous episode of care to admitting hospitals may reveal practice variations in the full care of the illness experienced by patients that can result in increased payments**.** Fourth, a 30-day preset window provides a standard observation period by which to compare all hospitals. Lastly, we designed the HF payment measure to be aligned

with HF quality measures, like CMS's publicly reported HF mortality measure, which is reported 30 days after admission. The HF payment measure captures payments for Medicare patients across multiple care settings, services, and supplies (inpatient, outpatient, skilled nursing facility, home health, hospice, physician/clinical laboratory/ambulance services, and durable medical equipment, prosthetics/orthotics, and supplies).

Payment Calculation

The overarching goal of the measure is to calculate payments that reflect differences in the care provided for patients with HF rather than differences based on geography or policy adjustments. In order to remove payment adjustments unrelated to clinical care we developed the measure by "stripping" or "standardizing" payments as detailed below:

- Stripping refers to removing geographic differences and policy adjustments in payment rates for individual services.
- Standardizing refers to averaging payments across geographic areas for those services where geographic differences in payment cannot be stripped.

By removing payment adjustments unrelated to clinical care, our measure reflects differences in payment due to practice variation at the hospital level. The body of the report presents the current measure specifications, methodology, and results in detail. Although the methodology of this payment measure is developed for HF, it can be applied to other disease conditions such as acute myocardial infarction (AMI) and pneumonia.

Risk-Adjustment and Statistical Model

To compare relative hospital payments, we adjusted for hospital case-mix by including patient age and comorbid conditions that are clinically relevant to HF and have strong relationships with the payment outcome. To calculate hospital-specific risk-standardized payments, we estimated hierarchical generalized linear models. This strategy accounts for within-hospital correlation of the observed outcomes (total payments) and accommodates the assumption that underlying differences in quality across hospitals lead to systematic differences in outcomes.

Findings

Wide variation in payments for a HF episode of care persists after considering transfers, removing Medicare payment adjustments that are not related to clinical care (for example, geographic factors and policy adjustments), and adjusting for case mix.

1. INTRODUCTION

1.1. Background

In 2012 total Medicare expenditures were $574.2 billion, representing 3.6% of gross domestic product (GDP). Current estimates suggest that Medicare spending will increase to 5.6% of GDP by 2035 due to both an increase in the Medicare population as well as Medicare spending on each beneficiary.[1] The growth in Medicare spending is unsustainable and highlights the need to create incentives for high value care. A critical first step in moving toward high value care is to define an approach to calculate costs that is transparent to consumers and fair to providers. In this report, we describe the development of a "cost" measure that evaluates the cost of care for Medicare patients from the CMS perspective. This measure, using standardized payments, reflects differences in the management of care for patients with heart failure both during hospitalization and immediately post-discharge.

Payments, however, are difficult to interpret in isolation. Some high payment hospitals may have better clinical outcomes when compared with low payment hospitals; other high payment hospitals may not. In an effort to identify practice patterns that may be expensive without conferring a quality benefit, the heart failure (HF) payment measure specifications are aligned with current quality of care measures such as CMS's 30-day HF risk-standardized mortality rate (RSMR). In this way the measure can facilitate the profiling of hospital value and encourage the most efficient delivery of high quality care.

A payment measure that fairly profiles hospitals by adjusting for hospital case-mix and standardizes payments for geography is congruent with national efforts to increase the transparency of our healthcare system. Although the HF payment measure is not intended to be used in payment programs, when interpreted in the context of CMS's 30-day HF RSMR, it can provide key insights into those systems of care that provide high value as a patient moves from the inpatient to the outpatient setting. Because the payment measure spans an episode of care, it is complementary to and may uniquely inform innovative payment models such as bundled payments and Accountable Care Organizations (ACOs), both of which seek to improve healthcare value by optimizing the coordination of care across care settings.[2]

1.2. Assessing Cost of Care by Measuring Payments for Medicare Patients

There are many different ways to measure cost including, but not limited to, approximations using hospital charges, conversions of charges to costs using cost-to-charge ratios, and estimations based on Medicare payments. **For this task, we have defined the "cost" of care as payments made for Medicare patients for a HF episode of care.**

1.3. Measuring HF Payments

Heart failure is one of the leading causes of hospitalization for Americans 65 and over and costs roughly $34 billion annually.[3,4] It is a common condition in the elderly with a substantial range in payments due to different practice patterns. Furthermore, because 30-day all-cause mortality and readmission measures for HF are already publicly reported, HF serves as a model condition for assessing relative value for an episode of care that begins with an acute hospitalization. By focusing on one specific

condition, value assessments may provide actionable feedback to CMS and hospitals to incentivize targeted improvements in care.

1.4. Episode of Care

When considering payments to hospitals, we focused on a 30-day "episode of care" triggered by admission for several key reasons. First, hospitalizations represent a brief period of acute illness that requires ongoing management post-discharge. Second, decisions made at the admitting hospital affect not only the hospitalization payments, but payments for care in the immediate post-discharge period. Third, assessing payments for a continuous episode of care may reveal practice variations in the full care of the illness that triggered admission. For instance, lower inpatient payments may be counterbalanced by greater dependence on post-acute care, such as skilled nursing, in some regions. Such patterns would not be visible in an inpatient-only measure. Fourth, a 30-day preset window provides a standard observation period by which to compare all hospitals. Lastly, when pairing payments with quality, measures should be aligned as much as possible. Most publicly reported quality measures are reported for a 30-day period after admission or discharge (for example, CMS's 30-day RSMR and RSRR for HF).

Using the Chronic Condition Warehouse (CCW) data, we tracked payments for Medicare patients through the 30-day post-admission period. The CCW data are derived from Medicare claims in the Standard Analytic Files and contain payment information for all care settings, services, and supplies. The CCW data provide a unique opportunity to gain insight into a cascade of medical events triggered by HF hospitalization and the payments associated with those events. The specific goal of this task is to sum payments for Medicare patients, including index admission as well as post-discharge payments, for: readmission or other post-discharge inpatient care, skilled nursing facilities, outpatient providers, home health agencies, hospice care, physician/clinical laboratory/ambulance services, and durable medical equipment, prosthetics/orthotics, and supplies. This work will be used to better understand differences in the patterns of post-discharge care and associated payments made for Medicare patients across a continuum of care beginning with a hospitalization for HF and following patients 30 days after hospital admission.

1.5. Approach to Measure Development

We developed this measure in accordance with national guidelines and in consultation with clinical and measurement experts, key stakeholders, and the public. The proposed measure is consistent with the technical approach to outcomes measurement set forth in the National Quality Forum (NQF) guidance for outcomes measures,[5] CMS's Measure Management System (MMS),[6] and the guidance articulated in the American Heart Association's scientific statements, "Standards for Statistical Models Used for Public Reporting of Health Outcomes"[7] and "Standards for Measures Used for Public Reporting of Efficiency in Health Care."[8] During the measure development process, we obtained expert and stakeholder input via two mechanisms: first, through regular discussions with an advisory working group, and second, through meetings with a national Technical Expert Panel (TEP).

We held regular conference calls with our working group throughout the measure development phase. The working group included clinicians and other professionals with expertise in cardiology, biostatistics, health economics, measure development, and quality improvement. The working group meetings addressed key issues surrounding measure development, including detailed discussions regarding

specific decisions (for example, defining the appropriate measure cohort) to ensure the methodological rigor of the measure.

In addition to the working group and in alignment with CMS's MMS, we convened a TEP consisting of a group of recognized experts and stakeholders in relevant fields to provide input and feedback during measure development. To form the TEP, we posted a public call for nominations and selected individuals representing a range of perspectives including those of physicians, health economists, consumers, hospitals, and purchasers. In contrast to the working group meetings, the TEP meetings followed a more structured format consisting of the presentation of key issues, relevant data, and our proposed approach. This presentation was followed by open discussion of these issues with TEP members.

We posted the measure specifications and a summary of the TEP discussions publicly, after which we underwent a 40-day public comment period. We collected these comments through the MMS website and summarized them for CMS. We also posted the comments verbatim on the MMS website. We considered all submitted comments during the final stages of measure development.

1.6. Aims of the Measure

The primary objective of this work is to develop a 30-day episode-of-care HF payment measure that:

1. captures differences in the care provided by hospitals for patients with HF,
2. accounts for differences in the care coordinated by hospitals immediately post-discharge,
3. removes variation in payments due to payment adjustments that are not directly related to clinical care (for example, geography and policy adjustments),
4. adjusts for hospital case-mix,
5. assesses relative performance of hospitals, and
6. aligns with HF quality measures.

Using administrative claims data, we measure risk-standardized payments for Medicare patients for an episode of care that begins with an index admission for HF and ends 30 days after the index admission. The HF payment measure captures payments for Medicare patients across multiple care settings, services, and supplies (inpatient, outpatient, skilled nursing facility, home health, hospice, physician/clinical laboratory/ambulance services, and durable medical equipment, prosthetics/orthotics, and supplies). We remove payment adjustments unrelated to clinical care decisions. By risk-standardizing the payment measure, we are able to adjust for the case mix at any given hospital and compare a specific hospital's HF payment to an average hospital with a similar case mix. Key decisions in the development of the HF payment measure are aligned with key decisions in CMS's 30-day HF RSMR measure.

Our methodology is developed in accordance with accepted standards for outcomes measure development, including appropriate risk adjustment to allow for fair profiling of institutions and transparency of specifications.

Please note that for easy reference, we sometimes refer to the hospital-level, risk-standardized payment measure for a 30-day episode of care for HF simply as the HF payment measure in this document.

2. METHODS

2.1. Overview of Measure Methodology

We developed a hospital-level, risk-standardized payment measure for a 30-day episode of care for HF. The measure comprises a single summary risk-standardized payment and uses index admissions from two years of CCW data (2008-2009) to assess hospital performance. This measure is intended to capture differences in payment for a 30-day episode of care for HF at the hospital level. Payments for Medicare patients can vary for a number of reasons, including:

1. hospital practice patterns,
2. payment adjustments that reflect geography (for example, paying different amounts for the same service in different parts of the country),
3. payment adjustments that reflect policies (for example, indirect medical education and disproportionate share adjustments) that serve a broader mission of CMS, but do not reflect medical care, and
4. patient case mix.

To isolate payment variation that reflects practice patterns rather than CMS payment adjustments, we "strip" or "standardize" payments for each care setting. Stripping refers to removing geographic differences and policy adjustments in payment rates for individual services from the total payment for that service. Standardizing refers to averaging payments across geographic areas for those services where geographic differences in payment cannot be stripped. Stripping and standardizing the payments allows for a fair comparison across hospitals based solely on payments for decisions related to clinical care, as described in Section 2.5.

We adjust for case mix differences across hospitals by risk adjusting for patients' comorbid conditions identified in claims for acute inpatient hospital stays, hospital outpatient care, and physician, radiology, and laboratory services for the 12 months prior to the index admission as well as select conditions indicated by secondary diagnosis codes on index admission. We do not risk adjust for diagnoses that may be complications of care during the index admission (Appendix A). We used CMS Condition Category groups (CCs) to define the comorbid risk-adjustment variables. Additionally, we risk adjust for the patients' age.

We use generalized linear modeling to estimate the risk-adjustment model and validate the model via a split-sample process. An additional year of data was used for temporal validation of the risk-adjustment model as well. We then use hierarchical generalized linear regression to isolate a hospital-specific payment signal and to account for the clustering of admissions within each hospital. Finally, we calculate predicted and expected payments (as defined in Section 2.8) for each hospital.

2.2. Dataset

The CCW data are derived from the Medicare claims in the Standard Analytic Files. The CCW data contain data from the Medicare fee-for-service (FFS) institutional and non-institutional claims, enrollment and eligibility information, and assessment data for up to 100% of the Medicare beneficiary population for particular conditions. The data are organized by predefined chronic conditions including HF, but can also be used to define individualized patient cohorts as described below. The annual CCW

datasets include claims data from all seven standard files (inpatient, skilled nursing facility, outpatient, home health agency, hospice, carrier, and durable medical equipment) that can be linked across care settings, services, supplies, and years using a unique patient identifier. Specific information available in the CCW data includes diagnosis codes, procedure codes, quantity/units of services used, and payments made by CMS, patients, and other insurers to care providers. We describe our methodology for estimating payments for a HF episode of care below.

2.3. Cohort

Although the CCW data make a pre-defined cohort of HF available, to develop the measure **we created our own HF cohort from the CCW 2008 and 2009 100% sample of FFS beneficiaries to be aligned with CMS's publicly reported 30-day HF RSMR**. Consistent with CMS's 30-day HF RSMR, the measure includes hospitalizations with a principal discharge diagnosis of HF as classified by the International Classification of Diseases, Ninth revision, Clinical Modification (ICD-9-CM) codes 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, and 428.9. A full description of ICD-9-CM codes in the final cohort can be found in Appendix B. An **index hospitalization** is the initial HF admission that triggers the 30-day episode of care for this payment measure. The measure includes only those hospitalizations from short-stay acute care hospitals in the index cohort. The measure restricts the cohort to patients 65 and older and enrolled in FFS Medicare Parts A and B (with no Medicare Advantage coverage).

If a patient had more than one eligible index HF admission in 2008 or 2009, a randomly selected HF admission per year is included in the measure for two main reasons. First, repeated HF hospitalizations for the same patient are not independent events. Including all HF admissions from the same patient would introduce additional clustering of data within patients which can further complicate the analytic model. Second, this strategy is consistent with CMS's 30-day HF RSMR. After randomly selecting the index admission, any subsequent hospitalizations (including additional HF hospitalizations) within the 30-day post-admission period will be treated as readmissions as part of the first admission's episode of care.

Consistent with CMS's 30-day HF RSMR, the measure considers admissions with transfers as a single inpatient hospitalization. To confirm the diagnosis, patients with HF who transferred from one facility to another are required to have a principal discharge diagnosis of HF at both hospitals. The measure does not include transfers directly from the emergency department (ED) to a second hospital in our transfer scenario because the CMS payment structure does not classify ED care as an inpatient admission. In these cases, the episode of care begins with an inpatient admission at the receiving hospital.

2.3.1. Index Cohort Exclusions

We applied several exclusion criteria to the cohort of index admissions as delineated below and in Figure 1:

- Hospitalizations for patients without at least 30 days of post-admission enrollment in FFS Medicare

Rationale: This is necessary in order to identify the outcome (payments) in the dataset over the analytic period.

- Hospitalizations for patients admitted and discharged on the same day or next day (and not transferred or deceased)
  Rationale: These patients likely did not suffer clinically significant HF.

- Hospitalizations for patients transferred into the hospital
  Rationale: The episode of care begins with the first admitting hospital. If a patient is transferred, the payments for that second hospitalization are counted as part of the full episode payment associated with the first admitting hospital. That is to say, transferred patients are included in the measure, but the accepting hospital is not considered an index stay.

- Hospitalizations for patients with claims that contain inconsistent or unknown vital status
  Rationale: We exclude stays for patients that include inconsistent data (for example, date of death precedes date of admission).

- Hospitalizations for patients with claims that contain unreliable data
  Rationale: We exclude stays for patients that include unreliable data (for example, age is greater than 115 or gender from enrollment data and claim are incongruent).

- Hospitalizations for patients discharged against medical advice (AMA)
  Rationale: Hospitals had limited opportunity to implement high quality care.

- Hospitalizations for patients with hospice enrollment within one year prior to or on the date of an index admission
  Rationale: This exclusion is made for CMS's 30-day HF RSMR and allows the cohort to be as closely aligned with this measure as possible.

- Hospitalizations for patients transferred to federal hospitals
  Rationale: We do not have claims data for these hospitals, so including these patients would cause payments to be underestimated.

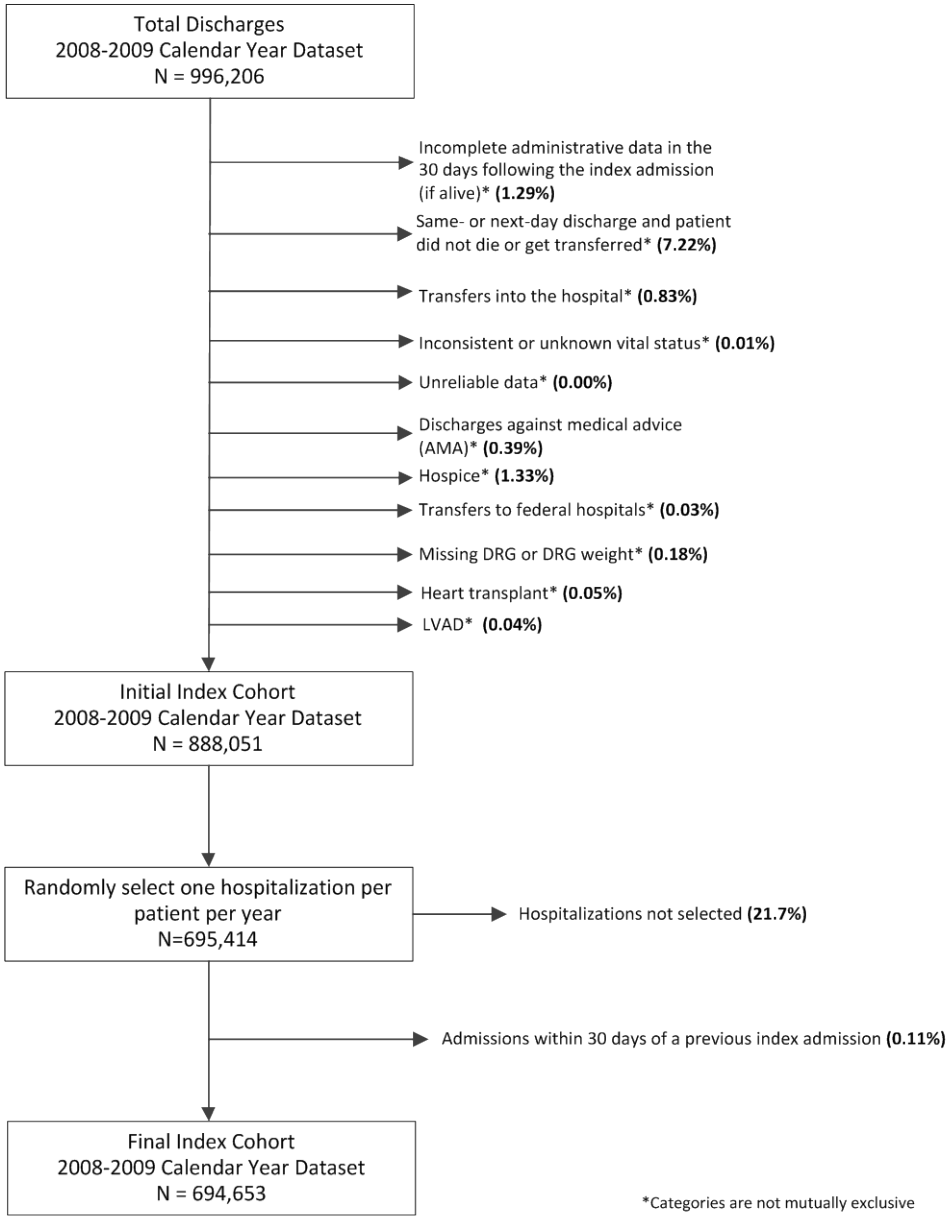
- Hospitalizations for patients without a diagnosis related group (DRG) or DRG weight for their index hospitalization
  Rationale: We cannot calculate a payment for these patients' index admission; this would make the entire episode of care appear substantially less expensive.

- Hospitalizations for patients with an index admission within 30 days of a previous index admission
  Rationale: This exclusion criterion is applied after one admission per patient per year is randomly selected; therefore it is only applicable to multi-year combined data.

- Hospitalizations for patients who receive a heart transplant during the episode of care
  Rationale: These patients are clinically distinct, generally very high payment cases, and not representative of the typical heart failure patient that this measure aims to capture.

- Hospitalizations for patients who receive a Left Ventricular Assist Device (LVAD) during the episode of care
  Rationale: These patients are clinically distinct, generally very high payment cases, and not representative of the typical heart failure patient that this measure aims to capture.

Figure 1.Index HF Cohort for the 2008-2009 Calendar Year Sample



2.4. Outcome

The primary outcome of this measure is the hospital-level, risk-standardized payment for a HF episode of care. The HF payment measure captures payments for Medicare patients across multiple care

settings, services, and supplies (inpatient, outpatient, skilled nursing facility, home health, hospice, physician/clinical laboratory/ambulance services, and durable medical equipment, prosthetics/orthotics, and supplies). We remove payment adjustments unrelated to clinical care decisions. By risk standardizing the payment measure, we are able to adjust for case mix at any given hospital and compare a specific hospital's HF payment to an average hospital with a similar case mix. We define our analytic timeframe as beginning with the index admission for HF to 30 days post-admission.

2.4.1. 30-day Timeframe

We considered 30 days post-admission as a clinically reasonable time frame for multiple reasons:

a. Within a 30-day time frame, payments are more likely attributable to care received during the index hospitalization and during the transition to the post-discharge setting.

b. The 30-day preset window provides a standard observation period by which to compare all hospitals.

c. The 30-day post-admission time frame is consistent with other CMS measures endorsed by the NQF and publicly reported by CMS, including CMS's 30-day HF RSMR. We designed the HF payment measure to align with CMS's 30-day HF RSMR to facilitate assessments of health care value.

