Developing Risk-Adjusted Avoidable Hospitalizations and Emergency Department Visits Quality Measures

A report by staff from RTI International for the Medicare Payment Advisory Commission

Zhanlian Feng, PhD
Benjamin Silver, PhD
Micah Segelman, PhD
Madeleine Jones, BS
Melvin J. Ingber, PhD
Christopher Beadles, MD, PhD
Richard Pickett, BS
RTI International

•

MedPAC
425 I Street, NW
Suite 701
Washington, DC 20001
(202) 220-3700
Fax: (202) 220-3759
www.medpac.gov

•

August 2019

May 2019

Developing Risk-Adjusted Avoidable Hospitalizations and Emergency Department Visits Quality Measures

Final Report

Prepared for

Ledia Tabor, MPH
Medicare Payment Advisory Commission
425 I Street, NW Suite 701
Washington, DC 20001

Prepared by

Zhanlian Feng, PhD
Benjamin Silver, PhD
Micah Segelman, PhD
Madeleine Jones, BS
Melvin J. Ingber, PhD
Christopher Beadles, MD, PhD
Richard Pickett, BS
RTI International
3040 E. Cornwallis Road
Research Triangle Park, NC 27709

RTI Project Number 0215539.003.000.001

Contents

Tables

Executive Summary

Background

The Medicare Payment Advisory Commission (MedPAC) has established a set of principles for measuring quality of care provided under the auspices of the Medicare program. These principles hold that Medicare quality incentive programs should use a small set of population-based outcome, patient experience, and value measures to assess the quality of care across different populations, such as beneficiaries enrolled in Medicare Advantage (MA) plans, accountable care organizations (ACOs), and fee-for-service (FFS) in defined market areas, as well as those cared for by specified hospitals, groups of clinicians, and post-acute care (PAC) providers.

The Commission has discussed including avoidable hospitalizations (AHs) and avoidable emergency department (ED) visits (AVs) in this small set of measures, given the adverse patient impact and high cost of these events. AHs and AVs may result from inadequate access to ambulatory care or inadequate coordination of ambulatory care received, and as such, may reflect the effectiveness of the ambulatory care system. Well-calibrated measures of AHs and AVs based on administrative data can provide a useful gauge of care access and quality within the ambulatory care system.

Medicare currently uses some potentially preventable hospital use measures for quality measurement. For example, some of the Agency for Healthcare Research and Quality's (AHRQ) Prevention Quality Indicators (PQIs) for ambulatory care sensitive conditions (ACSC) are part of the ACO measure set, and Medicare publicly reports MA plan performance on a measure of hospitalizations for potentially preventable complications that is based on the AHRQ PQI measure. These measures have differences in how they are calculated, and are not adequately risk adjusted to be used for the entire Medicare population. Therefore, we developed a common measure of AHs that can be used across FFS, MA and ACOs. Although some research has been done to define AV quality measures, Medicare currently has not incorporated AVs into existing quality measurement programs. We compiled the existing research to create an AV measure that can be used across Medicare payment models.

This report summarizes the definition of AH and AV measures and the development of a risk-adjustment model for calculating expected rates of AHs and AVs, both nationally and at the market area level, using FFS (which includes ACOs) Medicare claims data. Because we were able to use a large amount of data from the FFS beneficiary population to determine the risk-adjustment model (about 30 million beneficiaries), this measure could be applied to ACO and MA populations. We calculated these rates across two types of market areas: (1) MedPAC-defined market areas (MMAs) and (2) Dartmouth-defined hospital service areas (HSAs). To understand if the measure can be used to compare performance of ambulatory

care systems treating FFS beneficiaries, we examined the extent of variation in risk-adjusted AH and AV rates across all market areas and profiled five specific market areas of interest to MedPAC: Boston, Houston, Minneapolis, Orlando, and Phoenix. Furthermore, we analyzed differences in risk-adjusted AH and AV rates among population subgroups stratified by select beneficiary characteristics.

Methods

We used the Medicare Master Beneficiary Summary Files (MBSF), the Centers for Medicare & Medicaid Services' Hierarchical Condition Category (HCC) files, Inpatient National Claims History files, and outpatient files from calendar years 2015 through 2017 in this analysis. Beneficiaries who were enrolled in Medicare FFS Parts A and B for the full calendar year were eligible for sample selection in each year. We excluded beneficiaries who were enrolled in a MA plan at any point during the year, decedents, and those who lived outside of the 50 U.S. states. Beneficiaries who were missing information on market areas or on any covariate used for risk adjustment were also excluded.