2.4.2 Prorating Payments

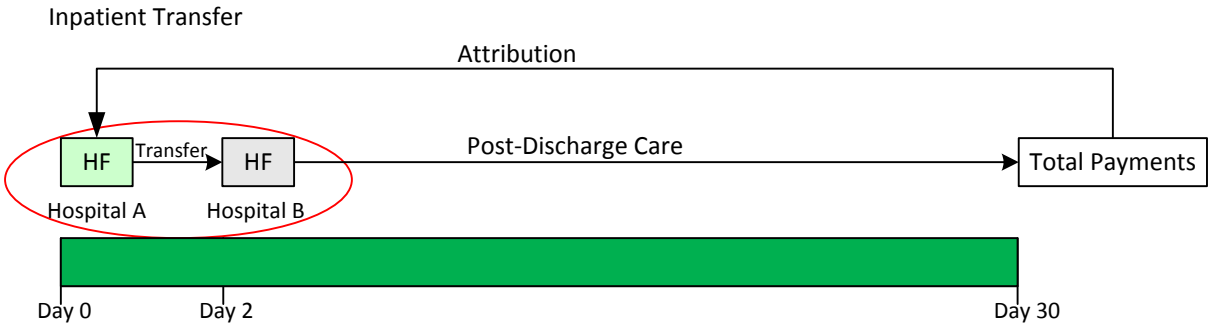
Some claims overlap the beginning or end date of the analytic timeframe. If a claim for payment began prior to the index admission but ended in the analytic timeframe, it was excluded from our calculation. If a claim for payment began within the analytic timeframe, but ended after the last date of our 30-day post-admission period, we prorated the payment for the claim over the days in the analytic timeframe (Appendix C).

2.4.3 Transfer Scenarios

Medicare reduces payments when patients are transferred to another inpatient prospective payment system (IPPS) hospital and have a length of stay at least one day less than the geometric mean length of stay for the DRG. Under this policy, transferring hospitals are paid a per diem rate. For stays at the transferring hospital that are equal to or greater than the geometric mean length of stay for the DRG, transferring hospitals receive a full DRG payment.[9] We assign the per diem rate or the full DRG rate to the transferring hospital where applicable, and then add it to the payment for the hospital that received the transfer patient to calculate the payment for the index admission. We then aggregate total patient-level payments for each post-discharge care setting over the defined time period.

Because the episode of care begins at the time of index admission, we assign this combined inpatient payment along with any payments made for post-discharge care to the transferring hospital (Figure 2). This approach aligns with CMS's 30-day HF RSMR.

Figure 2.Episode of Care for Transfer Patient



2.4.4 Removing Payment Adjustments

The overarching goal of the measure is to calculate payments that reflect differences in the care provided for patients with HF rather than differences in payments based on geography (for example, cost of living and wage index) or policy adjustments (for example, indirect medical education and disproportionate share). Because these payment adjustments do not reflect the care delivered by hospitals, we remove geography and policy adjustments when calculating payments for each care setting, service, and supply by stripping or standardizing as described below.

2.5. Calculating Payments for Different Care Settings, Services, and Supplies

Medicare pays for health care services using a number of different payment systems that are generally organized by delivery setting (Appendix D). These payment systems consider not only the products the Medicare patient is buying in each setting, but also the characteristics of the care provider, the extent to which the same product may be furnished in different settings, and the market circumstances that affect providers' costs. Payment amounts within each payment system are usually updated annually (for example, the IPPS) with some fee schedules having quarterly updates (for example, Durable Medical Equipment/Prosthetics Orthotics and Supplies [DME/POS]). Information on CMS reimbursement rates for each care setting are made publicly available through either final rules published in the Federal Register or fee schedules provided on the CMS website. A summary of Medicare's reimbursement system for most care settings is publicly available at the Medicare Payment Advisory Committee (MedPAC) website.[9] Below, we describe the key features of these payment systems and how we use these CMS payment algorithms to determine an episode-of-care payment for HF that isolates clinical care decisions. Appendix D provides payment diagrams for all care settings along with our approach to stripping or standardizing payments.

2.5.1. Inpatient Care Settings

2.5.1.1. Acute Inpatient Hospitals

Medicare beneficiaries sometimes require hospitalization for an acute illness.

How Medicare Reimburses Acute Inpatient Hospitals

Medicare pays most acute inpatient hospitals through a prospective payment system (PPS). This system uses DRG-specific weights to calculate a payment above or below the fixed payment, known as the base payment rate (operating and capital), which reflects the cost (labor and non-labor) to deliver care to a patient for an average Medicare hospitalization. The DRG payment covers routine operating costs attributable to patient care, including nursing services, room and board, and diagnostic and ancillary services. In addition to the primary discharge diagnosis, DRGs account for up to eight secondary diagnoses and up to six procedures performed during the stay. Other factors that inform DRG assignment are age, gender, and discharge destination. CMS assigns a unique weight to each DRG indicating the relative costliness of inpatient treatment for patients in a given DRG. Conditions that involve greater resource utilization (usually associated with procedures, comorbidities, or complications) are assigned higher DRG weights.

Table 1 demonstrates the calculation of payments for the most frequent DRGs for HF patients in our cohort hospitalized in 2009. These DRGs are ordered by the amount of the DRG payment made to hospitals rather than by the frequency in our cohort.

Table 1.Most Expensive DRGs in HF Patients in 2009

DRG	MS-DRG Title	Surgical	DRG Weight	Payment*	% of Index Admissions
226	Cardiac defibrillator implant w/o cardiac cath w MCC	Yes	6.7117	$37,267.25	0.38%
227	Cardiac defibrillator implant w/o cardiac cath w/o MCC	Yes	4.9961	$27,741.24	0.69%
242	Permanent cardiac pacemaker implant w MCC	Yes	3.7029	$20,560.65	0.38%
264	Other circulatory system o.r. procedures	Yes	2.5329	$14,064.13	0.49%
286	Circulatory disorders except AMI, w card cath w MCC	No	1.9769	$10,976.90	1.31%
280	Acute myocardial infarction, discharged alive w MCC	No	1.9404	$10,774.23	1.36%
291	Heart failure and shock w MCC	No	1.4601	$8,107.32	37.92%
287	Circulatory disorders except AMI, w card cath w/o MCC	No	1.0252	$5,692.51	1.95%
292	Heart failure and shock w CC	No	1.0069	$5,590.89	31.35%
293	Heart failure and shock w/o CC/MCC	No	0.7220	$4,008.96	19.58%

* This amount is arrived at by multiplying the FY 2009 operating and capital base payment amounts by the DRG weight

Medicare makes a number of payment adjustments which affect the total payment for an inpatient stay. Three major categories of adjustments include geography, policy, and outlier payments. Medicare adjusts for differences across hospitals in cost of living (geographic factor) and labor costs (wage index). Policy adjustments can result in additional payments to reflect the cost of teaching medical trainees (indirect medical education) and providing care to low-income patients (disproportionate share). Finally, Medicare makes “outlier payments” for admissions when the hospital’s gross costs exceed a threshold amount that includes the DRG rate plus the amount payable for indirect medical education, disproportionate share payments, and a fixed dollar amount set annually by CMS. Outlier payments are not automatic: a hospital must make a specific request and must identify the actual cost associated with each outlier case.

Approach to Stripping Payments

In our calculation of payments for the index HF hospitalization, we omit geographic factors and policy adjustments. We first multiply the operating and capital base payment rates by the DRG weight for each claim to arrive at our stripped payment. Medicare reduces payments when patients are transferred to another IPPS hospital and have a length of stay at least one day less than the geometric mean length of stay for the DRG. Under this policy, transferring hospitals are paid either a per diem rate or, for stays that are equal to or greater than the geometric mean length of stay for the DRG, a full DRG payment. When applicable, we include this rule in our payment calculation. We then add any applicable outlier payments (after removing any wage index adjustment) that hospitals receive for unusually high-cost claims where applicable.

2.5.1.2. Inpatient Psychiatric Facilities (IPFs)

Medicare beneficiaries sometimes require hospitalization for an acute psychiatric illness.

How Medicare Reimburses IPFs

Medicare pays IPFs through a PPS. Under the IPF PPS, federal per diem base rates are adjusted for geographic factors, patient characteristics (psychiatric DRG, age, comorbidities, and length of stay), and facility characteristics (urban/rural and indirect medical education). Additional payments are made to IPFs based on the presence of a qualifying ED, the number of electroconvulsive therapy (ECT) treatments furnished, and outlier payments for cases with very high costs.

Approach to Stripping Payments

We multiply the base payment by adjustments for the patients' psychiatric DRG, age, and comorbidities, and omit any adjustments for wage index, cost of living, or facility characteristics. We then account for length of stay, presence of an ED, and any ECT treatments to arrive at our stripped payment. We add outlier payments but remove the wage index adjustment for these payments where applicable.

2.5.1.3. Inpatient Rehabilitation Facilities (IRFs)

After a hospitalization, some patients need intensive inpatient rehabilitation services such as physical, occupational, or speech therapy. To qualify for treatment in an inpatient rehabilitation setting, patients must be able to tolerate and benefit from three hours of therapy per day. These settings may be freestanding hospitals or specialized, hospital-based units.

How Medicare Reimburses IRFs

Medicare pays IRFs through a PPS. Under the IRF PPS, the IRF base rate is adjusted for geographic factors, patient characteristics (case mix group), facility characteristics (urban/rural, disproportionate share, and indirect medical education), length of stay, and outlier payments. Case mix groups are informed primarily by the patient's condition (age, comorbidities, functional and cognitive statuses, and diagnoses requiring rehabilitation). Each case mix group has a national relative weight reflecting the expected relative costliness of treatment for patients in that specific case mix group compared with the average Medicare inpatient rehabilitation patient.

Approach to Stripping Payments

We multiply the base payment rate by the case mix group weight and omit any adjustments for wage index or facility characteristics. We then adjust for length of stay to arrive at our stripped payment. Where applicable, we add outlier payments but remove the wage index adjustment for these payments.

2.5.1.4. Long Term Care Hospitals (LTCHs)

Patients with clinically complex problems, such as multiple acute or chronic conditions, may need hospital care for extended periods of time. LTCHs must have an average Medicare length of stay greater than 25 days.

How Medicare Reimburses LTCHs

Medicare pays LTCHs through a PPS. Under the LTCH PPS, the LTCH base rate is adjusted for geographic factors, patient characteristics (Medicare severity long-term care [MS-LTC]-DRG), length of stay, and outlier payments. MS-LTC-DRGs are informed primarily by the patient's condition (age, gender, principal and secondary diagnoses, procedures, and discharge status). Each MS-LTC-DRG has a national relative weight reflecting the expected relative costliness of treatment for patients in that specific LTC-DRG compared with the average Medicare LTC patient.

Approach to Stripping Payments

We multiply the base payment rate by the MS-LTC-DRG weight and omit any adjustments for wage index. We then adjust for length of stay to arrive at our stripped payment. Where applicable, we add outlier payments but remove the wage index adjustment for these payments.

2.5.2. Outpatient Care Settings

Medicare pays for some outpatient services under the Outpatient Prospective Payment System (OPPS), including most hospital-based outpatient services. Outpatient services that do not fall under the OPPS are reimbursed using other fee schedules or payment systems (for example, Medicare Clinical Diagnostic Laboratory Fee Schedule) as detailed later in this document.

2.5.2.1. Hospital Outpatient Services and Community Mental Health Centers (CMHCs)

Medicare beneficiaries receive a wide range of services in hospital outpatient departments. These vary from simple injections to complex procedures requiring anesthesia, and can include emergency room visits as well as observation stays. CMHCs provide outpatient as well as partial hospitalization services to Medicare beneficiaries, including physician services, psychiatric nursing, counseling, and social services.

How Medicare Reimburses Hospital Outpatient Services and CMHCs

Medicare pays for most hospital outpatient services provided to Medicare beneficiaries using the OPPS. Partial hospitalization services furnished by CMHCs are also reimbursed under the OPPS. All services are paid according to ambulatory payment classifications (APCs), which group services according to similar clinical characteristics and in terms of resources required. Healthcare common procedure coding system (HCPCS) codes are grouped into over 500 APCs. Each APC is weighted and has a prospective payment amount associated with it. APC payments may be discounted when certain services or procedures, such as bilateral procedures, are provided.

A conversion factor (similar to a base payment) is multiplied by a wage index to account for geographic variations in hospitals' labor costs. This number is then multiplied by the APC relative weight. In addition, add-ons such as pass-through payments for new drugs and technical devices, outlier payments for high-cost services, and hold harmless payments for certain hospitals are applied.

Approach to Stripping Payments

We multiply the conversion factor by the APC weight and omit any adjustments for wage index. We then account for reduced or discontinued procedures, where applicable, as well as unit count to arrive at our OPPS stripped payment. We do not include pass-through payments for new drugs and technical devices or hold harmless payments for certain hospitals. For outpatient hospital services not paid under the OPPS, we apply the clinical lab fee schedule, ambulance fee schedule, physician fee schedule, DME/POS/PEN fee schedule, and Part B drug fee schedule where applicable. Also, where applicable, we add outlier payments but remove the wage index adjustment for the payments.

2.5.2.2. Comprehensive Outpatient Rehabilitation Facilities (CORFs) and Outpatient Rehabilitation Facilities (ORFs)

Outpatient therapy services include physical therapy, occupational therapy, and speech-language pathology services. Medicare covers these services if they are furnished by a skilled professional, are appropriate and effective for a patient's condition, and are reasonable in terms of frequency and duration. The beneficiary must be under the care of a physician, have a treatable condition, and be improving.

How Medicare Reimburses CORFs and ORFs

Medicare pays for outpatient rehabilitation therapy according to fees established in the physician fee schedule. Under this fee schedule, a conversion factor set by Medicare is adjusted for complexity of service/expense as well as geographic factors. The unit of payment is each individual service. All services are classified and reported to CMS according to their HCPCS code. Payment rates are based on relative values units (RVUs), which account for the relative costliness of the following components of the service provided: clinician's work, practice expenses, and malpractice insurance. A separate geographic practice cost index (GPCI) for each of these work components reflects geographic differences in these costs in the market where the service is rendered.

Approach to Stripping Payments

We multiply the conversion factor by the work RVU, transitioned non-facility practice expense RVU, and malpractice insurance RVU weights and omit any adjustments for work GPCI, non-facility practice expertise GPCI, and/or malpractice insurance GPCI to arrive at our stripped payment.

2.5.2.3. Renal Dialysis Facilities (RDFs)

Individuals with end-stage renal disease require dialysis or renal transplant to survive. Medicare pays for both hemodialysis and peritoneal dialysis.

How Medicare Reimburses RDFs

Medicare pays dialysis providers a predetermined composite rate that is intended to cover the bundle of services, tests, certain drugs, and supplies required for either facility-based or home-based dialysis treatments. The composite rate is then adjusted for geographic factors. A drug add-on further supplements the payment, and CMS provides an additional adjustment for case mix using a patient's age, body surface area, and body mass index. Facility-based payments are capped at an amount equal to three dialysis sessions per week; however, home-based dialysis may be provided more frequently.

Approach to Stripping Payments

Given that renal dialysis payment rates are adjusted by patient-specific body measurements that are not available in our data, we begin with the actual payment made to an RDF for patient care (including patient out-of-pocket payments) and remove payment adjustment attributable to wages using the RDF wage index published by CMS.

2.5.2.4. Rural Health Clinics (RHCs)

RHCs are clinics that are located in areas designated by the Bureau of the Census as rural, and by the Secretary of the Department of Health and Human Services as

underserved. Services rendered by approved RHCs to Medicare beneficiaries are covered under Medicare.

How Medicare Reimburses RHCs

Payments to RHCs for covered services furnished to Medicare patients are made by an all-inclusive rate for each visit. This rate includes services from providers as well as supplies. Each year Congress determines this RHC per visit payment limit.

Approach to Stripping Payments

We begin with the actual payment made to an RHC for patient care and remove payment adjustment attributable to wages using the skilled nursing facility (SNF) state-specific rural wage index published by CMS.

2.5.2.5. Federally Qualified Health Clinics (FQHCs)

FQHCs provide access to primary care in areas where primary care resources are constrained. FQHCs are required to be community-centered and either not-for-profit or public organizations that emphasize coordination of care.

How Medicare Reimburses FQHCs

Payments are made much like they are made to RHCs. FQHC payments are an all-inclusive per visit amount based on reasonable costs. The FQHC payment methodology includes one urban and one rural payment limit.

Approach to Payments

Given the resources necessary to determine whether each FQHC is located in a rural or urban area, we did not adjust for wages in the current data. We use the total payment received by the FQHC as the payment for a FQHC claim.

2.5.2.6. Ambulatory Surgical Centers (ASCs)

ASCs are distinct facilities that furnish only ambulatory surgery.

How Medicare Reimburses ASCs

Medicare pays ASCs through a PPS. The unit of service is the individual surgical procedure. All services are paid according to APCs, which group services according to similar clinical characteristics and in terms of resources required. Each APC is weighted and has a prospective payment amount associated with it. APC payments may be discounted when certain services or procedures, such as bilateral procedures, are provided.

A conversion factor (similar to a base payment) is multiplied by a wage index to account for geographic variations in ASCs' labor costs. This number is then multiplied by the APC relative weight.

Approach to Stripping Payments

We begin with the conversion factor, omit any adjustments for wage index, multiply by the APC weight, multiply by the unit count, and make adjustments for multiple, reduced, or continued procedures where applicable.

2.5.2.7. Laboratory Services

Clinical lab services are tests on specimens taken from the human body (for example, blood or urine) and used to help physicians diagnose or assess health.

How Medicare Reimburses Laboratory Services

Medicare pays for laboratory services using state-specific fee schedules. Individual lab services are identified by a HCPCS code.

Approach to Standardizing Payments

For each lab service on the clinical diagnostic laboratory fee schedule, we calculate the standard unit payment by taking the average of the payments across all states. We then multiply the average payment for a particular service by the unit count for that service. For lab services reimbursed under the automated multi-channel chemistry code, we use the total payment received by the lab.

2.5.2.8. Ambulance Services

Medicare beneficiaries sometimes require ambulance services for transportation.

How Medicare Reimburses Ambulance Services

Medicare pays for ambulance services using a fee schedule that pays separately for type of mileage (ground or air) and level of support (based on RVUs) provided during the trip. Reimbursements are also adjusted for geographic differences in labor cost, as well as for service within urban or rural locations. Mileage type and level of support are indicated on the ambulance fee schedule by HCPCS code.

Approach to Standardizing Payments

We first calculate the average of the urban and rural mileage rates for each type of mileage at each level of ambulance service support for each state, and use these average state mileage and service rates to calculate a national average mileage and

service rate for each HCPCS code. We then multiply this national average rate by the unit count.

2.5.2.9. Part B Drugs

Medicare makes payments for drugs or biologicals that are administered by infusion or injection and not usually self-administered.

How Medicare Reimburses Part B Drugs

Medicare pays for Part B prescription drugs using a national fee schedule (there is no variation from state to state).

Approach to Payments

We assign the national fee schedule amount to all Part B Drug claims and multiply this amount by the unit count.

2.5.3. Other Care Settings

2.5.3.1. Skilled Nursing Facilities (SNFs)

Beneficiaries who need short-term skilled care on an inpatient basis following a hospital stay of at least three days are eligible to receive covered services in a SNF.

How Medicare Reimburses SNFs

Medicare pays for SNFs through a PPS. Under the SNF PPS, Medicare assigns a different per diem base payment rate to SNFs based on their urban or rural status for each of three components of care: a nursing component, a therapy component, and a non-case mix-adjusted component reflecting the costs of room and board and administrative services. Daily payments to SNFs are then determined by adjusting the base payment rates for geographic differences in labor cost and by adjusting the nursing component and therapy components of the base payment rates by patient characteristics (resource utilization groups [RUG]). RUGs are informed primarily by the patient's condition (comorbidities, activities of daily living score, therapy, and service use) and are intended to group patients with similar expected service needs. Each RUG has a nursing relative weight and a therapy relative weight reflecting the expected relative costliness of treatment for patients in that specific RUG compared with the average Medicare beneficiary in a SNF. In addition, SNFs receive a 128% increase in the Medicare PPS per diem payment for patients with acquired immunodeficiency syndrome (AIDS).

Approach to Standardizing Payments

We average the urban and rural SNF per diem base rates, multiply by the RUG weights, and omit adjustment factors for the wage index. We then multiply this number by the

number of days the patient is in a SNF and add a 128% AIDS adjustment if applicable. For critical access hospitals' swing-bed SNF claims, we use the total payment received by the SNF and remove the portion of the payment attributable to wage differences across geographic locations using the SNF state-specific rural wage index published by CMS.

2.5.3.2. Home Health Agencies (HHAs)

Beneficiaries who are generally confined to their homes and need skilled care from a nurse, physical therapist, or speech therapist on a part-time or intermittent basis are eligible to receive certain medical services at home. Covered services delivered by HHAs include: skilled nursing care; physical, occupational, and speech therapy; medical social work; and home health aide services.

How Medicare Reimburses HHAs

Medicare pays HHAs using a PPS and purchases home health services in units of 60-day episodes. Under the HHA PPS, Medicare assigns a base payment rate which is first adjusted for geographic factors and then adjusted for patient characteristics (by assigning each patient to a home health resource group [HHRG]). HHRG assignments are based on clinical and functional status as well as service use, and have a national relative weight reflecting the costliness of patients in that group compared with the average Medicare home health patient. Adjustments are also made for patients who receive fewer than five home health visits, are transferred to another HHA, or are discharged and readmitted to the same HHA within the 60-day time frame. Further adjustments are made for outlier payments and non-routine medical supplies. When there are fewer than five home health visits in the 60-day time frame, Medicare pays HHAs using the Low Utilization Payment Adjustment (LUPA) per visit rate, which is discipline-specific and depends on whether the visit was for home health aide, medical social services, occupational therapy, physical therapy, skilled nursing, or speech language pathology therapy. HHAs receive an add-on for LUPA episodes that occur as initial episodes in a sequence of adjacent episodes, or as the only episode.