We defined AHs using a combination of existing AH measures that are currently used in Medicare programs, including the Healthcare Effectiveness Data and Information Set (HEDIS) measures for Hospitalization for Potentially Preventable Complications and the AHRQ PQI measures. For AVs, we applied the same set of ACSCs used in defining AHs and incorporated additional specifications from a recently published study that convened a panel of experts to adapt the PQI measures to the ED setting. A physician reviewed both AH and AV definitions for clinical soundness.

The conditions considered for either an AH or an AV included diabetes, chronic obstructive pulmonary disease (COPD), asthma, hypertension, heart failure, bacterial pneumonia, urinary tract infection, cellulitis, and pressure ulcers. Three additional condition groups—upper respiratory infection/otitis/rhinitis, influenza (without pneumonia), and nonspecific back pain—were only included in the AV measure. AHs included both inpatient admissions and observation stays, whereas AVs consisted only of ED visits that did not result in an admission or observation stay. In our specifications, we included diagnosis and procedure codes from both HEDIS and PQI measures. We defined the outcome variable as the count of AHs or AVs per beneficiary in each year.

We used a zero-inflated negative binomial model to produce risk-adjusted counts of AHs or AVs. Risk factors (model covariates) included beneficiary age, sex, end-stage renal disease (ESRD), disability status, and 79 HCCs. We calculated market-level rates for both HSAs and MMAs. We identified all AHs and AVs, and aggregated both the observed and expected numbers of events of each type from the beneficiary level to the market area level in each year. Dividing the total number of observed AHs or AVs for each area by the total number of

expected AHs or AVs yielded the observed to expected (O to E) ratios, which in turn were multiplied by the mean market-level observed rates to obtain risk-standardized rates.

Key Findings

In each year, about 3% of all beneficiaries in the study population experienced at least one AH, and 6% experienced at least one AV. In 2017, the observed rate of AHs was 36 events per 1,000 beneficiaries, while the observed rate of AVs was 77 visits per 1,000 beneficiaries. Nationally, both observed and expected rates of AHs and AVs were above average for disabled beneficiaries, African Americans, American Indians/Alaska Natives, and beneficiaries dually eligible for Medicare and Medicaid. Both observed and risk-adjusted AH and AV rates varied considerably across market areas. For the MMAs in and around Boston, Houston, Orlando, Minneapolis, and Phoenix, adjusted AV rates were consistently lower than the national average. Adjusted AH rates tended to be higher in Boston and lower in Phoenix.

Discussion

Our analysis reveals substantial variation in the risk-adjusted rates of AHs and AVs across market areas, suggesting potential opportunities for improvement in ambulatory care. To the extent that risk-adjusted rates of AHs and AVs suggest problems in the access to and quality of ambulatory care for patients, the variation in these rates across market areas can be used to evaluate the relative performance of local ambulatory care delivery systems. This variation can also be used to identify and explore "hot spots"—areas with relatively high AH or AV rates—for better-targeted use of limited resources in quality improvement initiatives. The lower rate of AHs relative to AVs may have been driven in part by heightened Medicare policy efforts to reduce hospital readmissions; providers may not have been incentivized to reduce AVs as much as AHs. Going forward, MedPAC may continue testing the risk-adjusted AH and AV measures and apply these measures to other populations and entities, including enrollees in MA plans, ACOs, and groups of physicians or other providers participating in the Medicare program.

Conclusion

AHs and AVs constitute important quality measures because a substantial portion of hospitalizations and ED visits can be prevented with adequate access to high-quality ambulatory care. Risk-adjusted rates of AHs and AVs developed from this analysis can be used as performance indicators of the ambulatory care systems in a given market. The considerable variation in both AH and AV rates across market areas suggests opportunities to improve the quality of care and the potential to use these measures to compare quality across local health care markets.

1. Background

The Medicare Payment Advisory Commission (MedPAC) has established a set of principles for measuring quality of care provided under the auspices of the Medicare program. These principles hold that Medicare quality incentive programs should use a small set of outcomes, patient experience, and value measures to assess the quality of care across different populations, such as beneficiaries enrolled in Medicare Advantage (MA) plans, accountable care organizations, and fee-for-service (FFS) in defined market areas, as well as those cared for by specified hospitals, groups of clinicians, and post-acute care (PAC) providers. The Commission has discussed including avoidable hospitalizations (AHs) and avoidable emergency department (ED) visits (AVs) in this small set of measures, given the adverse patient impact and high costs of these events (MedPAC, 2018).