Approach to Stripping Payments

We multiply the base payment by the HHRG weight and omit adjustment factors for the wage index. We then modify this total if the patient is transferred to another HHA or discharged and readmitted to the same HHA before 60 days. We then add any DME/POS/Oxygen add-ons or outlier payments (after removing the wage index adjustment) when applicable. For patients with fewer than five home health visits in the 60-day time frame, we apply the LUPA per visit payment rates with LUPA add-ons when applicable.

2.5.3.3. Hospice

Terminally ill beneficiaries, defined as having a life expectancy of six months or less, may receive hospice care. Hospice benefits cover a wide range of services including:

physicians, skilled nursing, counseling, medical social services, drugs for pain control and symptom management, physical, occupational, and speech therapy, home health aides, and inpatient respite care.

How Medicare Reimburses Hospice

Medicare pays hospices for each day a beneficiary is eligible and under hospice care regardless of the amount of services provided on any given day. Payments are made according to a fee schedule that has individual base payment amounts for four categories of care: routine home care, continuous home care, inpatient respite care, and general inpatient care. Each hospice payment rate is then adjusted for geographic factors. Routine home care, inpatient respite care, and general inpatient care are paid the geographically-adjusted daily rate. Continuous home care is paid a geographically-adjusted hourly rate when care is delivered during a period of crisis and is provided in the home for eight or more hours in a 24-hour period beginning at midnight. Any applicable physician fees are added to the total hospice payment.

Approach to Stripping Payments

For continuous home care, we divide the base payment by 24 hours and multiply it by the number of hours of care and add any physician fees where applicable. For routine home care, inpatient respite care, and general inpatient care, we multiply the base payment by the number of days of care and add any applicable physician fees.

2.5.4 Physicians, Physician Extenders, and Social Work Services

Medicare beneficiaries sometimes require the care of physicians or physician extenders for a number of different clinical services.

How Medicare Reimburses Physician, Physician Extenders, and Social Work Services

Medicare uses a fee schedule based on a list of services and their corresponding payment rates to compensate individual providers. Medicare pays a higher physician fee for services provided in non-facility settings, such as physicians' offices, and a lower physician fee for services furnished in facilities, such as hospitals. Physician fees are lower in facility settings because physicians' practice costs are generally lower in facilities. Also, in this case, Medicare pays both the facility and the physician. Each service has a weight, or RVU, that measures the relative costliness of three components of resources used to provide physician services: physician work, practice expenses, and malpractice insurance.

Medicare also uses three GPCIs to adjust for geographic factors related to physician work, practice expenses, and malpractice insurance, respectively. To arrive at the payment amount a conversion factor is multiplied by the total of the RVU weight multiplied by the GPCI weight for each type of resource. Adjustments are then made for certain circumstances such as multiple surgical procedures performed on the same day for the same patient, preoperative and postoperative management without surgical care, or bilateral surgery. Adjustments in payment

are also made for care given by non-physicians such, as physician assistants and clinical social workers.

Approach to Stripping Payments

For services provided in a facility setting (for example, the hospital outpatient department), we multiply the conversion factor by the work RVU, transitioned facility practice expense RVU, and malpractice insurance RVU weights, and omit any adjustments for work GPCI, facility practice expertise GPCI, and/or malpractice insurance GPCI. For services provided in a non-facility setting (for example, a physician's office), we multiply the conversion factor by the work RVU, transitioned non-facility practice expense RVU, and malpractice insurance RVU weights, and omit any adjustments for work GPCI, non-facility practice expertise GPCI, and/or malpractice insurance GPCI. We then adjust this total for the circumstances listed in the paragraph above and make any adjustments for care given by non-physicians. This adjusted payment amount is then multiplied by the unit count of the service provided.

2.5.5 Durable Medical Equipment/Prosthetics and Orthotics/Parenteral and Enteral Nutrition (DME/POS/PEN)

Beneficiaries who require medical equipment, prosthetics, orthotics, other supplies, or parenteral and enteral nutrition to treat their illness receive it through DME/POS/PEN.

How Medicare Reimburses DME

Medicare pays for DME/POS/PEN using a combination of state-specific fee schedules (for DME/POS) and a national fee schedule (for PEN).

Approach to Standardizing Payments

For DME/POS claims, we average the payment rate across the state for each item (identified by HCPCS code) on the fee schedule. Where applicable, we adjust the payment rates for new, used, or rental equipment. We then multiply by the unit count. If a patient receives Part B drugs in conjunction with DME, we add the Part B drug payment.

For PEN claims, we assign items the amounts specified in the national fee schedule.

2.6. Model Development and Validation Samples

For model development, we used the full 2008 and 2009 calendar year 100% sample of HF patients to derive the cohort. To define the outcome, we used the full calendar years of 2008 and 2009 as well as January 2010 data to cover the 30-day episode-of-care period for index admissions in December 2009. All final model results presented in Sections 3.2 and 3.3 were produced using this sample. To determine variables for inclusion in the model (variable selection), we used a randomly selected 50% sample of the full 2009 sample (Sample A1). We used the other half of the full 2009 sample (Sample A2) and full 2008 sample (Sample B) to assess model validity. Table 2 summarizes the different data samples and their purposes.

Table 2.2008-2009 HF Payment Model Development and Validation Samples*

Sample	% of Total Sample	Purpose
Sample A (Full Sample)	100% 2009	Development (cohort, outcome definition, and determination of functional form of risk-adjustment model)
Sample A1 (Development)	50% 2009 (randomly selected)	Development (variable selection; validity testing)
Sample A2 (Validation)	50% 2009 (remaining 50%)	Development (validity testing)
Sample B (Validation)	100% 2008	Development (cohort, outcome definition, and validity testing)

2.7. Approach to Risk Adjustment

The goal of risk adjustment for this measure is to account for patient age and comorbid conditions that are clinically relevant and have strong relationships with the outcome, while illuminating important quality differences between hospitals.

Comorbidities for inclusion in risk adjustment are identified in administrative claims during the 12 months prior to and including the index admission. To assemble the more than 15,000 ICD-9 codes into clinically coherent variables for risk adjustment, the measure employs the publicly available CMS CCs to group ICD-9 codes into CCs,[10] and selects comorbidities on the basis of clinical relevance and statistical significance.

The measure does not adjust for the patient's admission source or discharge disposition (for example, a skilled nursing facility) because these factors are associated with the structure of the health care system and the different care patterns the measure seeks to illuminate. Because hospitals should not be held to different standards of care based on the demographics of their patients, the measure does not adjust for socioeconomic status (SES), gender, race, or ethnicity. Variation in payments associated with these characteristics may indicate differences in the care provided to vulnerable populations, and adjusting for these factors would obscure these disparities. The measure does not adjust for hospital characteristics either (for example, teaching status), since this would hold different types of hospitals to different standards, and because such characteristics may exist on a causal pathway to the outcome rather than act as confounders. This approach is consistent with NQF guidelines.[11]

2.7.1. Complications of Hospitalization

Complications occurring during hospitalization are not comorbid illnesses and may reflect hospital quality of care; therefore, they should not be used for risk adjustment. Although adverse events during hospitalization may increase the payments for a HF episode of care, including them as covariates in a risk-adjusted model could obscure payment differentials related to the quality of care delivered by hospitals. YNNHSC/CORE has previously reviewed every CMS-CC and identified those which, if they only occur during the index hospitalization,

* 2008 payments were inflation adjusted to 2009 dollars

would be considered potential complications rather than comorbidities. For example, fluid, electrolyte or base disorders; sepsis; and acute liver failure are CMS-CCs that could potentially be complications of care (Appendix A).

2.7.2. Case Mix Adjustment: Candidate Comorbid Risk Variables

Our goal was to develop a parsimonious model that accounted for differences in patient case mix at the time of index admission that were strongly associated with total payment for a HF 30-day episode of care. The candidate variables for the model were derived from secondary diagnoses of the index hospital stay (excluding potential complications), inpatient data, outpatient hospital data, and carrier files for physician, radiology and laboratory services during the 12 months prior to the index hospital stay.

To select candidate variables, we started with the 189 CCs. We used the ICD-9-to-CC assignment map, which is maintained by CMS and posted on the QualityNet website. A team of clinicians reviewed all 189 CCs and excluded those that were not relevant to the Medicare population or not clinically relevant to the HF payment outcome (for example, attention deficit disorder and female infertility). Some of these CCs were combined into clinically coherent groups. The remaining clinically relevant CCs, along with age were selected as candidate comorbid risk variables. A complete list of candidate variables is presented in Table 3.

2.7.3 Case Mix Adjustment: Choice of Functional Form

As is typical with data for healthcare payments, our dependent variable – total payment for a HF 30-day episode of care – is both right-skewed and leptokurtotic (skewness= 2.9; kurtosis = 15.2). This is illustrated in Figure 3. We Winsorized payments at the 99.5th percentile to improve model performance and prevent drastically altering the performance of hospitals with an unrepresentative and expensive outlier patient. This reduced the skewness (2.2) and kurtosis (6.1) of the data as illustrated in Figure 4. To address estimation problems that can arise with non-normally distributed data, we employed the algorithm suggested by Manning & Mullahy.[12] Using this algorithm and Sample A, we compared several alternative models in order to determine the best estimation approach. Based on these assessments, we chose to estimate a generalized linear model with a log link and a Gamma distribution.

Figure 3.Distribution of Unadjusted Patient-Level Payments for a HF 30-Day Episode of Care in 2009 (N=346,592 Patients)

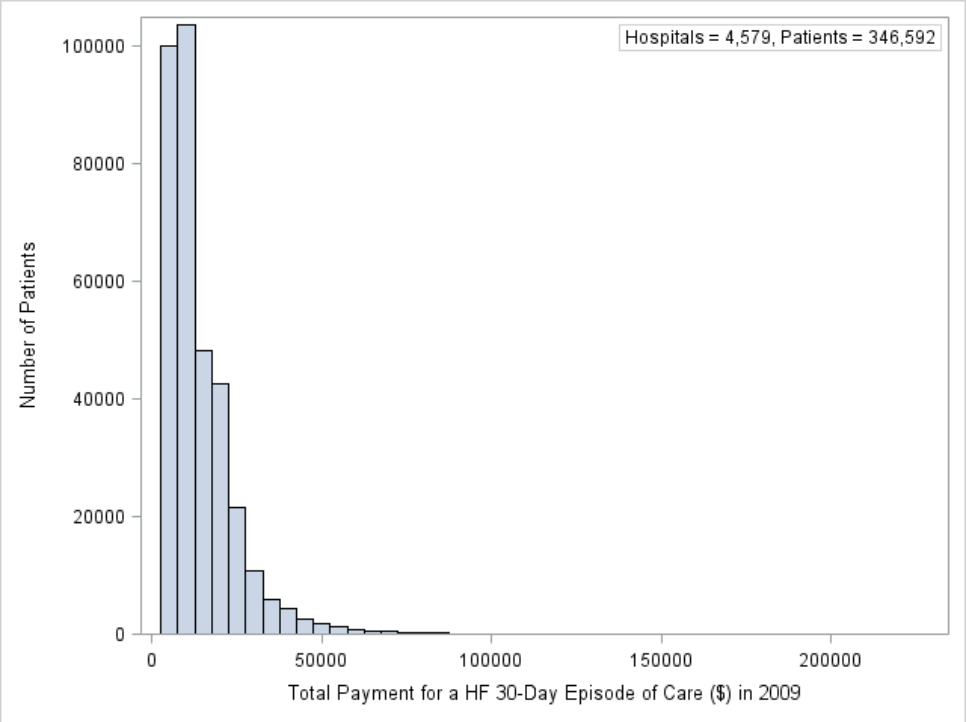
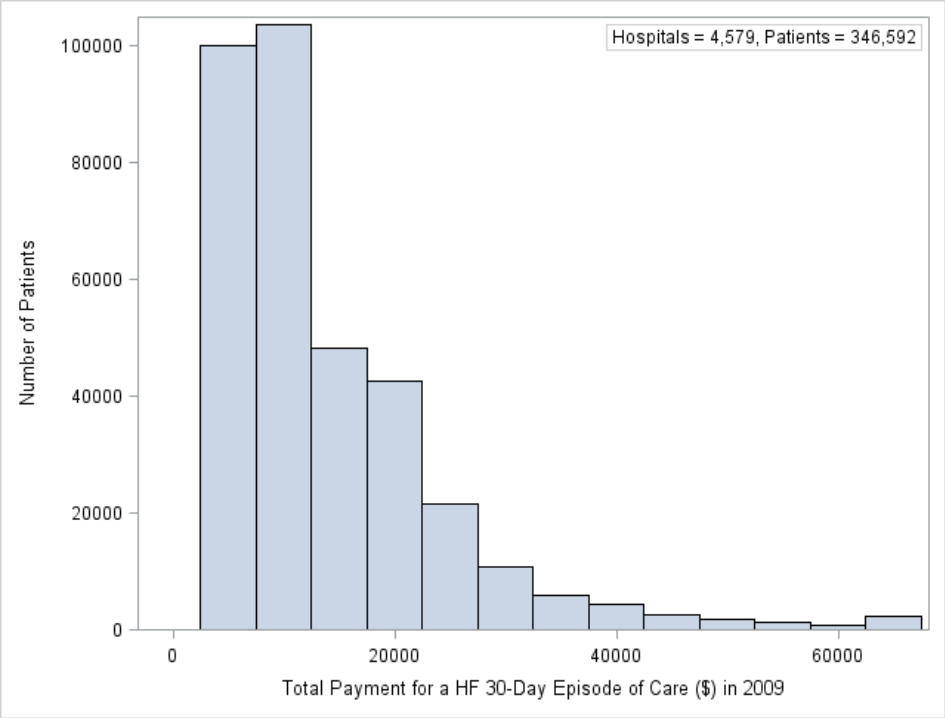


Figure 4.Distribution of Unadjusted Patient-Level Payments Winsorized at 99.5% for a HF 30-Day Episode of Care in 2009 (N=346,592 Patients)



2.7.4. Final Variable Selection

To inform variable selection, we performed a modified approach to stepwise generalized linear model regression. We used Sample A1 to create 1,000 bootstrap samples. For each sample, we ran a generalized linear model that included all candidate variables. Specifically, let Y_{ij} denote the outcome (total payment for a HF 30-day episode of care) for the j^{th} patient admitted to the i^{th} hospital; and $\mathbf{Z}_{ij}$ denotes the candidate risk factors where $\mathbf{Z}_{ij} = (Z_{1ij}, Z_{2ij}, \ldots, Z_{pij})$ is a set of *p* patient-specific variables (for example, age, comorbid conditions). Let I denote the total number of hospitals and n_i the number of index patient stays in hospital i. We assume the outcome is related linearly to the risk factors via a known link function, h(·), as follows:

$$h(Y_{ij}) = \alpha + \beta \mathbf{Z}_{ij} \qquad (1)$$

In our case, h(·) is the log link and we assumed a Gamma distribution for the outcome. We estimated these generalized linear models using the SAS software system (SAS 9.3 GENMOD procedure).

The results were summarized to show the percentage of times that each of the candidate variables was significantly associated with HF payment (at the $p<0.05$ level) in the 1,000 bootstrap samples (for example, 70% would mean that the candidate variable was significant at $p<0.05$ in 70% of the bootstrap samples). We also assessed the direction and magnitude of the regression coefficients.

The working group reviewed these results and decided to retain all risk-adjustment variables above a 90% cutoff (in other words, to retain variables that were significant at the 0.05 level in at least 90% of the bootstrap samples). We chose the 90% cutoff because variables above this threshold demonstrated a relatively robust association with HF payment and were clinically relevant. The final risk-adjusted HF payment model included 32 variables (Table 4).

Table 3.2008-2009 HF Payment Model Candidate Variables

Category	Variable	CC
Demographics	Age (65 – 74)	N/A
Demographics	Age (75 – 84)	N/A
Demographics	Age (>=85)	N/A
Other Comorbidity	Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence	CC 77-79
Other Comorbidity	Congestive Heart Failure	CC 80
Other Comorbidity	Acute Coronary Syndrome	CC 81, 82
Other Comorbidity	Angina Pectoris/Old Myocardial Infarction	CC 83
Other Comorbidity	Coronary Atherosclerosis/Other Chronic Ischemic Heart Disease	CC 84
Other Comorbidity	Heart Infection/Inflammation, Except Rheumatic	CC 85
Other Comorbidity	Valvular and Rheumatic Heart Disease	CC 86
Other Comorbidity	Congenital cardiac/circulatory defect	CC 87, 88
Other Comorbidity	Hypertensive Heart Disease and/or Renal Disease or Encephalopathy	CC 89, 90
Other Comorbidity	Hypertension	CC 91

Category	Variable	CC
Other Comorbidity	History of Infection	CC 1, 3-5
Other Comorbidity	Septicemia/Shock	CC 2
Other Comorbidity	Other Infectious Diseases	CC 6
Other Comorbidity	Metastatic Cancer and Acute Leukemia and Other Major Cancers	CC 7, 8
Other Comorbidity	Cancer	CC 9, 11, 12
Other Comorbidity	Breast, Prostate, Colorectal, and Other Cancers and Tumors	CC 10
Other Comorbidity	Other Neoplasms	CC 13
Other Comorbidity	Benign Neoplasms of Skin, Breast, Eye	CC 14
Other Comorbidity	Diabetes and Diabetes Complications	CC 15-19, 119-120
Other Comorbidity	Protein-Calorie Malnutrition	CC 21
Other Comorbidity	Other Significant Endocrine and Metabolic Disorders	CC 22
Other Comorbidity	Disorders of Fluid/Electrolyte/Acid-Base	CC 23
Other Comorbidity	Obesity/Disorders of Thyroid, Cholesterol, Lipids	CC 24
Other Comorbidity	Liver and Biliary Disease	CC 25-30
Other Comorbidity	Intestinal Obstruction/Perforation	CC 31
Other Comorbidity	Pancreatic Disease	CC 32
Other Comorbidity	Inflammatory Bowel Disease	CC 33
Other Comorbidity	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	CC 34
Other Comorbidity	Appendicitis	CC 35
Other Comorbidity	Other Gastrointestinal Disorders	CC 36
Other Comorbidity	Bone/Joint/Muscle Infections/Necrosis	CC 37
Other Comorbidity	Rheumatoid Arthritis and Inflammatory Connective Tissue Disease	CC 38
Other Comorbidity	Disorders of the Vertebrae and Spinal Discs	CC 39
Other Comorbidity	Osteoarthritis of Hip or Knee	CC 40
Other Comorbidity	Osteoporosis and Other Bone/Cartilage Disorders	CC 41
Other Comorbidity	Congenital/Developmental Skeletal and Connective Tissue Disorders	CC 42
Other Comorbidity	Other Musculoskeletal and Connective Tissue Disorders	CC 43
Other Comorbidity	Severe Hematological Disorders	CC 44
Other Comorbidity	Disorders of Immunity	CC 45
Other Comorbidity	Coagulation Defects and Other Specified Hematological Disorders	CC 46
Other Comorbidity	Iron Deficiency and Other/Unspecified Anemias and Blood Disease	CC 47
Other Comorbidity	Delirium and Encephalopathy	CC 48
Other Comorbidity	Dementia and Senility	CC 49, 50
Other Comorbidity	Drug/Alcohol Psychosis or Dependence	CC 51, 52
Other Comorbidity	Drug/Alcohol Abuse, Without Dependence	CC 53
Other Comorbidity	Schizophrenia/Major Depressive/Bipolar Disorders	CC 54, 55
Other Comorbidity	Reactive and Unspecified Psychosis	CC 56
Other Comorbidity	Personality Disorders	CC 57
Other Comorbidity	Depression	CC 58
Other Comorbidity	Anxiety Disorders	CC 59
Other Comorbidity	Other psychiatric disorders	CC 60
Other Comorbidity	Mental retardation or developmental disability	CC 61-64
Other Comorbidity	Other Developmental Disability	CC 65

Category	Variable	CC
Other Comorbidity	Plegia, Paralysis, Spinal Cord Disorder and Amputation	CC 67-69, 100, 101, 177, 178
Other Comorbidity	Muscular Dystrophy	CC 70
Other Comorbidity	Polyneuropathy	CC 71
Other Comorbidity	Multiple Sclerosis	CC 72
Other Comorbidity	Parkinson's and Huntington's Diseases	CC 73
Other Comorbidity	Seizure Disorders and Convulsions	CC 74
Other Comorbidity	Coma, Brain Compression/Anoxic Damage	CC 75
Other Comorbidity	Mononeuropathy, Other Neurological Conditions/Injuries	CC 76
Other Comorbidity	Arrhythmias	CC 92, 93
Other Comorbidity	Other and Unspecified Heart Disease	CC 94
Other Comorbidity	Stroke	CC 95, 96
Other Comorbidity	Cerebrovascular Disease	CC 97-99
Other Comorbidity	Cerebrovascular Disease and Left Effects	CC 102, 103
Other Comorbidity	Vascular or Circulatory Disease	CC 104-106
Other Comorbidity	Cystic fibrosis	CC 107
Other Comorbidity	COPD	CC 108
Other Comorbidity	Fibrosis of lung or other chronic lung disorder	CC 109
Other Comorbidity	Asthma	CC 110
Other Comorbidity	History of Pneumonia	CC 111-113
Other Comorbidity	Pleural Effusion/Pneumothorax	CC 114
Other Comorbidity	Other Lung Disorders	CC 115
Other Comorbidity	Legally Blind	CC 116
Other Comorbidity	Major Eye Infections/Inflammations	CC 117
Other Comorbidity	Retinal Detachment	CC 118
Other Comorbidity	Retinal Disorders, Except Detachment and Vascular Retinopathies	CC 121
Other Comorbidity	Glaucoma	CC 122
Other Comorbidity	Other Eye Disorders	CC 124
Other Comorbidity	Significant Ear, Nose, and Throat Disorders	CC 125
Other Comorbidity	Hearing Loss	CC 126
Other Comorbidity	Other Ear, Nose, Throat, and Mouth Disorders	CC 127
Other Comorbidity	Kidney Transplant Status	CC 128
Other Comorbidity	Dialysis Status	CC 130
Other Comorbidity	Renal Failure	CC 131
Other Comorbidity	Nephritis	CC 132
Other Comorbidity	Urinary Obstruction and Retention	CC 133
Other Comorbidity	Incontinence	CC 134
Other Comorbidity	Urinary Tract Infection	CC 135
Other Comorbidity	Other urinary tract disorders	CC 136
Other Comorbidity	Female Genital Disorders	CC 138, 139
Other Comorbidity	Male genital disorders	CC 140
Other Comorbidity	Decubitus Ulcer of Skin	CC 148
Other Comorbidity	Chronic Ulcer of Skin, Except Decubitus	CC 149
Other Comorbidity	Extensive Burns	CC 150, 151
Other Comorbidity	Cellulitis, Local Skin Infection	CC 152
Other Comorbidity	Other Dermatological Disorders	CC 153
Other Comorbidity	Head Injury	CC 154-156