Conceptually, an AH or AV refers to hospital use that could have been prevented with appropriate, high-quality, and timely care in ambulatory care settings (Moy, Chang, & Barrett, 2013). In other words, AHs and AVs may result from inadequate access to ambulatory care or inadequate coordination of ambulatory care received, and as such, may reflect the effectiveness of the ambulatory care system (MedPAC, 2017). Although payers often examine total hospital utilization for measures of total spending in cost containment efforts, identification of potentially avoidable hospital transfers for ambulatory care sensitive conditions (ACSCs) can offer more-useful insights into the quality of care provided to a beneficiary and to inform qualify improvement initiatives in Medicare.

In practice, there is no consensus on the best or optimal definition of an AH or AV. Existing definitions usually are based on administrative data and clinical expert opinion on whether a particular hospital visit with certain conditions could be prevented. Despite this challenge, AH and AV measures based on administrative data, if properly calibrated, can be useful indicators of potentially low-quality, or low-value, care for quality reporting and cost-reduction efforts (AHRQ, 2019; MedPAC, 2018).

Several measures of potentially preventable inpatient admissions exist and are currently in use across various quality measurement programs and alternative payment models. The Agency for Healthcare Research and Quality's (AHRQ) Prevention Quality Indicators (PQIs), which measure the rate of AHs for a series of ACSCs, are part of the accountable care organization measure set. Medicare also publicly reports MA plan performance on a measure of hospitalizations for potentially preventable complications that is based on the AHRQ PQI measure (AHRQ, 2019). The Potentially Preventable 30-Day Post-Discharge Readmission Measure, used in the Centers for Medicare & Medicaid Services (CMS) Skilled Nursing Facility Quality Reporting Program, also builds on the PQI measures (CMS, 2019). A recent study has also attempted to adapt the PQI measure specifications to the outpatient/ED setting (Davies et al., 2017), but work in this area has been even more limited, and these

specifications have yet to be used in quality measurement or payment policy. Other definitions of potentially avoidable hospitalization based on the ACSC concept were also applied in studies on high-need and high-cost populations, such as individuals dually eligible for Medicare and Medicaid, in both home and community-based settings (Walsh et al., 2010, 2012) and in long-term care nursing facilities (Ingber et al. 2017). A common limitation among existing AH and AV measures is that most of them are not adequately risk adjusted for the entire Medicare population.

Previous work has shown that from 2005 to 2012, the national age-sex adjusted rate of AHs (defined by the AHRQ PQIs) among the U.S. adult (18 years of age or older) population decreased 18.5%, from 1,941 to 1,582 stays per 100,000 people, while the age-sex adjusted rate of AVs (also measured by the AHRQ PQIs) increased 11.4%, from 2,350 to 2,618 treat-and-release visits per 100,000 people (Fingar, Barrett, Elixhauser, Stocks, & Steiner, 2015). These trends could reflect an increased tendency of hospitals treating patients on an outpatient basis (e.g., putting them under observation care) instead of admitting them as inpatients (Feng, Wright, and Mor, 2012), not necessarily an actual reduction in potentially preventable hospital utilization. The rates of these AHs and AVs also vary widely across regions. A MedPAC analysis of FFS Medicare beneficiaries in 2014 showed that relative to the population-weighted national average, the highest-performing market areas (10th percentile) had 0.85 times the rate of AHs and 0.24 times the rate of AVs (both adjusted for age and burden of chronic illness), whereas the lowest-performing market areas (90th percentile) had 1.32 times the rate of AHs and 1.29 times the rate of AVs (MedPAC, 2017). A more-recent analysis of FFS Medicare beneficiaries in 2016, also conducted by MedPAC, found variation by more than twofold in the observed rate of unadjusted AHs, both overall and separately by chronic and acute conditions (MedPAC, 2018).

It is important to understand the nature of variation in AH and AV rates across local health care markets and the degree to which it reflects genuine differences in quality versus differences in underlying patient risk. For example, in a region of the country with an older population or a higher-than-average rate of comorbidities, one would expect a relatively higher rate of admission for heart failure independent of the quality of ambulatory care received. Therefore, accounting for such differences is essential to obtain the risk-adjusted rate of these potentially preventable events. Calculated at the local market area level, comparatively high risk-adjusted rates of AHs and AVs can be used to identify opportunities for improvement in an area's ambulatory care systems, even though not every AH and AV can be averted (MedPAC, 2017).