Category	Variable	CC
Other Comorbidity	Vertebral Fractures	CC 157
Other Comorbidity	Hip Fracture/Dislocation	CC 158
Other Comorbidity	Major Fracture, Except of Skull, Vertebrae, or Hip	CC 159
Other Comorbidity	Internal Injuries	CC 160
Other Comorbidity	Traumatic Amputation	CC 161
Other Comorbidity	Other Injuries	CC 162
Other Comorbidity	Poisonings and Allergic Reactions	CC163
Other Comorbidity	Major Complications of Medical Care and Trauma	CC 164
Other Comorbidity	Other Complications of Medical Care	CC 165
Other Comorbidity	Major Symptoms, Abnormalities	CC 166
Other Comorbidity	Minor Symptoms, Signs, Findings	CC 167
Other Comorbidity	Major Organ Transplant Status	CC 174
Other Comorbidity	Other organ transplant/replacement	CC 175

Table 4.2008-2009 HF Payment Model Final Variables

Description	2008-2009 Sample (%)
Demographics	
Age (65 – 74)	23.40%
Age (75 – 84)	39.95%
Age (>=85)	36.65%
Cardiovascular	
Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence (CC 77-79)	21.34%
Angina Pectoris/Old Myocardial Infarction (CC 83)	24.68%
Heart Infection/Inflammation, Except Rheumatic (CC 85)	3.25%
Major Congenital Cardiac/Circulatory Defect (CC87)	1.64%
Hypertension (CC 91)	84.17%
Other Comorbidity	
History of Infection (CC 1, 3-5)	1.44%
Other Infectious Diseases (CC 6)	34.73%
Protein-Calorie Malnutrition (CC 21)	7.66%
Other Significant Endocrine and Metabolic Disorders (CC 22)	9.59%
Obesity/Disorders of Thyroid, Cholesterol, Lipids (CC 24)	74.34%
Other Gastrointestinal Disorders (CC 36)	52.86%
Bone/Joint/Muscle Infections/Necrosis (CC 37)	2.37%
Other Musculoskeletal and Connective Tissue Disorders (CC 43)	68.48%
Delirium and Encephalopathy (CC 48)	6.28%
Dementia and Senility (CC 49, 50)	21.65%
Schizophrenia/Major Depressive/Bipolar Disorders (CC 54-55)	5.81%
Other Psychiatric Disorders (CC60)	10.11%
Arrhythmias (CC 92, 93)	62.82%
Cerebrovascular Disease (CC 97-99)	22.15%
Vascular or Circulatory Disease (CC 104-106)	48.62%
History of Pneumonia (CC 111-113)	43.55%
Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	29.31%
Dialysis Status (CC 130)	3.46%
Renal Failure (CC 131)	40.20%
Decubitus Ulcer of Skin (CC 148)	5.02%
Chronic Ulcer of Skin, Except Decubitus (CC 149)	11.03%
Cellulitis, Local Skin Infection (CC 152)	17.41%
Hip Fracture/Dislocation (CC 158)	4.04%
Internal Injuries (CC 160)	1.38%

2.8. Statistical Approach to Risk-Standardized Payment (RSP)

To calculate hospital-specific RSPs, we estimate hierarchical generalized linear models using Samples A and B. This strategy accounts for within-hospital correlation of the observed outcomes and accommodates the assumption that underlying differences in quality across hospitals lead to systematic differences in outcomes. We model the total payment as a function of patient age and select comorbidities, with a hospital-specific random effect.

We use the following strategy to calculate the hospital-specific RSPs. We calculate these payments as the ratio of "predicted" HF payment to expected HF payment, and multiply by the national unadjusted average HF payment. The predicted HF payment for each hospital is estimated using its patient mix and an estimated hospital-specific intercept. The expected HF payment for each hospital is estimated given the same patient mix but the average intercept among all hospitals in the sample.

Operationally, the expected HF payment for each hospital is obtained by summing the expected HF payments for all patients in the hospital. The expected HF payment for each patient is calculated via the hierarchical model by applying the estimated regression coefficients to the observed patient characteristics and adding the average intercept. The predicted HF payment for each hospital is calculated by summing the predicted HF payments for all patients in the hospital. The predicted HF payment for each patient is calculated through the hierarchical model by applying the estimated regression coefficients to the patient characteristics observed and adding the hospital-specific intercept.

More specifically, we use a hierarchical generalized linear model to account for the natural clustering of observations within hospitals and adjust for the selected risk factors. The model employs a log link and a Gamma distribution with a hospital-specific random effect as follows:

$$h(Y_{ij}) = \alpha_i + \beta \mathbf{Z}_{ij} \quad (2)$$

$$\alpha_i = \mu + \omega_i; \qquad \omega_i \sim N(0, \tau^2) \quad (3)$$

where α_i represents the hospital-specific intercept, $\mathbf{Z}_{ij}$ is defined the same as in equation (1), μ is the average intercept across all hospitals in the sample, and τ^2 is the between-hospital variance component.[13] This model separates within-hospital variation from between-hospital variation. The hierarchical generalized linear models are estimated using the SAS software system (SAS 9.3 GLIMMIX procedure).

2.8.1 Hospital Performance Reporting

Using the selected set of risk factors, we fit the hierarchical generalized linear model defined by Equations (2) - (3) and estimate the parameters, $\hat{\mu}$, $\{\alpha_i, \alpha_2, \ldots, \alpha_I\}$, $\hat{\beta}$, and $\hat{\tau}^2$. We calculate a standardized outcome measure, RSP_i, for each hospital by computing the ratio of the predicted HF payment to the expected HF payment, and multiplying by the national unadjusted average HF payment, $\bar{y}$. Specifically, we calculate

Predicted $$\hat{y}_{ij}(Z_{ij}) = h^{-1}(\hat{a}_i + \hat{\beta}\mathbf{Z}_{ij}) \quad (4)$$

Expected $$\hat{e}_{ij}(Z_{ij}) = h^{-1}(\hat{\mu} + \hat{\beta}\mathbf{Z}_{ij}) \quad (5)$$

$$\widehat{RSP}_i(Z_{ij}) = \frac{\sum_{j=1}^{n_i} \hat{y}_{ij}(Z)}{\sum_{j=1}^{n_i} \hat{e}_{ij}(Z)} \times \bar{y} \quad (6)$$

Again, i indexes hospitals, j indexes patients within hospitals, and n_i is the number of patients within hospital i. If "predicted" total payment is higher (or lower) than "expected" total payment for a given hospital, then its $\widehat{RSP}_i$ will be higher (or lower) than the national unadjusted average payment. For each hospital, we can compute an interval estimate of RSP_i to characterize the level of uncertainty around the point estimate using bootstrapping simulations. The point estimate and interval estimate can be used to characterize and compare hospital performance (for example, higher than expected, as expected, or lower than expected). See Figure 5 for our overall analysis steps.

2.8.2 Creating Interval Estimates

Because the statistic described in Equation 6 (Section 2.8.1), $\widehat{RSP}_i$, is a complex function of parameter estimates, we use the re-sampling technique – bootstrapping – to derive an interval estimate. Bootstrapping has the advantage of avoiding unnecessary distributional assumptions.

Algorithm:

Let *I* denote the total number of hospitals in the sample. We repeat steps 1-4 below for B times, where *B* is the number of bootstrap samples desired (with b indexes the *b*th bootstrap sample):

1. Sample *I* hospitals with replacement.

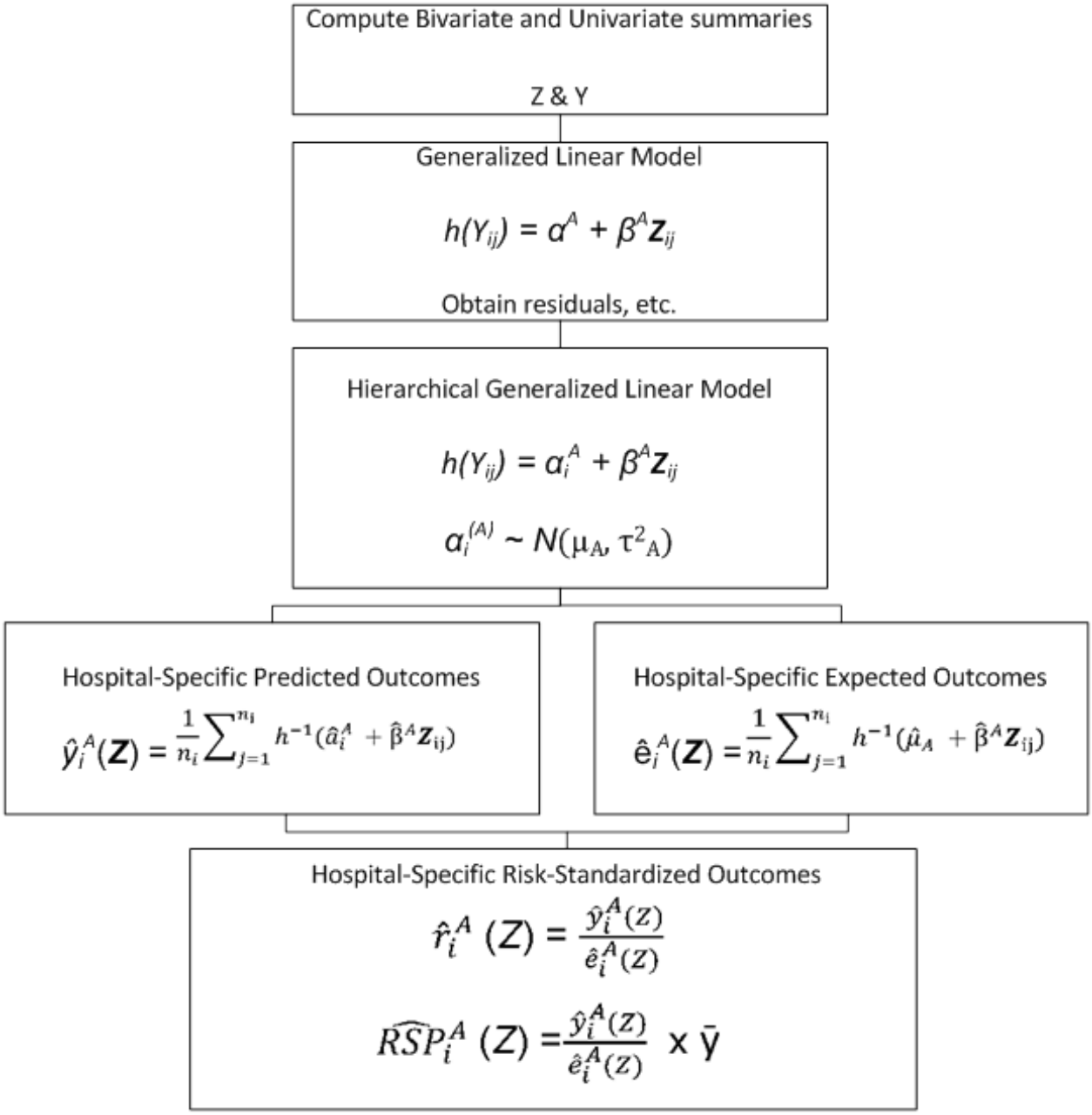
2. Fit the hierarchical generalized linear model using all patients within each sampled hospital. If some hospitals are selected more than once in a bootstrapped sample, we treat them as distinct so that we have *I* random effects to estimate the variance components. At the conclusion of Step 2, we have:
   a. $\hat{\beta}^{(b)}$ (estimated regression coefficients of the risk factors)
   b. The parameters governing the random effects, hospital adjusted outcomes, distribution, $\hat{\mu}^{(b)}$ and $\hat{\tau}^{2(b)}$
   c. The set of hospital-specific intercepts and corresponding variances, $\{\hat{\alpha}_i^{(b)}, \widehat{var}(\alpha_i^{(b)}); i = 1,2,\dots,I\}$

3. We generate a hospital random effect by sampling from the distribution of the hospital-specific distribution obtained in Step 2c. We approximate the distribution for each random effect by a normal distribution. Thus, we draw $\alpha_i^{(b*)} \sim N(\hat{\alpha}_i^{(b)}, \widehat{var}(\hat{\alpha}_i^{(b)}))$ for the unique set of hospitals sampled in Step 1.

4. Within each unique hospital *i* sampled in Step 1, and for each patient *j* in that hospital, we calculate $\hat{y}_{ij}^{(b)}$, $\hat{e}_{ij}^{(b)}$, and $\widehat{RSP}_i(Z)^{(b)}$ where $\hat{\beta}^{(b)}$ and $\hat{\mu}^{(b)}$ are obtained from Step 2 and $\hat{\alpha}_i^{(b*)}$ is obtained from Step 3.

Ninety-five percent interval estimates (or alternative interval estimates) for the hospital-standardized outcome can be computed by identifying the 2.5th and 97.5th percentiles of the B estimates (or the percentiles corresponding to the alternative desired intervals).[14]

Figure 5.Analysis Steps



3. RESULTS

3.1. Model Development and Validation Results

Table 5 shows the number of index admissions and number of hospitals associated with each of the samples used for measure development and validation, as outlined in Section 2.6.

Table 5.Description of 2008-2009 Development and Validation Samples

Sample	% of Total Sample	Purpose	Number of Index Admissions	Number of Hospitals
Sample A (Full Sample)	100% 2009	Development (cohort, outcome definition, determination of functional form of risk-adjustment model)	346,592	4,579
Sample A1 (Development)	50% 2009 (randomly selected)	Development (variable selection; validity testing)	173,296	4,508
Sample A2 (Validation)	50% 2009 (remaining 50%)	Development (validity testing)	173,296	4,493
Sample B (Validation)	100% 2008	Development (cohort, outcome definition, and validity testing)	348,061	4,579

The frequencies of final selected risk factors for all samples, as shown in Table 6, are consistent across the development and validation samples.

Table 6.2008-2009 HF Payment Model Risk Factor Frequencies in Development and Validation Samples

Risk-Adjustment Category	Risk-Adjustment Variable	2009 Sample A1 (%)	2009 Sample A2 (%)	2008 Sample B (%)
Demographics	Age (65 – 74)	23.40	23.46	23.39
Demographics	Age (75 – 84)	39.67	39.49	40.30
Demographics	Age (>=85)	36.92	37.05	36.31
Cardiovascular	Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence (CC 77-79)	21.88	21.97	20.76
Cardiovascular	Angina Pectoris/Old Myocardial Infarction (CC 83)	24.19	24.13	25.19
Cardiovascular	Heart Infection/Inflammation, Except Rheumatic (CC 85)	3.33	3.40	3.14
Cardiovascular	Major Congenital Cardiac/Circulatory Defect (CC87)	1.70	1.65	1.61
Cardiovascular	Hypertension (CC 91)	84.30	84.50	83.93
Other Comorbidity	History of Infection (CC 1, 3-5)	1.47	1.49	1.41
Other Comorbidity	Other Infectious Diseases (CC 6)	35.22	35.03	34.33
Other Comorbidity	Protein-Calorie Malnutrition (CC 21)	8.27	8.04	7.17
Other Comorbidity	Other Significant Endocrine and Metabolic Disorders (CC 22)	10.07	10.04	9.12
Other Comorbidity	Obesity/Disorders of Thyroid, Cholesterol, Lipids	75.14	75.50	73.38

Risk-Adjustment Category	Risk-Adjustment Variable	Sample A1 (%)	2009 Sample A2 (%)	2008 Sample B (%)
	(CC 24)			
Other Comorbidity	Other Gastrointestinal Disorders (CC 36)	53.23	53.08	52.58
Other Comorbidity	Bone/Joint/Muscle Infections/Necrosis (CC 37)	2.42	2.44	2.31
Other Comorbidity	Other Musculoskeletal and Connective Tissue Disorders (CC 43)	68.72	68.92	68.15
Other Comorbidity	Delirium and Encephalopathy (CC 48)	6.60	6.60	5.96
Other Comorbidity	Dementia and Senility (CC 49, 50)	21.66	21.73	21.61
Other Comorbidity	Schizophrenia/Major Depressive/Bipolar Disorders (CC 54-55)	5.90	5.86	5.74
Other Comorbidity	Other Psychiatric Disorders (CC60)	10.18	10.16	10.05
Other Comorbidity	Arrhythmias (CC 92, 93)	63.38	63.25	62.33
Other Comorbidity	Cerebrovascular Disease (CC 97-99)	22.22	22.17	22.11
Other Comorbidity	Vascular or Circulatory Disease (CC 104-106)	49.23	48.96	48.14
Other Comorbidity	History of Pneumonia (CC 111-113)	43.73	43.96	43.25
Other Comorbidity	Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	29.55	29.39	29.15
Other Comorbidity	Dialysis Status (CC 130)	3.45	3.50	3.45
Other Comorbidity	Renal Failure (CC 131)	41.46	41.60	38.88
Other Comorbidity	Decubitus Ulcer of Skin (CC 148)	4.94	4.96	5.09
Other Comorbidity	Chronic Ulcer of Skin, Except Decubitus (CC 149)	11.19	11.11	10.91
Other Comorbidity	Cellulitis, Local Skin Infection (CC 152)	17.51	17.63	17.25
Other Comorbidity	Hip Fracture/Dislocation (CC 158)	4.05	4.04	4.02
Other Comorbidity	Internal Injuries (CC 160)	1.41	1.43	1.33

3.1.1. Results of Risk-Adjustment Model in Development and Validation Samples

Table 7 reports the estimated coefficients, standard errors, payment ratios (PRs) (exponentiated coefficient estimate), and 95% confidence intervals for the PRs associated with each risk factor generated from the 2009 development sample (sample A1). Table 8 and Table 9 present the same information for the 2009 and 2008 validation samples. PRs are similar across samples.