The purpose of this project is to develop a risk-adjustment model for calculating expected rates of AHs and AVs, both nationally and at the market area level relative to national average rates, using FFS Medicare claims data for 2015–2017. These rates are calculated and examined across two types of market areas—MedPAC-defined market areas designed to

match insurance markets served by private plans, and Dartmouth-defined hospital service areas (HSAs)—each formed by groups of ZIP codes wherein residents receive most of their inpatient care from hospitals within the same area. These risk-adjusted AH and AV rates represent population-based measures of avoidable hospital utilization, consistent with the MedPAC principles for measuring quality (MedPAC, 2018). These measures can inform future efforts by the Medicare program to develop value-based payment incentive programs.

Specifically, we address the following objectives in this report:

1. Describe the methodology used to develop risk-adjusted AH and AV measures at the national and local market area levels.
2. Describe the national trends in AH and AV rates from 2015 to 2017.
3. Examine the extent of variation in risk-adjusted AH and AV rates across market areas.
4. Examine differences in risk-adjusted AH and AV rates among population subgroups stratified by select beneficiary characteristics (age, gender, race and ethnicity, original reason for Medicare eligibility, and Medicare-Medicaid dual eligibility status) at the national level.
5. Profile five specific market areas of interest to MedPAC: Boston, Houston, Minneapolis, Orlando, and Phoenix.
6. Explore the degree of correlation between the risk-adjusted AH and AV rates cross-sectionally and the correlation across the years for each measure.

2. Methods

2.1 Study Design and Population

The population of interest for this study was Medicare beneficiaries enrolled in Medicare fee-for-service (FFS) Parts A and B for the full calendar year, annually, during our study period (2015 to 2017). For each of the 3 years, we included all beneficiaries 18 years of age or older appearing in the Master Beneficiary Summary File (MBSF) who were enrolled in Parts A and B for all 12 months of the year, were not enrolled in a Medicare Advantage plan at any point in the year, and did not die during the year. This ensures that all included beneficiaries had the full year of claims data to calculate the rates of our outcomes of interest for each year. Our sample was further limited to beneficiaries living in the 50 United States and the District of Columbia who could be matched successfully to both of the market areas in our analyses. Finally, we excluded beneficiaries who were missing information for one or more of the covariates described below to ensure complete data for our risk-adjustment models.

2.2 Data Sources

Our data were drawn from the 100% Medicare administrative claims data for calendar years 2015 through 2017. The sample of beneficiaries was identified using the MBSF, which contains enrollment and demographic information for beneficiaries enrolled in the Medicare program at any point in the calendar year. The demographic characteristics used in the risk-adjustment models were also drawn from this file, and Hierarchical Condition Category (HCC) data used in the models were drawn from the Medicare HCC data file (see Section 2.5 for additional detail on the covariates selected for the model). Inpatient hospitalizations were drawn from the Medicare Inpatient National Claims History data files, and emergency department (ED) visits and observation stays were drawn from the Outpatient National Claims History files. All data were obtained under a Data Use Agreement between MedPAC and the Centers for Medicare & Medicaid Services.

2.3 How Market Areas Were Defined

In this analysis, we used two different definitions of market areas: (1) hospital service areas (HSAs) defined by the Dartmouth Atlas Project (2019), and (2) MedPAC market areas (MMAs). The Dartmouth HSAs represent areas of the country where most individuals would obtain hospital care from a specific hospital. This makes them particularly useful for comparing the quality of care provided by hospitals. The MMAs are primarily derived from core-based statistical areas (CBSA), which represent larger units of geography than counties, which have traditionally been used to represent market areas. CBSAs are combinations of metropolitan and micropolitan areas defined by the United States Office of Management and Budget and generally consist of one or more counties and a major urban center. Under the MedPAC definition, areas not included in a CBSA are assigned to market

areas using health service areas as defined by the National Center for Health Statistics. There are 3,436 HSAs and 1,231 MMAs across the 50 U.S. states and the District of Columbia.