Table 7.Generalized Linear Model Results for 2009 Development Sample A1 (N=173,296 at 4,508 hospitals)

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PR
Intercept	N/A	9.48	0.01	-	-
Demographics	Age (65 – 74)	0.07	0.00	1.08	1.07 – 1.09
Demographics	Age (75 – 84)	0.06	0.00	1.06	1.06 – 1.07
Demographics	Age (>=85) (reference group)	0.00	-		
Cardiovascular	Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence (CC 77-79)	0.03	0.00	1.03	1.02 – 1.04
Cardiovascular	Angina Pectoris/Old Myocardial Infarction (CC	-0.04	0.00	0.97	0.96 – 0.97

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PR
	83)				
Cardiovascular	Heart Infection/Inflammation, Except Rheumatic (CC 85)	0.09	0.01	1.10	1.08 – 1.11
Cardiovascular	Major Congenital Cardiac/Circulatory Defect (CC87)	0.06	0.01	1.06	1.04 – 1.08
Cardiovascular	Hypertension (CC 91)	-0.07	0.00	0.94	0.93 – 0.94
Other Comorbidity	History of Infection (CC 1, 3-5)	0.08	0.01	1.09	1.06 – 1.11
Other Comorbidity	Other Infectious Diseases (CC 6)	0.03	0.00	1.03	1.03 – 1.04
Other Comorbidity	Protein-Calorie Malnutrition (CC 21)	0.13	0.01	1.14	1.13 – 1.15
Other Comorbidity	Other Significant Endocrine and Metabolic Disorders (CC 22)	0.07	0.01	1.07	1.06 – 1.08
Other Comorbidity	Obesity/Disorders of Thyroid, Cholesterol, Lipids (CC 24)	-0.05	0.00	0.95	0.95 – 0.96
Other Comorbidity	Other Gastrointestinal Disorders (CC 36)	-0.03	0.00	0.98	0.97 – 0.98
Other Comorbidity	Bone/Joint/Muscle Infections/Necrosis (CC 37)	0.06	0.01	1.06	1.04 – 1.08
Other Comorbidity	Other Musculoskeletal and Connective Tissue Disorders (CC 43)	-0.01	0.00	0.99	0.98 – 0.99
Other Comorbidity	Delirium and Encephalopathy (CC 48)	0.03	0.01	1.03	1.02 – 1.05
Other Comorbidity	Dementia and Senility (CC 49, 50)	0.02	0.00	1.02	1.01 – 1.03
Other Comorbidity	Schizophrenia/Major Depressive/Bipolar Disorders (CC 54-55)	0.06	0.01	1.06	1.05 – 1.08
Other Comorbidity	Other Psychiatric Disorders (CC60)	-0.02	0.00	0.98	0.97 – 0.99
Other Comorbidity	Arrhythmias (CC 92, 93)	-0.01	0.00	0.99	0.98 – 0.99
Other Comorbidity	Cerebrovascular Disease (CC 97-99)	0.03	0.00	1.03	1.02 – 1.04
Other Comorbidity	Vascular or Circulatory Disease (CC 104-106)	0.02	0.00	1.02	1.01 – 1.03
Other Comorbidity	History of Pneumonia (CC 111-113)	0.09	0.00	1.10	1.09 – 1.11
Other Comorbidity	Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	-0.02	0.00	0.98	0.98 – 0.99
Other Comorbidity	Dialysis Status (CC 130)	0.15	0.01	1.16	1.14 – 1.18
Other Comorbidity	Renal Failure (CC 131)	0.07	0.00	1.08	1.07 – 1.08
Other Comorbidity	Decubitus Ulcer of Skin (CC 148)	0.04	0.01	1.04	1.03 – 1.06
Other Comorbidity	Chronic Ulcer of Skin, Except Decubitus (CC 149)	0.05	0.01	1.05	1.04 – 1.06
Other Comorbidity	Cellulitis, Local Skin Infection (CC 152)	0.02	0.00	1.02	1.01 – 1.03
Other Comorbidity	Hip Fracture/Dislocation (CC 158)	0.03	0.01	1.03	1.02 – 1.05
Other Comorbidity	Internal Injuries (CC 160)	0.06	0.01	1.06	1.04 – 1.09

Table 8.Generalized Linear Model Results for 2009 Validation Sample A2 (N=173,296 at 4,493 hospitals)

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PR
Intercept	N/A	9.47	0.01	-	–
Demographics	Age (65 – 74)	0.08	0.00	1.08	1.07 – 1.09
Demographics	Age (75 – 84)	0.06	0.00	1.06	1.05 – 1.07
Demographics	Age (>=85) (reference group)	0.00	-	-	
Cardiovascular	Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence (CC 77-79)	0.03	0.00	1.03	1.02 – 1.03
Cardiovascular	Angina Pectoris/Old Myocardial Infarction (CC 83)	-0.03	0.00	0.97	0.96 – 0.98

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PR
Cardiovascular	Heart Infection/Inflammation, Except Rheumatic (CC 85)	0.11	0.01	1.11	1.10 – 1.13
Cardiovascular	Major Congenital Cardiac/Circulatory Defect (CC87)	0.05	0.01	1.05	1.02 – 1.07
Cardiovascular	Hypertension (CC 91)	-0.06	0.00	0.94	0.94 – 0.95
Other Comorbidity	History of Infection (CC 1, 3-5)	0.07	0.01	1.07	1.04 – 1.09
Other Comorbidity	Other Infectious Diseases (CC 6)	0.03	0.00	1.03	1.02 – 1.03
Other Comorbidity	Protein-Calorie Malnutrition (CC 21)	0.12	0.01	1.12	1.11 – 1.13
Other Comorbidity	Other Significant Endocrine and Metabolic Disorders (CC 22)	0.07	0.01	1.08	1.07 – 1.09
Other Comorbidity	Obesity/Disorders of Thyroid, Cholesterol, Lipids (CC 24)	-0.05	0.00	0.96	0.95 – 0.96
Other Comorbidity	Other Gastrointestinal Disorders (CC 36)	-0.03	0.00	0.97	0.96 – 0.97
Other Comorbidity	Bone/Joint/Muscle Infections/Necrosis (CC 37)	0.06	0.01	1.06	1.04 – 1.08
Other Comorbidity	Other Musculoskeletal and Connective Tissue Disorders (CC 43)	-0.01	0.00	0.99	0.99 – 1.00
Other Comorbidity	Delirium and Encephalopathy (CC 48)	0.04	0.01	1.04	1.02 – 1.05
Other Comorbidity	Dementia and Senility (CC 49, 50)	0.03	0.00	1.03	1.02 – 1.03
Other Comorbidity	Schizophrenia/Major Depressive/Bipolar Disorders (CC 54-55)	0.06	0.01	1.07	1.05 – 1.08
Other Comorbidity	Other Psychiatric Disorders (CC60)	-0.01	0.00	0.99	0.98 – 1.00
Other Comorbidity	Arrhythmias (CC 92, 93)	-0.01	0.00	0.99	0.99 – 1.00
Other Comorbidity	Cerebrovascular Disease (CC 97-99)	0.02	0.00	1.02	1.02 – 1.03
Other Comorbidity	Vascular or Circulatory Disease (CC 104-106)	0.02	0.00	1.02	1.01 – 1.03
Other Comorbidity	History of Pneumonia (CC 111-113)	0.10	0.00	1.11	1.10 – 1.11
Other Comorbidity	Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	-0.02	0.00	0.98	0.97 – 0.99
Other Comorbidity	Dialysis Status (CC 130)	0.15	0.01	1.16	1.14 – 1.18
Other Comorbidity	Renal Failure (CC 131)	0.07	0.00	1.07	1.06 – 1.08
Other Comorbidity	Decubitus Ulcer of Skin (CC 148)	0.02	0.01	1.02	1.01 – 1.04
Other Comorbidity	Chronic Ulcer of Skin, Except Decubitus (CC 149)	0.06	0.01	1.06	1.01 – 1.04
Other Comorbidity	Cellulitis, Local Skin Infection (CC 152)	0.02	0.00	1.02	1.01 – 1.03
Other Comorbidity	Hip Fracture/Dislocation (CC 158)	0.06	0.01	1.06	1.04 – 1.07
Other Comorbidity	Internal Injuries (CC 160)	0.08	0.01	1.08	1.05 – 1.10

Table 9.Generalized Linear Model Results for 2008 Validation Sample B (N=348,061 at 4,579 hospitals)

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PR
Intercept	N/A	9.43	0.00		-
Demographics	Age (65 – 74)	0.07	0.00	1.07	1.07 – 1.08
Demographics	Age (75 – 84)	0.05	0.00	1.05	1.05 – 1.06
Demographics	Age (>=85) (reference group)	0.00	-		
Cardiovascular	Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence (CC 77-79)	0.02	0.00	1.02	1.02 – 1.03
Cardiovascular	Angina Pectoris/Old Myocardial Infarction (CC 83)	-0.02	0.00	0.98	0.97 – 0.98
Cardiovascular	Heart Infection/Inflammation, Except Rheumatic (CC 85)	0.08	0.01	1.08	1.07 – 1.10

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PR
Cardiovascular	Major Congenital Cardiac/Circulatory Defect (CC87)	0.04	0.01	1.04	1.03 – 1.06
Cardiovascular	Hypertension (CC 91)	-0.05	0.00	0.95	0.94 – 0.95
Other Comorbidity	History of Infection (CC 1, 3-5)	0.05	0.01	1.05	1.04 – 1.07
Other Comorbidity	Other Infectious Diseases (CC 6)	0.03	0.00	1.03	1.02 – 1.03
Other Comorbidity	Protein-Calorie Malnutrition (CC 21)	0.12	0.00	1.13	1.12 – 1.14
Other Comorbidity	Other Significant Endocrine and Metabolic Disorders (CC 22)	0.05	0.00	1.06	1.05 – 1.06
Other Comorbidity	Obesity/Disorders of Thyroid, Cholesterol, Lipids (CC 24)	-0.04	0.00	0.96	0.96 – 0.97
Other Comorbidity	Other Gastrointestinal Disorders (CC 36)	-0.02	0.00	0.98	0.98 – 0.98
Other Comorbidity	Bone/Joint/Muscle Infections/Necrosis (CC 37)	0.06	0.01	1.06	1.05 – 1.07
Other Comorbidity	Other Musculoskeletal and Connective Tissue Disorders (CC 43)	0.00	0.00	1.00	0.99 – 1.00
Other Comorbidity	Delirium and Encephalopathy (CC 48)	0.03	0.00	1.04	1.03 – 1.04
Other Comorbidity	Dementia and Senility (CC 49, 50)	0.03	0.00	1.03	1.02 – 1.03
Other Comorbidity	Schizophrenia/Major Depressive/Bipolar Disorders (CC 54-55)	0.06	0.00	1.06	1.05 – 1.07
Other Comorbidity	Other Psychiatric Disorders (CC60)	-0.01	0.00	0.99	0.99 – 1.00
Other Comorbidity	Arrhythmias (CC 92, 93)	-0.01	0.00	0.99	0.99 – 1.00
Other Comorbidity	Cerebrovascular Disease (CC 97-99)	0.02	0.00	1.02	1.02 – 1.03
Other Comorbidity	Vascular or Circulatory Disease (CC 104-106)	0.02	0.00	1.02	1.02 – 1.03
Other Comorbidity	History of Pneumonia (CC 111-113)	0.07	0.00	1.08	1.07 – 1.08
Other Comorbidity	Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	-0.02	0.00	0.98	0.98 – 0.99
Other Comorbidity	Dialysis Status (CC 130)	0.14	0.01	1.15	1.14 – 1.17
Other Comorbidity	Renal Failure (CC 131)	0.05	0.00	1.06	1.05 – 1.06
Other Comorbidity	Decubitus Ulcer of Skin (CC 148)	0.04	0.00	1.04	1.03 – 1.05
Other Comorbidity	Chronic Ulcer of Skin, Except Decubitus (CC 149)	0.05	0.00	1.05	1.04 – 1.06
Other Comorbidity	Cellulitis, Local Skin Infection (CC 152)	0.02	0.00	1.02	1.01 – 1.03
Other Comorbidity	Hip Fracture/Dislocation (CC 158)	0.04	0.01	1.04	1.03 – 1.05
Other Comorbidity	Internal Injuries (CC 160)	0.08	0.01	1.08	1.06 – 1.10

For each generalized linear model, we compute six summary statistics to assess model performance: calibration (a measure of over-fitting) predictive ratios by deciles and bottom and top 1% of predicted payment, distribution of residuals, mean absolute prediction error (MAPE), root–mean-square error (RMSE), and model chi-square. Model performance results are summarized in Table 10.

Over-fitting can result in the phenomenon in which a model describes the relationship between predictive variables and the outcome well in the development sample, but fails to provide valid predictions in new patients.

A predictive ratio is an estimator's ratio of predicted outcome to observed outcome.[15] A predictive ratio of 1.0 indicates an accurate prediction. A ratio greater than 1.0 indicates overprediction, and a ratio less than 1.0 indicates underprediction.

Taking together all of the model diagnostics shown in Table 10, the model performs well across all samples. The results of calibration testing, however, suggest that there may be differences in payment over time. Further investigation of the effect of time on payments is warranted.

Table 10.Generalized Linear Model Performance for 2008-2009 Development and Validation Samples

Indices	2009 Development Sample A1	2009 Validation Sample A2	2008 Validation Sample B
Number of hospital stays	173,296	173,296	348,061
Number of hospitals	4,508	4,493	4,579
Unadjusted mean payment	$14,147	$14,159	$13,457
Calibration (γ0, γ1)[†]	(0.00,1.00)	(0.10,0.99)	(1.24,0.87)
Discrimination – Predictive Ratios Bottom 1% (lowest)	1.01	1.01	1.02
Discrimination – Predictive Ratios First Decile	1.02	1.03	1.02
Discrimination – Predictive Ratios Second Decile	1.02	1.02	1.01
Discrimination – Predictive Ratios Third Decile	1.00	1.01	1.00
Discrimination – Predictive Ratios Fourth Decile	0.99	0.99	1.00
Discrimination – Predictive Ratios Fifth Decile	1.00	0.99	1.00
Discrimination – Predictive Ratios Sixth Decile	0.98	0.98	0.99
Discrimination – Predictive Ratios Seventh Decile	0.99	0.99	0.99
Discrimination – Predictive Ratios Eighth Decile	0.99	0.98	1.00
Discrimination – Predictive Ratios Ninth Decile	1.00	1.00	0.99
Discrimination – Predictive Ratios Tenth Decile	1.02	1.03	1.02
Discrimination – Predictive Ratios Top 1% (highest)	1.09	1.07	1.06
Residuals Lack of Fit (Pearson Residual Fall %) <-2	0.00	0.00	0.00
Residuals Lack of Fit (Pearson Residual Fall %) [-2, 0)	64.47	64.52	64.68
Residuals Lack of Fit (Pearson Residual Fall %) [0, 2)	32.87	32.80	32.62
Residuals Lack of Fit (Pearson Residual Fall %) [2+	2.68	2.68	2.70
MAPE	7274.62	7279.82	6825.75
RMSE	10100.44	10113.85	9473.21
Model χ^2 [DF][‡] (p-value)	3060.13 [31] (<0.001)	3066.00 [31] (<0.001)	4593.50 [31] (<0.001)

[†] Over-Fitting Indices (γ_0, γ_1) provide evidence of over-fitting and require several steps to calculate. Let *b* denote the *estimated vector* of regression coefficients. *Predicted Payment* ($\hat{p}$) = exp{Xb}), and *Z = Xb* (for example, the linear predictor that is a scalar value for everyone). A new generalized linear model that includes only an intercept and a slope by regressing the Y on Z with a log link is fitted in the validation sample; for example, Ln (E(Y|Z))= $\gamma_0 + \gamma_1 Z$. Estimated values of γ_0 far from 0 and estimated values of γ_1 far from 1 provide evidence of over-fitting.

[‡] Model χ2 (DF) provides evidence of a global test of goodness of fit of the model, where the null hypothesis is that all the parameters of covariates are 0s. Take the deviance from the model with intercept only and minus the deviance in the full model with all covariates. It gives us a chi-square statistics with the degree of freedom equal the number of variables tested.

3.2. Final Model Results

The results presented below for the final hierarchical generalized linear model are for the full 2008-2009 combined samples (Sample A and Sample B combined). The list of covariates and coefficients, standard errors, PR, and 95% confidence intervals for the PR associated with each risk factor are shown in Table 11.

Table 11.Hierarchical Generalized Linear Model Results for Full 2008-2009 Sample

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PRs
Intercept	N/A	9.41	0.00	-	
Demographics	Age (65 – 74)	0.07	0.00	1.08	1.07 – 1.08
Demographics	Age (75 – 84)	0.05	0.00	1.05	1.05 – 1.06
Demographics	Age (>=85) (reference group)	0.00	-		
Cardiovascular	Respiratory Arrest/Cardiorespiratory Failure/Respirator Dependence (CC 77-79)	0.02	0.00	1.02	1.02 – 1.03
Cardiovascular	Angina Pectoris/Old Myocardial Infarction (CC 83)	-0.03	0.00	0.97	0.97 – 0.97
Cardiovascular	Heart Infection/Inflammation, Except Rheumatic (CC 85)	0.08	0.00	1.08	1.07 – 1.09
Cardiovascular	Major Congenital Cardiac/Circulatory Defect (CC87)	0.03	0.01	1.03	1.02 – 1.05
Cardiovascular	Hypertension (CC 91)	-0.05	0.00	0.95	0.94 – 0.95
Other Comorbidity	History of Infection (CC 1, 3-5)	0.06	0.01	1.06	1.05 – 1.08
Other Comorbidity	Other Infectious Diseases (CC 6)	0.02	0.00	1.02	1.02 – 1.03
Other Comorbidity	Protein-Calorie Malnutrition (CC 21)	0.12	0.00	1.13	1.12 – 1.14
Other Comorbidity	Other Significant Endocrine and Metabolic Disorders (CC 22)	0.06	0.00	1.06	1.05 – 1.07
Other Comorbidity	Obesity/Disorders of Thyroid, Cholesterol, Lipids (CC 24)	-0.04	0.00	0.96	0.95 – 0.96
Other Comorbidity	Other Gastrointestinal Disorders (CC 36)	-0.02	0.00	0.98	0.98 – 0.99
Other Comorbidity	Bone/Joint/Muscle Infections/Necrosis (CC 37)	0.06	0.01	1.06	1.05 – 1.07
Other Comorbidity	Other Musculoskeletal and Connective Tissue Disorders (CC 43)	0.00	0.00	1.00	0.99 – 1.00
Other Comorbidity	Delirium and Encephalopathy (CC 48)	0.03	0.00	1.03	1.02 – 1.03
Other Comorbidity	Dementia and Senility (CC 49, 50)	0.03	0.00	1.03	1.03 – 1.04
Other Comorbidity	Schizophrenia/Major Depressive/Bipolar Disorders (CC 54-55)	0.05	0.00	1.05	1.04 – 1.06
Other Comorbidity	Other Psychiatric Disorders (CC60)	-0.01	0.00	0.99	0.99 – 1.00
Other Comorbidity	Arrhythmias (CC 92, 93)	-0.02	0.00	0.98	0.98 – 0.99
Other Comorbidity	Cerebrovascular Disease (CC 97-99)	0.02	0.00	1.02	1.01 – 1.02
Other Comorbidity	Vascular or Circulatory Disease (CC 104-106)	0.02	0.00	1.02	1.01 – 1.02
Other Comorbidity	History of Pneumonia (CC 111-113)	0.09	0.00	1.09	1.09 – 1.10
Other Comorbidity	Other Ear, Nose, Throat, and Mouth Disorders (CC 127)	-0.02	0.00	0.98	0.98 – 0.99
Other Comorbidity	Dialysis Status (CC 130)	0.14	0.01	1.15	1.14 – 1.16
Other Comorbidity	Renal Failure (CC 131)	0.06	0.00	1.06	1.06 – 1.07

Risk-Adjustment Category	Risk-Adjustment Variable	Estimate	Standard Error	Payment Ratio (PR)	95% Confidence Interval for PRs
Other Comorbidity	Decubitus Ulcer of Skin (CC 148)	0.04	0.00	1.04	1.03 – 1.04
Other Comorbidity	Chronic Ulcer of Skin, Except Decubitus (CC 149)	0.05	0.00	1.05	1.05 – 1.06
Other Comorbidity	Cellulitis, Local Skin Infection (CC 152)	0.02	0.00	1.02	1.01 – 1.02
Other Comorbidity	Hip Fracture/Dislocation (CC 158)	0.05	0.00	1.05	1.04 – 1.06
Other Comorbidity	Internal Injuries (CC 160)	0.06	0.01	1.06	1.05 – 1.08

3.2.1. Distribution of Unadjusted and Adjusted Hospital-Specific HF 30-Day Episode-of-Care Payment

The estimated between-hospital variance from the hierarchical generalized linear model is 0.014 (SE=0.0004). The HF payment for a hospital with one standard deviation above average was 1.27 times that of a hospital with one standard deviation below average.

Both unadjusted (Figure 6) and adjusted (Figure 7) payments from HF admission to 30 days post-admission vary considerably across hospitals (Table 12.Distribution of Unadjusted and Risk-Standardized Payments for Hospitals with a Minimum of 25 HF Index Admissions (2008-2009 combined). For hospitals with at least 25 cases, the hospital unadjusted HF 30-day episode-of-care payment ranges from $6,865 to $26,696 across 3,714 hospitals with a median (interquartile range) of $13,016 ($11,717, $14,331). The mean ± SD hospital unadjusted payment is $13,081 ± $2,025. After adjusting for patient case mix, the risk-standardized payment at the hospital-level has a median (interquartile range) of $13,781 ($12,907, $14,786). The mean ± SD risk-standardized hospital payment is $13,922 ± $1,432, ranging from $9,630 to $20,646 across 3,714 hospitals.

While we include all hospitals when estimating the risk-adjustment model, we exclude hospitals with fewer than 25 total cases from the summary statistics below, since estimates for hospitals with fewer cases are less reliable, and CMS's past approach to public reporting has been not to report these results. The volume of HF hospitalizations among the included hospitals ranges from 25 to 1,877 index HF admissions, with a mean of 184 index admissions and a median of 120 index admissions.