2.4 Outcome Measures

In our risk-adjustment models, the unit of analysis was the Medicare beneficiary. The outcomes of interest were the number of avoidable hospitalizations (AHs) and the number of avoidable ED visits (AVs), based on a defined set of ambulatory care sensitive conditions (described below). We identified all inpatient admissions, observation stays, and ED visits that included beneficiaries made to short-stay acute or critical access hospitals defined in the Medicare Provider of Services file (Hospital Type Code 1 or 11). We summed the number of hospital visits of each type for each beneficiary included in our study population each year.

Inpatient admissions were identified from all inpatient claims. ED visits were flagged as claims containing at least one line with any of the following codes: Healthcare Common Procedure Coding System (HCPCS) codes 99281 to 99285, 99291, or G0380 to G0384, or Revenue Center Codes 0450 to 0459 and 0981. Observation stays were flagged as claims with at least one line satisfying all of the following criteria: (1) HCPCS code G0378 with at least eight revenue units, (2) a claim line for an ED visit (as previously defined) or HCPCS codes G0463 or G0379 elsewhere on the claim, and (3) no lines on the claim indicating a Revenue Center Status Code of T on the same date (indicating a significant procedure subject to multiple procedure discounting).

Because a single hospital visit can occasionally span multiple claims, claims for the same beneficiary in the same hospital with overlapping admission and discharge dates were consolidated into a single visit. In the case of transfers, defined as consecutive hospital stays (i.e., the second visit began within 1 day of discharge) for the same beneficiary in different hospitals, the second hospital visit was not counted toward the total visits. Finally, outpatient claims that contained both ED and observation care were considered observation stays, and inpatient admissions that also included ED and/or observation care were counted as inpatient admissions.

We defined AHs using a combination of existing AH measures that are currently used in Medicare programs, including the Healthcare Effectiveness Data and Information Set (HEDIS) measures for Hospitalization for Potentially Preventable Complications published by the National Committee for Quality Assurance (NCQA, 2019), and the Prevention Quality Indicator (PQI) measures published by the Agency for Healthcare Research and Quality (AHRQ, 2019). For AVs, we applied the same set of ambulatory care sensitive conditions as used in defining AHs, and incorporated additional specifications from a recently published study that convened a panel of experts to adapt the PQI measures to the ED setting (Davies

et al., 2017). These measures and research identify AHs and AVs as hospital stays with certain diagnosis codes indicating one of several ambulatory care sensitive conditions. These conditions are listed in ***Table 2-1***.

Table 2-1. Ambulatory Care Sensitive Conditions

Condition	Type	AH	AV
Diabetes, short term	Chronic	X	X
Diabetes, long term	Chronic	X	X
Chronic obstructive pulmonary disease (COPD)	Chronic	X	X
Asthma	Chronic	X	X
Hypertension	Chronic	X	X
Heart failure	Chronic	X	X
Bacterial pneumonia	Acute	X	X
Urinary tract infection	Acute	X	X
Cellulitis	Acute	X	X
Pressure ulcers	Acute	X	X
Upper respiratory infection/otitis/rhinitis	Acute		X
Influenza	Acute		X
Nonspecific back pain	Acute		X

AH = avoidable hospitalization; AV = avoidable emergency department (ED) visit.

Most of the included conditions could be considered either an AH or an AV. In other words, the visits are considered ambulatory care sensitive regardless of whether the patients are admitted or treated entirely as outpatients. These include chronic conditions, such as diabetes (short or long term), chronic obstructive pulmonary disease (COPD), asthma, hypertension, and heart failure, and acute conditions, such as bacterial pneumonia, urinary tract infections, cellulitis, and pressure ulcers. Three additional condition groups—upper respiratory infection/otitis/rhinitis, influenza (without pneumonia), and nonspecific back pain—were determined to be ambulatory care sensitive only when appearing in the ED (Corwin, Parker, & Brown, 2016; Davies et al., 2017). In other words, if ultimately admitted (or treated under observation), the conditions were considered serious enough that they were no longer ambulatory care sensitive. These three types of conditions were only included in the AV measure.

A challenge in identifying AHs and AVs during our study was a change in the reporting of diagnoses on Medicare claims. International Classification of Diseases, Version 9 (ICD-9), codes were reported on Medicare claims up through the third quarter of 2015. As of the fourth quarter of 2015, providers began reporting Version 10 of these codes (ICD-10). To ensure consistency of our approach in identifying AHs and AVs, we reviewed the HEDIS and

PQI specifications for each ambulatory care sensitive condition from both ICD-9 and ICD-10. Although there was considerable overlap in the codes listed, some codes appeared in only one measure. We therefore elected to include diagnosis and procedure codes from both measures in our specifications. In addition, two experts (including a physician) from the RTI International team with extensive experience with cross-walking ICD Versions 9 and 10 reviewed the specifications and identified any additional codes not included in either measure. Final specifications, including all diagnosis codes in the condition groups, are available upon request (these were already delivered to MedPAC separately).

Our definition of AHs included both inpatient admissions and observation stays, whereas AVs consisted only of ED visits. There are advantages and disadvantages to this approach. One could argue that inpatient admissions should be distinct because they indicate an increased level of clinical severity when compared with ED visits and observation stays (which are both considered outpatient for billing purposes). Additionally, hospitals vary considerably in where they draw the line between ED and observation care, and observation stays often begin in the ED. However, there is a growing body of literature showing an increasing prevalence of observation stays and a shift of patients toward observation who would previously have been admitted to an inpatient stay (Feng et al., 2012; Silver et al., 2018; Wright, Jung, Feng, & Mor, 2014). Following suggestions by the MedPAC, we included both inpatient admissions and observation stays in the AH definition, effectively combining all cases that required care beyond the ED.

2.5 Covariates

We controlled for demographic characteristics, such as age and gender, and clinical characteristics, primarily based on HCCs. HCCs are groups of clinically related diagnoses with similar implications for health care utilization and cost. Age was divided into 5-year groupings separately for male and female patients. We adjusted for a total of 79 HCC categories (based on HCC Version 22) from the Medicare HCC data file. The HCCs were derived from ICD-9 and ICD-10 codes from the claims for each beneficiary in the prior year. In addition, we included end-stage renal disease (ESRD) status and disability status. Several variables, including the Medicare status code, current reason for Medicare entitlement, and an indicator for ESRD status, were used to determine ESRD status. Individuals over age 65 and originally eligible for Medicare because of disability were identified using age, original reason for Medicare entitlement, and an additional disability indicator from the HCC file.

We considered including interaction terms available in the HCC file that consist of HCCs that interacted with each other or with disability status. The purpose of these interaction terms would be to allow for the effect of having specific combinations of conditions to differ from the combined effect of the separate conditions. There were differences in which of the interaction terms were included in the HCC file in the 3 years of data, and we built a

standard set of interaction terms for the 3 years. As we describe further in the next section, we chose to not include these variables in our final risk-adjustment models.

2.6 Model Selection

We tested several different multivariate count model specifications. These included three basic model types: Poisson, negative binomial, and zero-inflated negative binomial (ZINB). The ZINB model is used to model data with a high proportion of zeros and is a two-part model. The first part predicts whether or not the individual has any events using a logistic model, and the second part uses a negative binomial model to predict the count of events. The final predicted count is the product of the probability of a nonzero count with the predicted count from the negative binomial model. In our case, we included the same predictors in both parts of the model, although in other contexts, the predictors in the two parts can be different. Because our ultimate goal is to calculate observed and expected rates at the market level, we did not account for clustering, and thus did not use fixed or random effects in these models.

To evaluate the performance of the models and select a final model, we used an approach similar to the methods for the Hosmer-Lemeshow test (Kramer and Zimmerman, 2007). For each model and for each year separately, we divided the population into deciles based on the predicted counts of events (AHs or AVs). For each decile, we compared the observed number of events to the predicted. An observed to expected (O to E) ratio closer to 1 for each decile indicates better model fit.

As part of our model selection process, we compared a full model to a reduced model. The full model contained all the covariates described above, including the HCC/disability interaction terms used in the payment context, and the reduced model dropped the interaction terms. ***Appendix A*** lists the interaction terms that were in the full model, but not in the reduced model.

Using the full models with all covariates for testing, we concluded that the Poisson model was the least appropriate. The dispersion parameter was statistically significantly different from 1, indicating overdispersion, and the O to E ratios for the deciles were far from 1 (***Tables 2-2*** and ***2-3***). This is consistent with other studies (Weaver et al., 2015) that found Poisson regression to be inferior to negative binomial and ZINB with hospitalization data. Furthermore, the ZINB had O to E ratios substantially closer to 1 for the deciles than the negative binomial or Poisson. We therefore chose the ZINB model.