Table 12.Distribution of Unadjusted and Risk-Standardized Payments for Hospitals with a Minimum of 25 HF Index Admissions (2008-2009 combined)

Summary Statistic	HF Episode-of-Care Payment (Unadjusted Mean)	HF Episode-of-Care Payment (Risk-Standardized)
N	3,714	3,714
Mean	$13,081	$13,922
SD	$2,025	$1,432
Min	$6,865	$9,630
10th Percentile	$10,619	$12,202
25th Percentile	$11,717	$12,907
Median	$13,016	$13,781
75th Percentile	$14,331	$14,786
90th Percentile	$15,589	$15,788
Max	$26,696	$20,646

Figure 6.Distribution of HF Episode-of-Care Unadjusted Payments for Hospitals with a Minimum of 25 HF Index Admissions (2008-2009 combined)

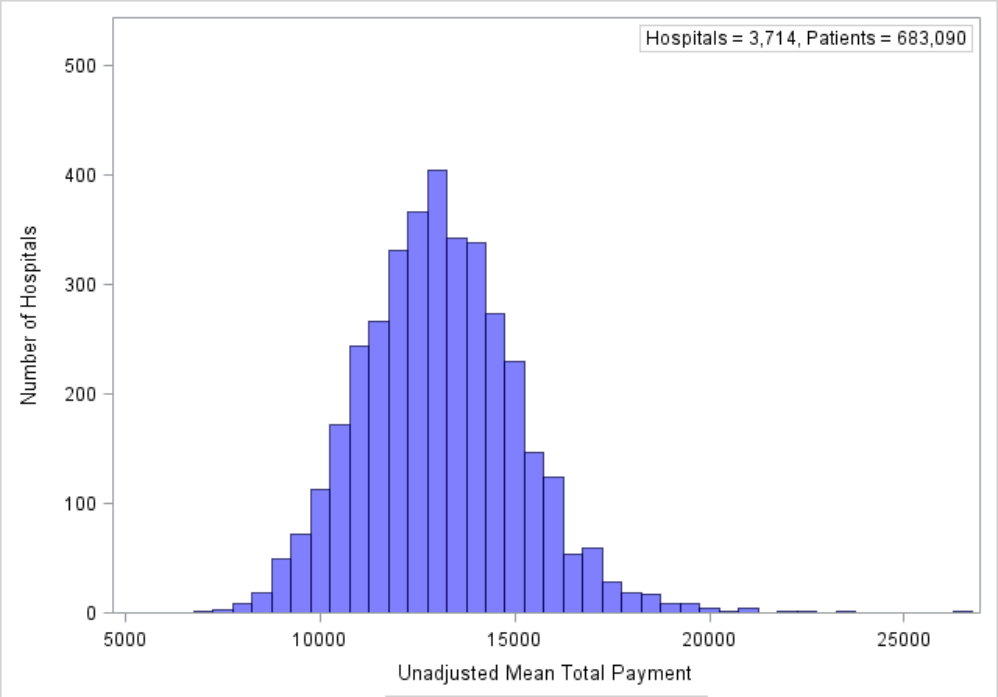
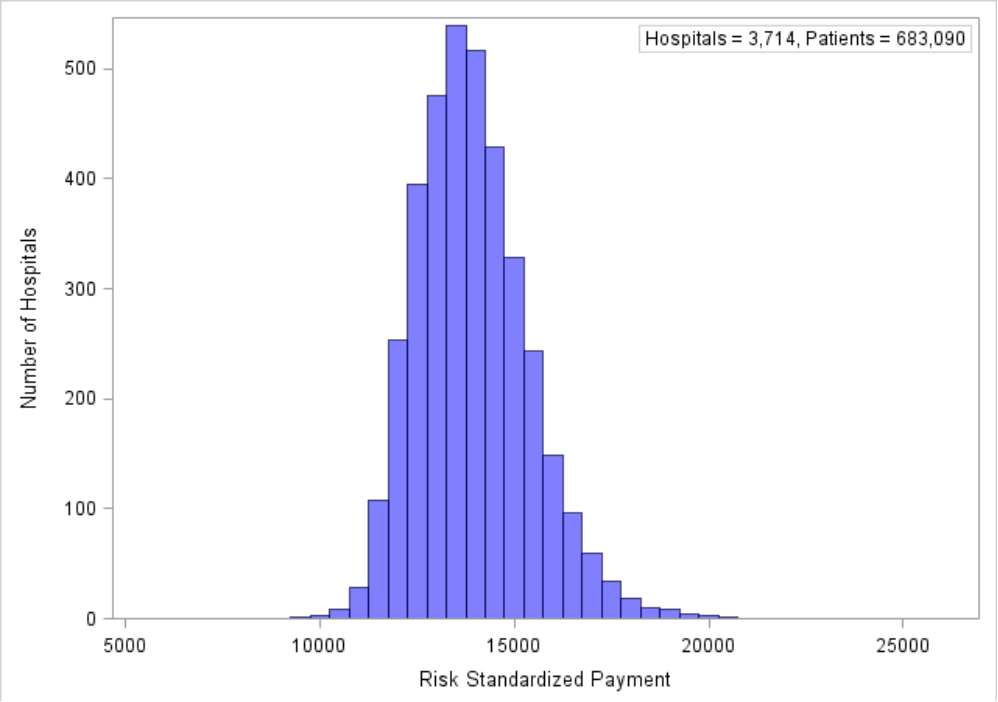


Figure 7.Distribution of HF Episode-of-Care RSPs for Hospitals with a Minimum of 25 HF Index Admissions (2008-2009 combined)



3.3. Measure Testing

3.3.1. Reliability Testing

We calculated the Intraclass Correlation Coefficient (ICC) in order to assess the reliability of the measure. The ICC score can be used to determine the extent to which assessments of a hospital using different but randomly selected subsets of patients produces similar measures of hospital performance. We calculated the RSP using a split-sample of the combined 2008-2009 data. Thus, we obtained two RSPs for each hospital, using an entirely distinct set of patients from the same time period. To the extent that the calculated measures of these two subsets agree, we have evidence that the measure assesses an attribute of the hospital, not of the patients. As a metric of agreement we calculated the ICC (2,1) as defined by Shrout and Fleiss.[16]

The agreement between the two independent assessments of each hospital was 0.752, which according to the conventional interpretation, is "substantial."[17]

3.3.1.1. Data Element Reliability

In constructing the HF payment measure we, aimed to utilize only those data elements from the claims that have both face validity and reliability. We avoided the use of fields that are coded inconsistently across hospitals or providers. Additionally, CMS has several hospital auditing programs in place to assess overall claims code accuracy, to ensure appropriate billing, and to recoup overpayment. CMS routinely conducts data analyses to identify potential problem areas and detect fraud, and audits important data fields used in our measures, including diagnosis and procedure codes, and other elements that are consequential to payment.[18]

3.3.2. Validity Testing

3.3.2.1. Validity of Claims-Based Measures

Our team has demonstrated the validity of claims-based measures for profiling hospitals for a number of prior measures by comparing either the measure results or the individual data elements against medical records. CMS validated the six NQF-endorsed claims-based measures currently in public reporting (mortality and readmission measures for AMI, heart failure, and pneumonia) with models that used medical record-abstracted data for risk adjustment. Specifically, claims model validation was conducted by building comparable models using abstracted medical record data for risk adjustment for heart failure patients (National Heart Failure data), AMI patients (Cooperative Cardiovascular Project data), and pneumonia patients (National Pneumonia Project dataset). When both models were applied to the same patient population, the hospital risk-standardized mortality and readmission rates estimated using the claims-based risk-adjustment models had a high level of agreement with the results based on the medical record model, thus supporting the use of the claims-based models for public reporting.

3.3.2.2. Validity of Development Process

We are developing this measure in consultation with national guidelines for publicly reported outcomes measures, outside experts, and the public. The measure is consistent with the technical approach to outcomes measurement set forth in National Quality Forum (NQF) guidance for outcomes measures,[19] CMS Measure Management System guidance, and the guidance articulated in the American Heart Association scientific statement "Standards for Statistical Models Used for Public Reporting of Health Outcomes.[20]

In order to examine the face validity of our methods for estimating payments for a HF episode of care, we compared our approach with two other measures that estimate payments for episodes of care. Specifically, we compared our methods with the:

- **American Board of Medical Specialties (ABMS) Acute Myocardial Infarction Episode of Care**, which estimates the cost of an episode of care for AMI at the hospital-level from the date of admission through 30 days post-admission for patients 18 years and older. They use claims data from all payers, including Medicare and private insurance. They standardize prices across three components of care: inpatient facility, ambulatory pharmacy, and "all other" (for example, evaluation and management, procedures, imaging, tests, and DME). Costs at the inpatient facility level are calculated based on DRG-level information and length of stay. Total inpatient costs are divided by inpatient days to arrive at a per diem multiplier. This per diem multiplier is used to calculate the inpatient facility cost for each unique episode of care. A similar strategy is applied to ambulatory pharmacy and "all other" costs. Risk adjustment includes comorbid conditions identified in the 12 months preceding the index AMI admission using both inpatient and outpatient claims. The hospital is the unit of reporting.
- **CMS Medicare Spending per Beneficiary (MSPB) measure**, which estimates the cost of an episode of care for all inpatient diagnoses at the hospital-level from three days prior to admission through 30 days post-discharge for Medicare FFS beneficiaries 18 years and older. Their cost outcome includes patient copayments and excludes geographic and policy adjustments. Risk adjustment includes age, hierarchical condition categories, enrollment status, long-term care variables, variable interaction terms, and MS-DRGs present 90 days prior to index admission. The hospital is the unit of reporting.

Although our measure is being developed independently of those above, we share several key decisions:

1. *Include episode of care*: Like ours, both measures begin with a hospitalization and end 30 days after admission (ours, ABMS) or discharge (MSPB). Conceptually, this strategy groups together those medical transactions that are temporally related to a hospitalization. In this way, the care provided during hospitalization, as well as the transition of care to post-discharge settings is attributed to the provider or hospital of the index admission.

2. *Isolate resource utilization:* Like ours, both measures attempt to isolate payment differentials due to resource utilization by removing payment adjustments that do not reflect the clinical care delivered, such as geographic factors and policy adjustments (ours, MSPB), or standardizing payment amounts for isolated services, labs, or supplies (ABMS).
3. *Perform risk adjustment*: Like ours, both measures employ a thorough and transparent approach to risk adjustment, although the specific risk-adjustment strategies differ technically.

In addition, we surveyed the TEP and asked each member to assess the face validity of our measure by rating the following statement using a six-point scale (1=Strongly Disagree, 2=Moderately Disagree, 3=Somewhat Disagree, 4=Somewhat Agree, 5=Moderately Agree, and 6=Strongly Agree):

> "This is a measure of payments for Medicare patients for a 30-day HF episode of care. The measure removes policy adjustments that are independent of care decisions and risk-adjusts based on case mix. The measure is intended to provide CMS a tool to compare payments across hospitals nationally to identify hospitals that have notably higher or lower payments associated with HF care. To what extent does the committee agree that this measure accomplishes this purpose?"

Among the eight TEP members who provided a response, one responded "Somewhat Agree," three responded "Moderately Agree," and four reported "Strongly Agree".

4. MAIN FINDINGS / SUMMARY

We present a hierarchical generalized linear regression model for assessing hospital-level, risk-standardized payments for a 30-day episode of care associated with an index admission for HF. Our approach to model development and risk adjustment is consistent with quality measure methods recommendations for publicly reported outcomes measures from NQF, CMS, and the American Heart Association scientific statement.[5-8] This proposed measure is based on administrative claims data for FFS Medicare beneficiaries 65 years and older, and is being developed with extensive input from clinical and methodological experts with knowledge and experience relevant to quality measurement.

The study sample is appropriately defined, consisting of patients having an inpatient stay with a primary discharge diagnosis of HF. The outcome is measured using stripped or standardized payments for Medicare patients starting with the index admission and continuing 30 days post-admission across all care settings, services, and supplies (except Part D). The risk-adjustment process accounts for patient age and comorbid conditions identified from: secondary diagnoses of the index hospital stay (excluding potential complications), inpatient data, outpatient hospital data, and carrier files for physician, radiology, and laboratory services during the 12 months prior to the index admission. The hierarchical generalized linear model accounts for hospital case mix and the clustering of patients within hospitals, thereby making the measure suitable for public reporting.

We find substantial variation in risk-standardized payments for a HF episode of care across hospitals. Implementation of this measure in conjunction with CMS's 30-day HF RSMR has the potential to improve the efficiency of care for patients with HF. Although the payment methodology is developed in a HF cohort, it can easily be applied to other disease conditions or episodes of care such as pneumonia and hip surgery.

5. REFERENCES

1. Boards of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds, *2013 Annual Report,* May 31, 2013.
2. Bundled Payments for Care Improvement (BPCI) Initiative: General Information 2013; http://innovation.cms.gov/initiatives/bundled-payments/. Accessed 8/2/2013, 2013.
3. Russo CA, Elixhauser, A. Hospitalizations in the Elderly Population, 2003. Agency for Healthcare Research and Quality. 2006.
4. Heidenriech PA, Trogdon JG, Khavjou OA, Butler J, Dracup K, Ezekowitz MD, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. *Circulation*. 2011;123(8):933–44.
5. National Voluntary Consensus Standards for Patient Outcomes: Phases I and II. http://www.qualityforum.org/projects/Patient_Outcome_Measures_Phases1-2.aspx.
6. Measures Management System Overview. 2012. http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/index.html?redirect=/MMS/19_MeasuresManagement SystemBlueprint.asp. Accessed 09/27/2012.
7. Krumholz HM, Brindis RG, Brush JE, et al. Standards for statistical models used for public reporting of health outcomes: an American Heart Association Scientific Statement from the Quality of Care and Outcomes Research Interdisciplinary Writing Group: cosponsored by the Council on Epidemiology and Prevention and the Stroke Council. Endorsed by the American College of Cardiology Foundation. *Circulation.* Jan 24 2006;113(3):456-462
8. Krumholz HM, Keenan PS, Brush JE, Jr., et al. Standards for measures used for public reporting of efficiency in health care: a scientific statement from the American Heart Association Interdisciplinary Council on Quality of Care and Outcomes Research and the American College of Cardiology Foundation. *Circulation.* Oct 28 2008;118(18):1885-1893.
9. Medpac. Medicare Background. 2011; http://www.medpac.gov/payment_basics.cfm. Accessed 09/27/2012.
10. Pope G, Ellis R, Ash A, et al. Principal Inpatient Diagnostic Cost Group Models for Medicare Risk Adjustment. *Health Care Financing Review.* 2000;21(3):26.
11. Measure Evaluation Criteria. 2011; http://www.qualityforum.org/docs/measure_evaluation_criteria.aspx. Accessed 09/26/2012.
12. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? *Journal of health economics.* Jul 2001;20(4):461-494.
13. Gatsonia C. Hierarchical Generalized Linear Models in the Analysis of Variations in Health Care Utilization. *Journal of the American Statistical Association.* 1999;94(445):29-42.
14. Normand S-L, Wang Y, Krumholz H. Assessing surrogacy of data sources for institutional comparisons. *Health Services and Outcomes Research Methodology.* 2007;7(1):79-96.
15. Ash AS, Byrne-Logan S. How Well Do Models Work? Predicting Health Care Costs. *Proceedings of the Section on Statistics in Epidemiology. American Statistical Association.* 1998.
16. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psychological bulletin.* 1979;86(2):420.
17. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *biometrics.* 1977:159-174.
18. *Recovery Auditing in the Medicare and Medicaid Programs for Fiscal Year 2011.* Centers for Medicare and Medicaid Services;2011.

19. National Quality Forum. National voluntary consensus standards for patient outcomes, first report for phases 1 and 2: A consensus report http://www.nysna.org/images/pdfs/practice/nqf_ana_outcomes_draft10.pdf. Accessed August 19, 2010.
20. Krumholz HM, Brindis RG, Brush JE, et al. Standards for statistical models used for public reporting of health outcomes - An American Heart Association scientific statement from the quality of care and outcomes research interdisciplinary writing group - Cosponsored by the Council on Epidemiology and Prevention and the Stroke Council - Endorsed by the American College of Cardiology Foundation. *Circulation.* Jan 24 2006;113(3):456-462.

6. APPENDICES

Appendix A. Potential Complications in the Index Admission for HF Payment Model

CC #	Description	Potential Complication in Index Admission
CC 1	HIV/AIDS	No
CC 2	Septicemia/Shock	Yes
CC 3	Central Nervous System Infection	No
CC 4	Tuberculosis	No
CC 5	Opportunistic Infections	No
CC 6	Other Infectious Diseases	Yes
CC 7	Metastatic Cancer and Acute Leukemia	No
CC 8	Lung, Upper Digestive Tract, and Other Severe Cancers	No
CC 9	Lymphatic, Head and Neck, Brain, and Other Major Cancers	No
CC 10	Breast, Prostate, Colorectal and Other Cancers and Tumors	No
CC 11	Other Respiratory and Heart Neoplasms	No
CC 12	Other Digestive and Urinary Neoplasms	No
CC 13	Other Neoplasms	No
CC 14	Benign Neoplasms of Skin, Breast, Eye	No
CC 15	Diabetes with Renal Manifestation	No
CC 16	Diabetes with Neurologic or Peripheral Circulatory Manifestation	No
CC 17	Diabetes with Acute Complications	Yes
CC 18	Diabetes with Ophthalmologic Manifestation	No
CC 19	Diabetes with No or Unspecified Complications	No
CC 20	Type I Diabetes Mellitus	No
CC 21	Protein-Calorie Malnutrition	No
CC 22	Other Significant Endocrine and Metabolic Disorders	No
CC 23	Disorders of Fluid/Electrolyte/Acid-Base	Yes
CC 24	Other Endocrine/Metabolic/Nutritional Disorders	No
CC 25	End-Stage Liver Disease	No
CC 26	Cirrhosis of Liver	No
CC 27	Chronic Hepatitis	No
CC 28	Acute Liver Failure/Disease	Yes
CC 29	Other Hepatitis and Liver Disease	No
CC 30	Gallbladder and Biliary Tract Disorders	No
CC 31	Intestinal Obstruction/Perforation	Yes
CC 32	Pancreatic Disease	No
CC 33	Inflammatory Bowel Disease	No
CC 34	Peptic Ulcer, Hemorrhage, Other Specified Gastrointestinal Disorders	Yes
CC 35	Appendicitis	No
CC 36	Other Gastrointestinal Disorders	No
CC 37	Bone/Joint/Muscle Infections/Necrosis	No
CC 38	Rheumatoid Arthritis and Inflammatory Connective Tissue Disease	No
CC 39	Disorders of the Vertebrae and Spinal Discs	No
CC 40	Osteoarthritis of Hip or Knee	No
CC 41	Osteoporosis and Other Bone/Cartilage Disorders	No

CC #	Description	Potential Complication in Index Admission
CC 42	Congenital/Developmental Skeletal and Connective Tissue Disorders	No
CC 43	Other Musculoskeletal and Connective Tissue Disorders	No
CC 44	Severe Hematological Disorders	No
CC 45	Disorders of Immunity	No
CC 46	Coagulation Defects and Other Specified Hematological Disorders	Yes
CC 47	Iron Deficiency and Other/Unspecified Anemias and Blood Disease	No
CC 48	Delirium and Encephalopathy	Yes
CC 49	Dementia	No
CC 50	Senility, Nonpsychotic Organic Brain Syndromes/Conditions	No
CC 51	Drug/Alcohol Psychosis	No
CC 52	Drug/Alcohol Dependence	No
CC 53	Drug/Alcohol Abuse, Without Dependence	No
CC 54	Schizophrenia	No
CC 55	Major Depressive, Bipolar, and Paranoid Disorders	No
CC 56	Reactive and Unspecified Psychosis	No
CC 57	Personality Disorders	No
CC 58	Depression	No
CC 59	Anxiety Disorders	No
CC 60	Other Psychiatric Disorders	No
CC 61	Profound Mental Retardation/Developmental Disability	No
CC 62	Severe Mental Retardation/Developmental Disability	No
CC 63	Moderate Mental Retardation/Developmental Disability	No
CC 64	Mild/Unspecified Mental Retardation/Developmental Disability	No
CC 65	Other Developmental Disability	No
CC 66	Attention Deficit Disorder	No
CC 67	Quadriplegia, Other Extensive Paralysis	No
CC 68	Paraplegia	No
CC 69	Spinal Cord Disorders/Injuries	No
CC 70	Muscular Dystrophy	No
CC 71	Polyneuropathy	No
CC 72	Multiple Sclerosis	No
CC 73	Parkinson's and Huntington's Diseases	No
CC 74	Seizure Disorders and Convulsions	No
CC 75	Coma, Brain Compression/Anoxic Damage	Yes
CC 76	Mononeuropathy, Other Neurological Conditions/Injuries	No
CC 77	Respirator Dependence/Tracheostomy Status	Yes
CC 78	Respiratory Arrest	Yes
CC 79	Cardio-Respiratory Failure and Shock	Yes
CC 80	Congestive Heart Failure	Yes
CC 81	Acute Myocardial Infarction	Yes
CC 82	Unstable Angina and Other Acute Ischemic Heart Disease	Yes
CC 83	Angina Pectoris/Old Myocardial Infarction	No
CC 84	Coronary Atherosclerosis/Other Chronic Ischemic Heart Disease	No
CC 85	Heart Infection/Inflammation, Except Rheumatic	No
CC 86	Valvular and Rheumatic Heart Disease	No
CC 87	Major Congenital Cardiac/Circulatory Defect	No

CC #	Description	Potential Complication in Index Admission
CC 88	Other Congenital Heart/Circulatory Disease	No
CC 89	Hypertensive Heart and Renal Disease or Encephalopathy	No
CC 90	Hypertensive Heart Disease	No
CC 91	Hypertension	No
CC 92	Specified Heart Arrhythmias	Yes
CC 93	Other Heart Rhythm and Conduction Disorders	Yes
CC 94	Other and Unspecified Heart Disease	Yes
CC 95	Cerebral Hemorrhage	Yes
CC 96	Ischemic or Unspecified Stroke	Yes
CC 97	Precerebral Arterial Occlusion and Transient Cerebral Ischemia	Yes
CC 98	Cerebral Atherosclerosis and Aneurysm	No
CC 99	Cerebrovascular Disease, Unspecified	No
CC 100	Hemiplegia/Hemiparesis	Yes
CC 101	Diplegia (Upper), Monoplegia, and Other Paralytic Syndromes	Yes
CC 102	Speech, Language, Cognitive, Perceptual	Yes
CC 103	Cerebrovascular Disease Late Effects, Unspecified	No
CC 104	Vascular Disease with Complications	Yes
CC 105	Vascular Disease	Yes
CC 106	Other Circulatory Disease	Yes
CC 107	Cystic Fibrosis	No
CC 108	Chronic Obstructive Pulmonary Disease	No
CC 109	Fibrosis of Lung and Other Chronic Lung Disorders	No
CC 110	Asthma	No
CC 111	Aspiration and Specified Bacterial Pneumonias	Yes
CC 112	Pneumococcal Pneumonia, Emphysema, Lung Abscess	Yes
CC 113	Viral and Unspecified Pneumonia, Pleurisy	No
CC 114	Pleural Effusion/Pneumothorax	Yes
CC 115	Other Lung Disorders	No
CC 116	Legally Blind	No
CC 117	Major Eye Infections/Inflammations	No
CC 118	Retinal Detachment	No
CC 119	Proliferative Diabetic Retinopathy and Vitreous Hemorrhage	No
CC 120	Diabetic and Other Vascular Retinopathies	No
CC 121	Retinal Disorders, Except Detachment and Vascular Retinopathies	No
CC 122	Glaucoma	No
CC 123	Cataract	No
CC 124	Other Eye Disorders	No
CC 125	Significant Ear, Nose, and Throat Disorders	No
CC 126	Hearing Loss	No
CC 127	Other Ear, Nose, Throat, and Mouth Disorders	No
CC 128	Kidney Transplant Status	No
CC 129	End Stage Renal Disease	Yes
CC 130	Dialysis Status	Yes
CC 131	Renal Failure	Yes
CC 132	Nephritis	Yes
CC 133	Urinary Obstruction and Retention	Yes

CC #	Description	Potential Complication in Index Admission
CC 134	Incontinence	No
CC 135	Urinary Tract Infection	Yes
CC 136	Other Urinary Tract Disorders	No
CC 137	Female Infertility	No
CC 138	Pelvic Inflammatory Disease and Other Specified Female Genital Disorders	No
CC 139	Other Female Genital Disorders	No
CC 140	Male Genital Disorders	No
CC 141	Ectopic Pregnancy	No
CC 142	Miscarriage/Abortion	No
CC 143	Completed Pregnancy With Major Complications	No
CC 144	Completed Pregnancy With Complications	No
CC 145	Completed Pregnancy Without Complication	No
CC 146	Uncompleted Pregnancy With Complications	No
CC 147	Uncompleted Pregnancy With No or Minor Complications	No
CC 148	Decubitus Ulcer of Skin	Yes
CC 149	Chronic Ulcer of Skin, Except Decubitus	No
CC 150	Extensive Third-Degree Burns	No
CC 151	Other Third-Degree and Extensive Burns	No
CC 152	Cellulitis, Local Skin Infection	Yes
CC 153	Other Dermatological Disorders	No
CC 154	Severe Head Injury	Yes
CC 155	Major Head Injury	Yes
CC 156	Concussion or Unspecified Head Injury	Yes
CC 157	Vertebral Fractures	No
CC 158	Hip Fracture/Dislocation	Yes
CC 159	Major Fracture, Except of Skull, Vertebrae, or Hip	Yes
CC 160	Internal Injuries	No
CC 161	Traumatic Amputation	No
CC 162	Other Injuries	No
CC 163	Poisonings and Allergic Reactions	Yes
CC 164	Major Complications of Medical Care and Trauma	No
CC 165	Other Complications of Medical Care	Yes
CC 166	Major Symptoms, Abnormalities	No
CC 167	Minor Symptoms, Signs, Findings	No
CC 168	Extremely Low Birth weight Neonates	No
CC 169	Very Low Birth weight Neonates	No
CC 170	Serious Perinatal Problem Affecting Newborn	No
CC 171	Other Perinatal Problems Affecting Newborn	No
CC 172	Normal, Single Birth	No
CC 173	Major Organ Transplant	No
CC 174	Major Organ Transplant Status	Yes
CC 175	Other Organ Transplant/Replacement	Yes
CC 176	Artificial Openings for Feeding or Elimination	Yes
CC 177	Amputation Status, Lower Limb/Amputation	Yes
CC 178	Amputation Status, Upper Limb	Yes
CC 179	Post-Surgical States/Aftercare/Elective	Yes

CC #	Description	Potential Complication in Index Admission
CC 180	Radiation Therapy	No
CC 181	Chemotherapy	No
CC 182	Rehabilitation	No
CC 183	Screening/Observation/Special Exams	No
CC 184	History of Disease	No
CC 185	Oxygen	No
CC 186	CPAP/IPPB/Nebulizers	No
CC 187	Patient Lifts, Power Operated Vehicles, Beds	No
CC 188	Wheelchairs, Commodes	No
CC 189	Walkers	No

Appendix B. ICD-9-CM Codes Included in Final Cohort

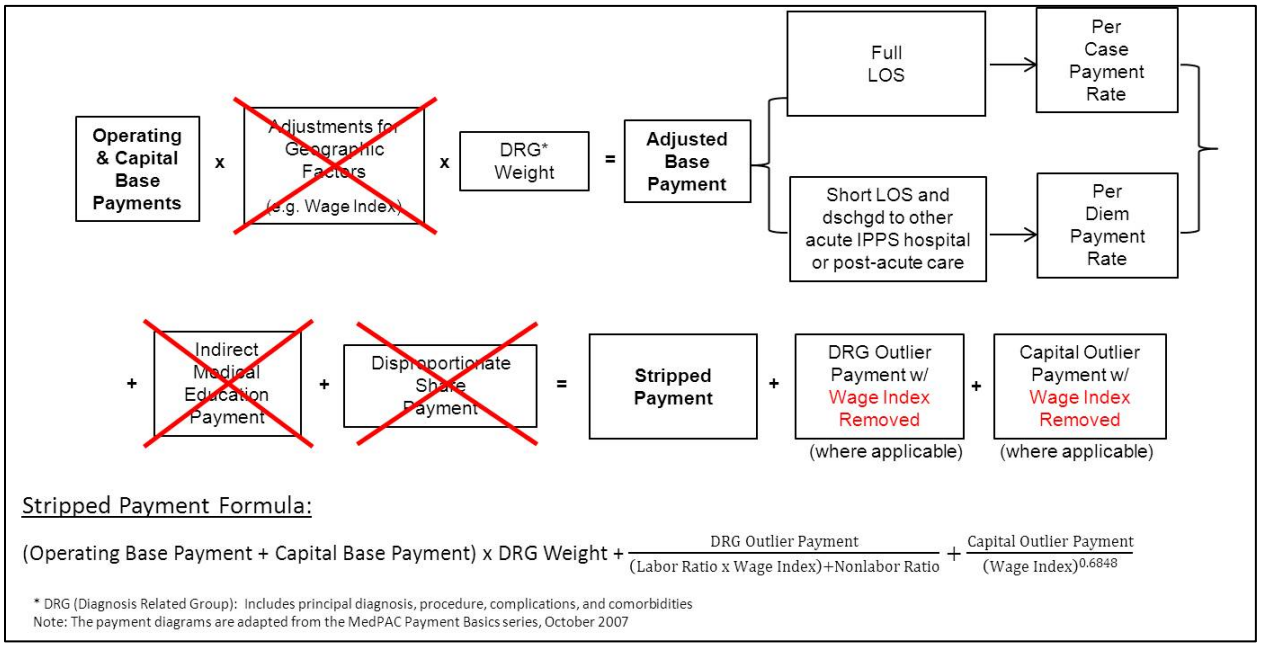
ICD-9-CM	Description
402.01	Malignant hypertensive heart disease with congestive heart failure (CHF)
402.11	Benign hypertensive heart disease with CHF
402.91	Hypertensive heart disease with CHF
404.01	Malignant hypertensive heart and renal disease with CHF
404.03	Malignant hypertensive heart and renal disease with CHF & renal failure (RF)
404.11	Benign hypertensive heart and renal disease with CHF
404.13	Benign hypertensive heart and renal disease with CHF & RF
404.91	Unspecified hypertensive heart and renal disease with CHF
404.93	Hypertension and non-specified heart and renal disease with CHF & RF
428.0	Congestive heart failure, unspecified
428.1	Left heart failure
428.20	Systolic heart failure, unspecified
428.21	Systolic heart failure, acute
428.22	Systolic heart failure, chronic
428.23	Systolic heart failure, acute or chronic
428.30	Diastolic heart failure, unspecified
428.31	Diastolic heart failure, acute
428.32	Diastolic heart failure, chronic
428.33	Diastolic heart failure, acute or chronic
428.40	Combined systolic and diastolic heart failure, unspecified
428.41	Combined systolic and diastolic heart failure, acute
428.42	Combined systolic and diastolic heart failure, chronic
428.43	Combined systolic and diastolic heart failure, acute or chronic
428.9	Heart failure, unspecified

Appendix C. Example of Included and Excluded Payments When Counting the 30-Day Episode of Care for a Patient with an Index Admission on May 3 and Discharged on May 8

Claim Type	Provider ID	Claim Date	Admission Type	Primary ICD-9	Payment	Included in Model?	Payment Included in Model	Comments
Carrier	123456	30Apr-30Apr	N/A	402.01	$255.61	N	$0.00	Started prior to the index admission.
Inpatient	234567	3May-4May	Admission	402.01	$1,109.49	Y	$1,109.49	This inpatient HF (402.01) admission defines the index admission date (5/3).
Inpatient	345678	4 May-8 May	Transfer	402.01	$8,008.15	Y	$8,008.15	This inpatient HF (402.01) discharge defines the discharge date (5/8).
Physician	567891	3 May-3 May	N/A	785.0	$367.20	Y	$367.20	Physician payments during the index stay
Physician	678910	3 May-3 May	N/A	428.0	$6.59	Y	$6.59	Physician payments during the index stay
Physician	789101	3 May-8 May	N/A	410.71	$350.52	Y	$350.52	Physician payments during the index stay
Physician	456789	5 May-5 May	N/A	414.01	$225.75	Y	$225.75	Physician payments during the index stay
Physician	345678	7 May-7 May	N/A	296.30	$148.39	Y	$148.39	Physician payments during the index stay
Inpatient	910112	30May-3Jun	Readmission	402.01	$4,262.13	Y (pro-rated)	$3,409.70	Payment is pro-rated, based only on the days which fall into the 30-day post-admission period. The amount included in the payment model would be: ($4262.13/5)*4 = $3409.70. Note that this second HF (402.01) admission does not count as another index admission - it counts as a readmission.
Skilled Nursing Facility	891011	3Jun-21Jun	Transfer	428.0	$1,652.28	N	$0.00	Started after the 30-day post-admission period.
				TOTAL	**$16,386.11**		**$13,625.79**	

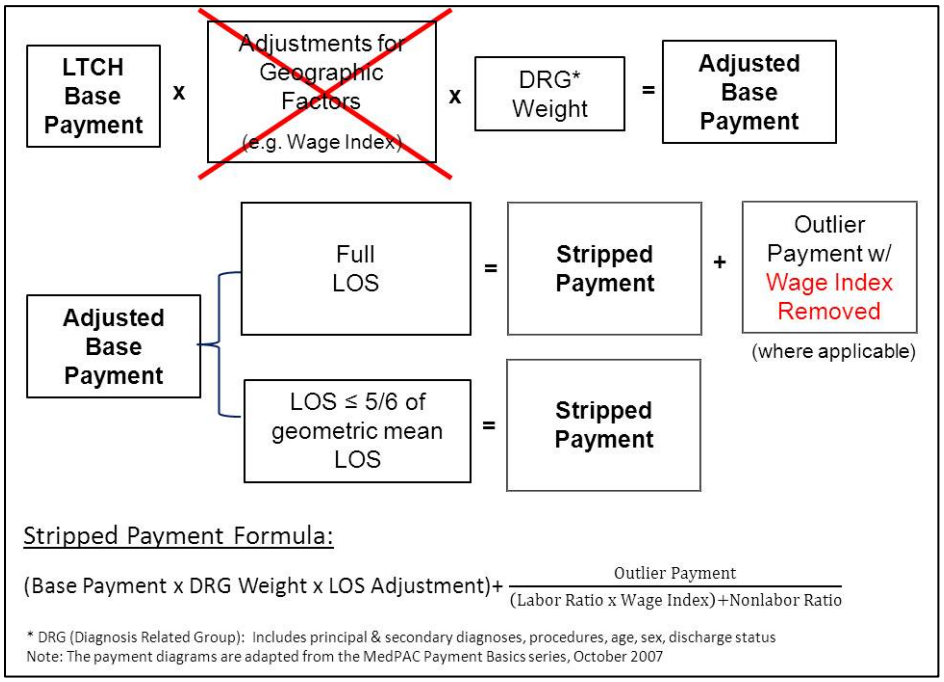
Appendix D. Stripped/Standardized Payment Diagrams

Inpatient Prospective Payment Setting: Stripped Payment

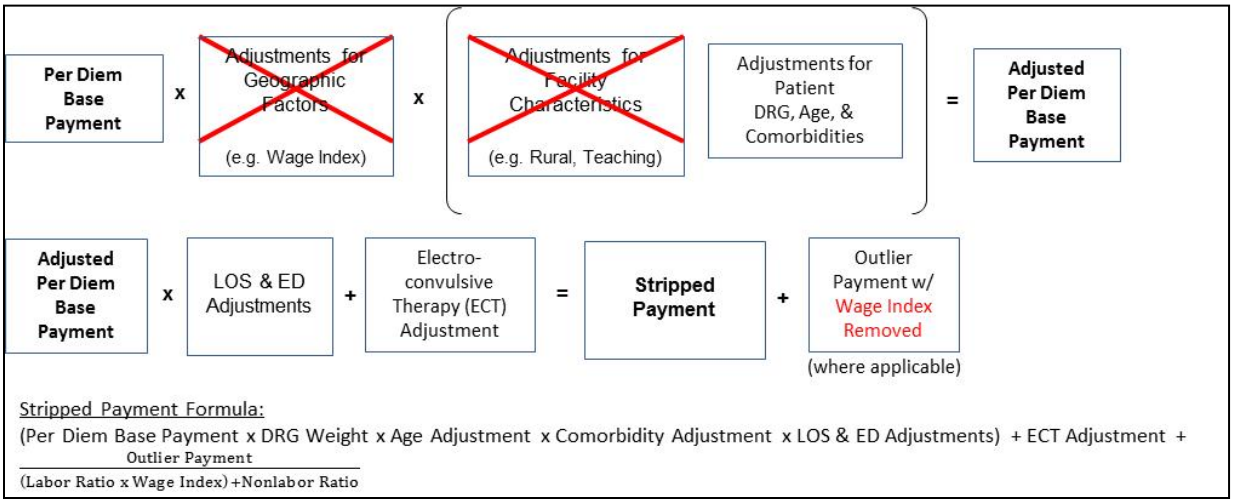


Note: Payments to critical access hospitals (CAHs) were calculated using the IPPS stripped payment formula.

Long Term Care Hospitals: Stripped Payment



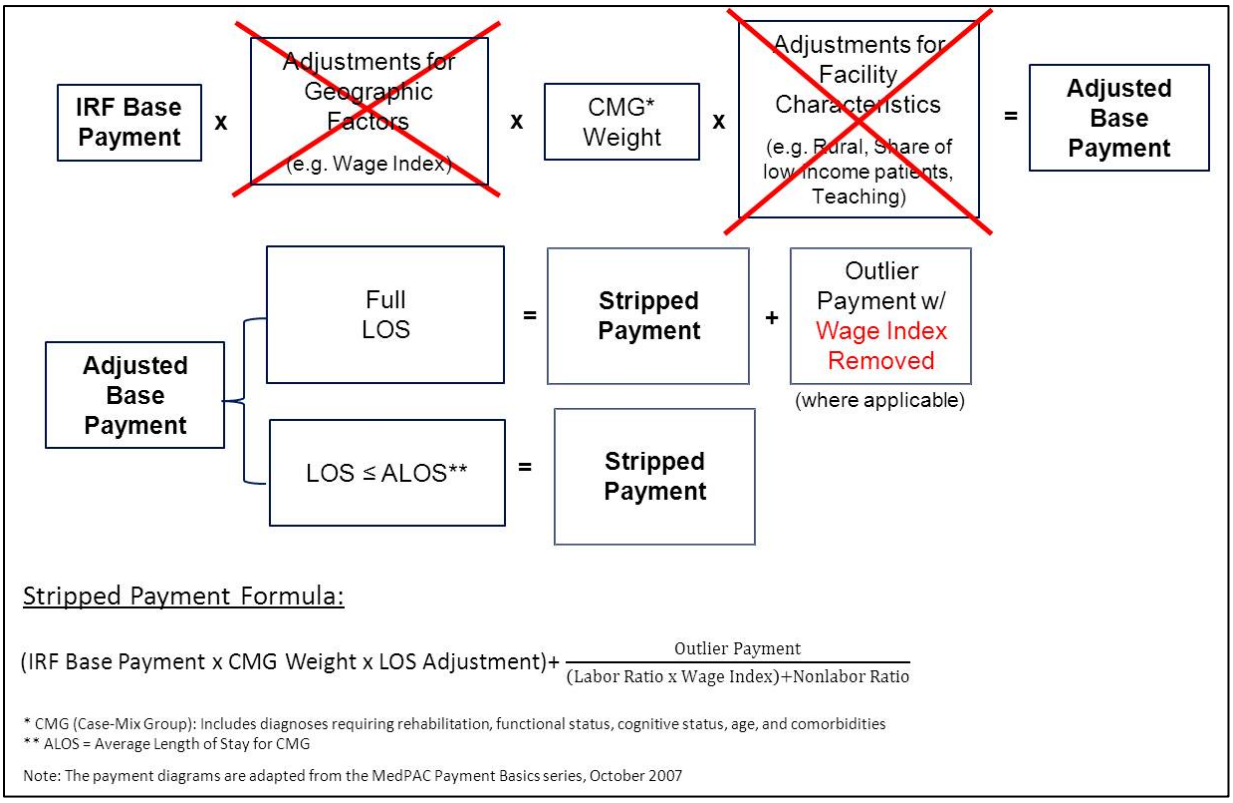
Inpatient Psychiatric Facility: Stripped Payment



Stripped Payment Formula:

$$(\text{Per Diem Base Payment} \times \text{DRG Weight} \times \text{Age Adjustment} \times \text{Comorbidity Adjustment} \times \text{LOS \& ED Adjustments}) + \text{ECT Adjustment} + \frac{\text{Outlier Payment}}{(\text{Labor Ratio} \times \text{Wage Index}) + \text{Nonlabor Ratio}}$$

Inpatient Rehabilitation Facility: Stripped Payment



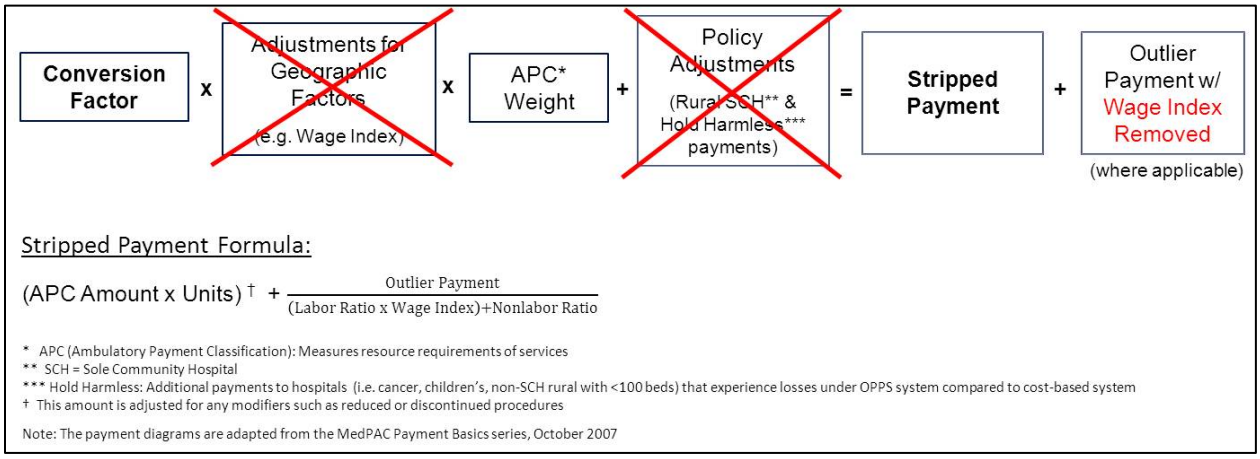
Stripped Payment Formula:

$$(\text{IRF Base Payment} \times \text{CMG Weight} \times \text{LOS Adjustment}) + \frac{\text{Outlier Payment}}{(\text{Labor Ratio} \times \text{Wage Index}) + \text{Nonlabor Ratio}}$$

* CMG (Case-Mix Group): Includes diagnoses requiring rehabilitation, functional status, cognitive status, age, and comorbidities
** ALOS = Average Length of Stay for CMG

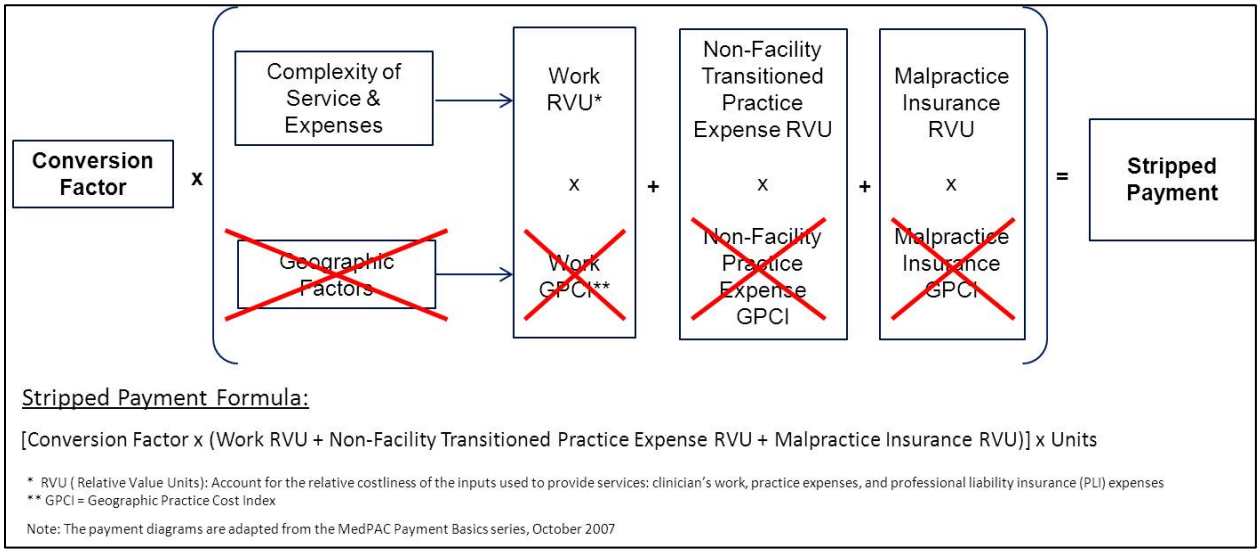
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Hospital Outpatient and Community Mental Health Centers (CMHCs): Stripped Payment

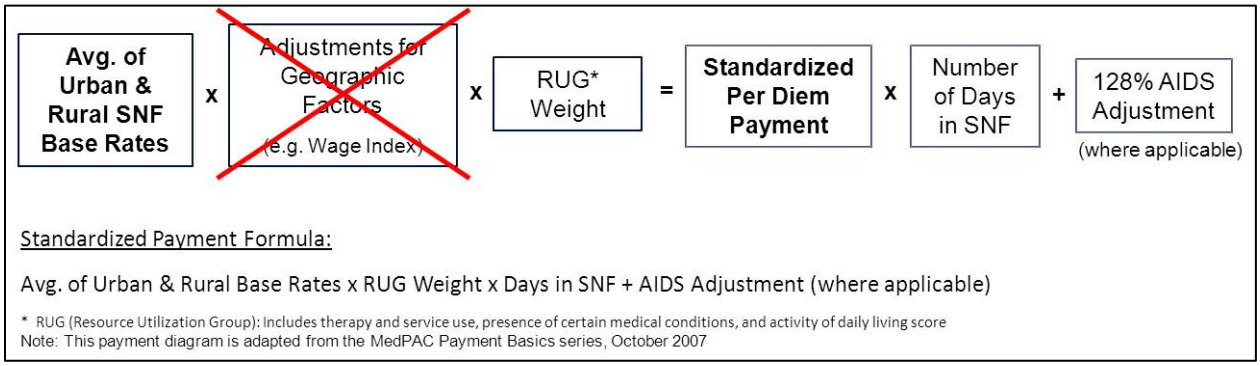


Note: Outpatient hospital claims can include services paid under the clinical lab, ambulance, physician, DME/POS/PEN, and Part B drugs fee schedules as well. Payments for those services are calculated according to the applicable payment formula.

Comprehensive Outpatient Rehabilitation Facilities (CORFs) and Outpatient Rehabilitation Facilities (ORFs): Stripped Payment



PPS SNF Claims: Standardized Payment



Standardized Payment Formula:

Avg. of Urban & Rural Base Rates x RUG Weight x Days in SNF + AIDS Adjustment (where applicable)

* RUG (Resource Utilization Group): Includes therapy and service use, presence of certain medical conditions, and activity of daily living score
Note: This payment diagram is adapted from the MedPAC Payment Basics series, October 2007

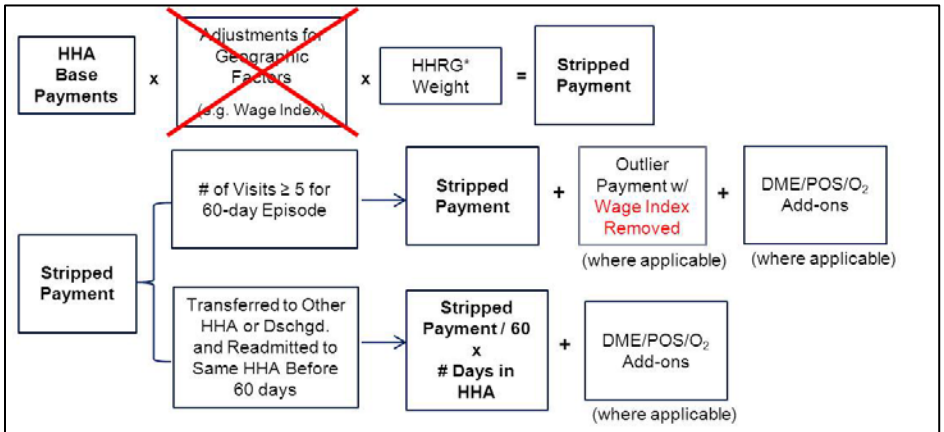
CAH Swing-Bed SNF Claims: Standardized Payment

Standardized Payment Formula†:

$$\frac{\text{Actual Payment} + \text{Co} - \text{Insurance}}{(\text{SNF Labor Ratio x Wage Index}) + (1 - \text{SNF Labor Ratio})}$$

† CAH-Swing Bed SNF Claims are not given a RUG weight
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Home Health Agency (HHA): Stripped Payment



Low Utilization Payment Adjustment (LUPA) HHA Claims:

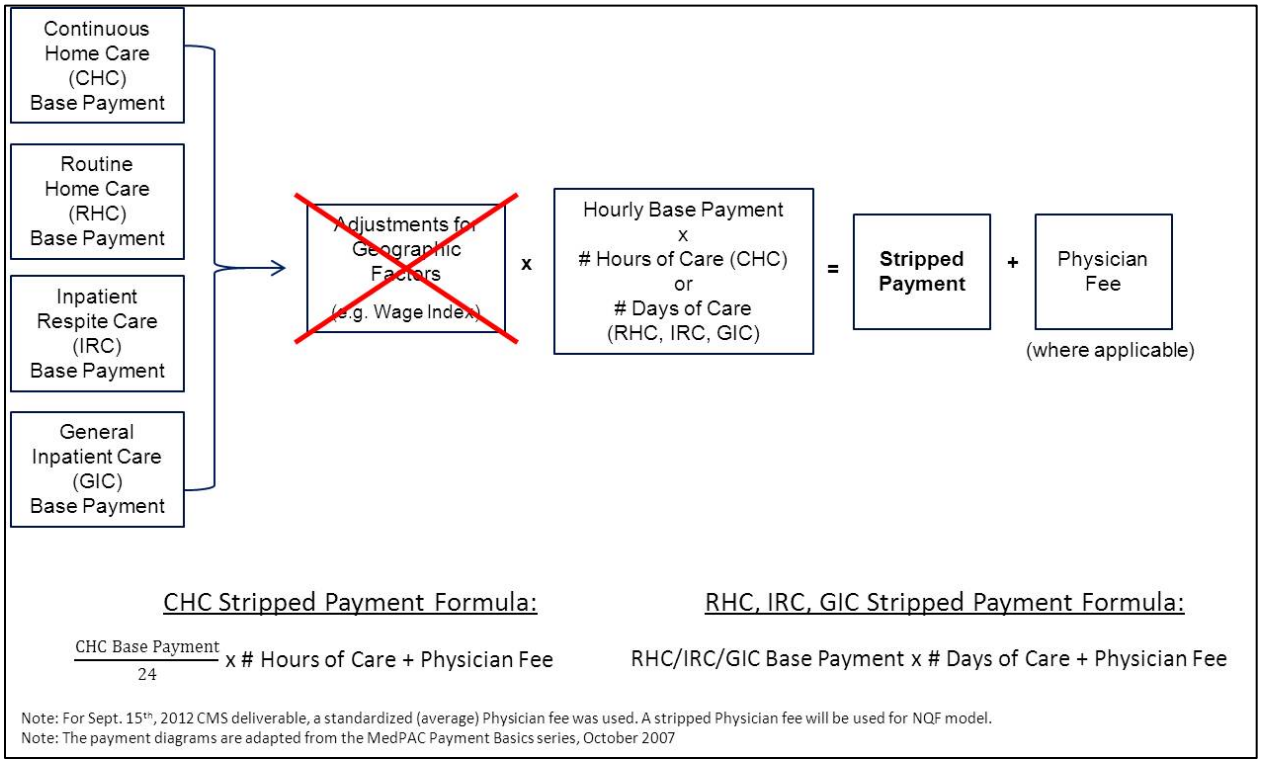
If HHA Claim has 4 or less visits in entire 60-day episode, the standardized LUPA per visit payment rate is applied. Standardized LUPA payment rate is published each year in the HHA PPS Final Rule.

Stripped Payment Formula:

$$\text{HHA Base Rate x HHRG Weight} + \frac{\text{Outlier Payment}}{(\text{Labor Ratio x Wage Index}) + \text{Nonlabor Ratio}} + \text{DME/POS/O}_2\text{ Add-ons}$$

* HHRG (Home Health Resource Group): Comprised of clinical, functional, and service utilization scores based on patient characteristics.
Note: HHA claims can include DME/Prosthetics/O_2 as well. Payment for those claim lines are calculated according to the DME/POS payment formula.
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

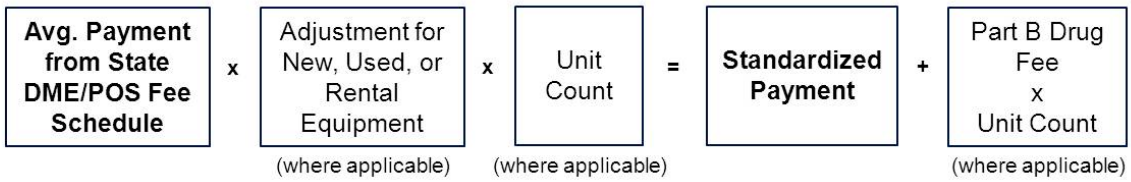
Hospice: Stripped Payment



Note: For Sept. 15th, 2012 CMS deliverable, a standardized (average) Physician fee was used. A stripped Physician fee will be used for NQF model.
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Durable Medical Equipment (DME)/Prosthetics, Orthotics, and Surgical Supplies (POS)/Parenteral and Enteral Nutrition (PEN) Claims: Standardized Payment

DME/POS Claims:



DME/POS Standardized Payment:

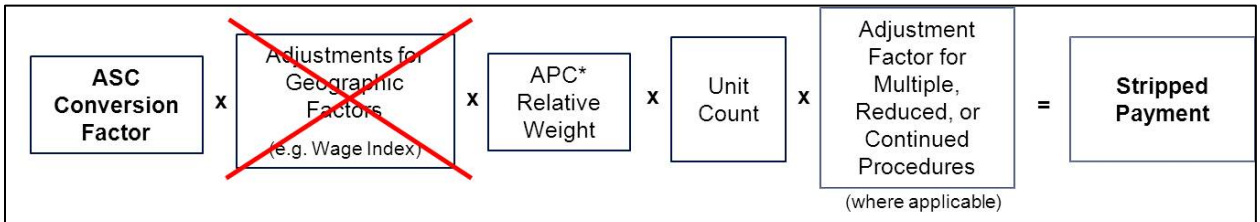
Avg. Payment from State DME/POS Fee Schedule x Adjustment for New, Used, or Rental Equipment x Unit Count + (Part B Drug Fee x Unit Count)

PEN Claims:

The PEN fee schedule is a national fee schedule (i.e. there is no variation from state to state). Thus, all PEN claims were assigned the PEN fee schedule amount.

Note: Where applicable, Part B Drugs associated with DME claims were assigned the DME infusion limit amount from the Part B Drugs fee schedule.
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Ambulatory Surgical Center (ASC): Stripped Payment



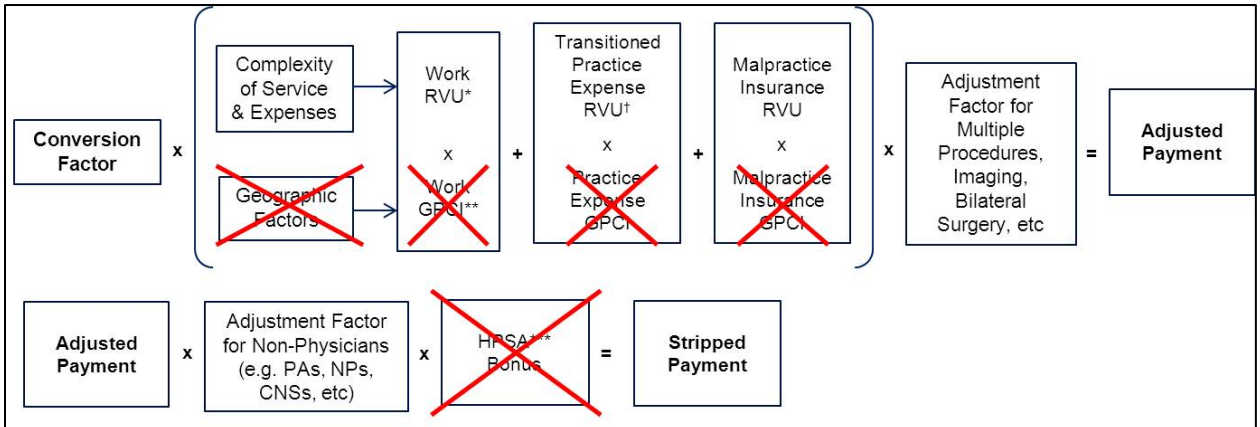
Stripped Payment Formula:

The amount equal to (ASC Conversion Factor x APC Relative Weight) is given on the ASC fee schedule.

(APC Fee Schedule Amount) x Unit Count x Adjustment Factor for Multiple, Reduced, or Continued Procedures

* APC = Ambulatory Payment Classification
Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Physician Services: Stripped Payment



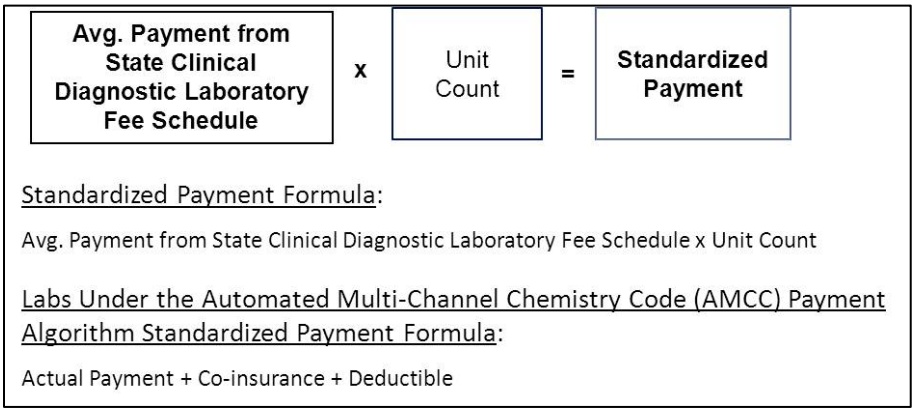
Stripped Payment Formula:

[Conversion Factor x (Work RVU + Transitioned Practice Expense RVU + Malpractice Insurance RVU)] x Adjustment Factor Related to Procedures x Adjustment Factor for Non-Physicians x Units

* RVU (Relative Value Units): Account for the relative costliness of the inputs used to provide services: clinician's work, practice expenses, and professional liability insurance (PLI) expenses
** GPCI = Geographic Practice Cost Index
*** HPSA = Health Professional Shortage Area
† The physician fee schedule lists separate PE RVUs for facility and non-facility settings.

Note: The payment diagrams are adapted from the MedPAC Payment Basics series, October 2007

Clinical Labs: Standardized Payment



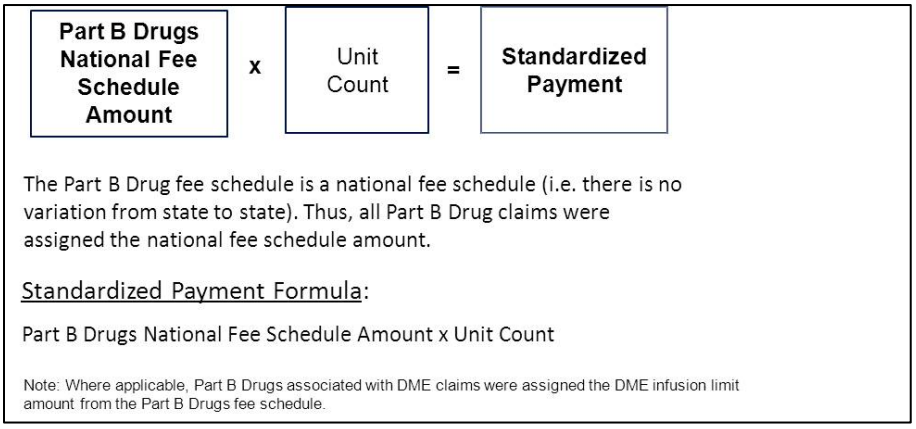
Standardized Payment Formula:

Avg. Payment from State Clinical Diagnostic Laboratory Fee Schedule x Unit Count

Labs Under the Automated Multi-Channel Chemistry Code (AMCC) Payment Algorithm Standardized Payment Formula:

Actual Payment + Co-insurance + Deductible

Part B Drugs: Standardized Payment



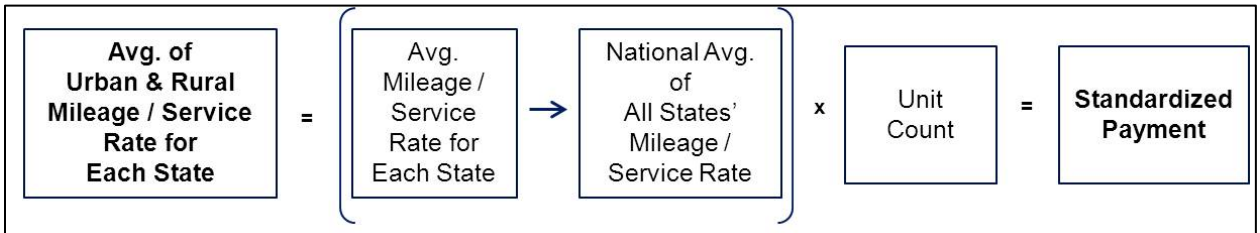
The Part B Drug fee schedule is a national fee schedule (i.e. there is no variation from state to state). Thus, all Part B Drug claims were assigned the national fee schedule amount.

Standardized Payment Formula:

Part B Drugs National Fee Schedule Amount x Unit Count

Note: Where applicable, Part B Drugs associated with DME claims were assigned the DME infusion limit amount from the Part B Drugs fee schedule.

Ambulance: Standardized Payment



Standardized Payment Formula:

Step 1:

$$\frac{\text{Urban+Rural Mileage / Service Rates}}{2} = \frac{\text{Average Mileage}}{\text{Service Rate for Each State}}$$

Step 2:

$$\frac{\sum \text{Avg.Mileage / Service Rate for Each State}}{\text{\# of States}} = \frac{\text{National Average Mileage}}{\text{Service Rate}}$$

Step 3:

$$\frac{\text{National Average Mileage}}{\text{Service Rate}} \times \text{Unit Count}$$

Rural Health Clinics (RHCs) and Federally Qualified Health Clinics (FQHCs): Standardized Payment

RHCs:

Each year Congress determines a RHC per visit payment limit. We remove the portion of the payment likely attributable to wages using the SNF state rural wage index.

Stripped Payment Formula:

$$\frac{\text{Actual Payment} + \text{Co} - \text{Insurance} + \text{Deductible}}{(\text{Outpatient Labor Ratio x Wage Index}) + (1 - \text{Outpatient Labor Ratio})}$$

FQHCs:

FQHC payments are an all-inclusive per visit amount based on reasonable costs. Given the resources necessary to determine whether the FQHC is located in a rural or urban area, we did not adjust for wages in the current data.

Standardized Payment Formula:

Actual Payment + Co-insurance

Note: A FQHC PPS is scheduled to be implemented in 2014.

Renal Dialysis Facilities (RDFs): Stripped Payment

Given that the 2008/2009 Renal Dialysis payment rates are adjusted by patient-specific body measurements which we do not have in our data, as well as capped at an amount equal to 3 dialysis sessions per week, we chose to remove the portion of the payment likely attributable to wages using the RDF wage index.

Stripped Payment Formula:

$$\frac{\text{Actual Payment} + \text{Co} - \text{Insurance} + \text{Deductible}}{(\text{Outpatient Labor Ratio x Wage Index}) + (1 - \text{Outpatient Labor Ratio})}$$

Note: A Renal Dialysis PPS was implemented in 2011.

Appendix E. Technical Expert Panel Member Roster

Name	Title	Organization	Area of Expertise
Amanda Kowalski, PhD	Assistant Professor of Economics	Yale University	Topic Knowledge
Anne-Marie Audet, MD, MSc, SM	Vice President, Health System Quality and Efficiency	Commonwealth Fund	Quality Improvement and Performance Measurement
David S. P. Hopkins, PhD	Senior Advisor	Pacific Business Group on Health	Consumer, Quality Improvement, Performance Measurement
Donald Casey, MD, MPH, MBA	Vice President and Medical Director	NYU Langone Medical Center	Quality Improvement and Performance Measurement
Kavita Patel, MD, MS	Brookings Institution, Managing Director for Clinical Transformation and Delivery	Engelberg Center for Health Care Reform	Topic Knowledge
Lesley Curtis, PhD, MS	Associate Professor in Medicine	Duke University	Topic Knowledge and Performance Measurement
Peter Bach, MD, MAPP	Director, Center for Health Policy and Outcomes	Memorial Sloan-Kettering Cancer Center	Quality Improvement, Topic Knowledge, Health Care Disparities
Peter Lindenauer, MD, MSc	Associate Professor of Medicine; Medical Director, Clinical and Quality Informatics; Director	Tufts University; Baystate Medical Center; Center for Quality of Care Research	Topic Knowledge, Performance Measurement, Quality Improvement
Scott Flanders, MD	Professor of Internal Medicine; Director of the Hospitalist Program	University of Michigan	Topic Knowledge and Quality Improvement
Stephen Schmaltz, PhD, MS, MPH	Associate Director, Center for Database Management and Analysis	Joint Commission	Quality Improvement and Performance Measurement
Terry Golash, MD	Senior Medical Director	Aetna	Purchaser perspective
Vivian Ho, PhD	James A. Baker III Institute Chair in Health Economics and Professor of Economics	Rice University	Topic Knowledge