Table 2-2. Observed to Expected (O to E) Ratio for Avoidable Hospitalizations (AHs), by Risk Decile, Year, and Model Type

	Negative Binomial			Poisson			ZINB, Full Model			ZINB, Reduced Model			ZINB ≤ 4[1]	ZINB ≤ 10[2]
Decile	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2017	2017
0	0.82	0.82	0.84	0.70	0.71	0.67	1.03	1.04	1.05	1.03	1.04	1.05	1.03	1.05
1	0.71	0.71	0.71	0.61	0.62	0.63	0.94	0.94	0.96	0.93	0.93	0.95	0.94	0.96
2	0.69	0.68	0.66	0.61	0.60	0.59	0.82	0.83	0.82	0.83	0.83	0.82	0.81	0.82
3	0.86	0.87	0.86	0.79	0.75	0.75	1.02	1.01	1.02	1.02	1.02	1.02	1.00	1.01
4	0.93	0.94	0.95	0.86	0.88	0.87	1.03	1.05	1.03	1.06	1.05	1.04	1.02	1.03
5	0.92	0.91	0.89	0.88	0.89	0.86	0.94	0.93	0.92	0.94	0.94	0.93	0.93	0.92
6	1.09	1.08	1.06	1.08	1.07	1.03	1.01	1.02	1.00	1.02	1.03	1.01	1.02	1.00
7	1.22	1.21	1.22	1.24	1.21	1.20	1.05	1.05	1.05	1.06	1.05	1.05	1.07	1.05
8	1.18	1.18	1.20	1.17	1.17	1.20	1.01	1.01	1.02	1.01	1.01	1.01	1.02	1.02
9	0.80	0.81	0.80	1.00	1.00	1.01	0.99	1.00	1.00	0.99	0.99	0.99	0.99	0.99

[1] Zero-inflated negative binomial (ZINB) after removing beneficiaries with more than four events.

[2] ZINB after removing beneficiaries with more than 10 events.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 07).

Table 2-3. Observed to Expected (O to E) Ratio for Avoidable Emergency Department Visits (AVs), by Risk Decile, Year, and Model Type

	Negative Binomial			Poisson			ZINB, Full Model			ZINB, Reduced Model			ZINB ≤ 4[1]	ZINB ≤ 10[2]
Decile	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017	2017	2017
0	0.86	0.82	0.87	0.83	0.71	0.84	1.05	1.04	1.06	1.05	1.04	1.06	1.04	1.06
1	0.89	0.71	0.92	0.86	0.62	0.90	0.99	0.94	0.99	0.99	0.93	0.99	0.99	0.99
2	0.84	0.68	0.86	0.82	0.60	0.83	0.94	0.83	0.95	0.94	0.83	0.95	0.95	0.95
3	0.96	0.87	0.95	0.94	0.75	0.93	0.96	1.01	0.96	0.96	1.02	0.96	0.97	0.96
4	1.02	0.94	1.03	1.01	0.88	1.01	0.98	1.05	0.98	0.98	1.05	0.98	0.99	0.98
5	1.10	0.91	1.09	1.09	0.89	1.09	1.01	0.93	1.02	1.00	0.94	1.02	1.02	1.02
6	1.07	1.08	1.06	1.12	1.07	1.05	1.04	1.02	1.01	1.04	1.03	1.01	1.01	1.01
7	1.07	1.21	1.06	1.04	1.21	1.07	1.01	1.05	1.01	1.01	1.05	1.01	1.01	1.01
8	1.05	1.18	1.05	1.05	1.17	1.06	0.99	1.01	0.99	0.99	1.01	0.99	0.99	0.99
9	0.93	0.81	0.93	0.98	1.00	0.98	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00

[1] Zero-inflated negative binomial (ZINB) after removing beneficiaries with more than four events.

[2] ZINB after removing beneficiaries with more than 10 events.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 07).

We considered two further issues. First, using the full model, we considered whether the presence of outliers with high observed counts of events may be affecting the modeling results. This analysis was partially motivated by the fact that the HEDIS measure of hospitalizations for potentially preventable complications excludes beneficiaries with three or more admissions because of concerns with modeling these observations with high counts of events (NCQA, 2018). A profile of outliers is presented in ***Appendix B***. Interestingly, we noticed very little difference in the O to E ratios when we dropped the outliers (***Tables 2-2*** and ***2-3***). Model coefficients also tended to be similar. Finally, we stratified the population by observed counts (instead of by predicted counts) and noted a generally monotonic increase in the expected count for each level of observed count. On the basis of these results, we decided to not exclude outliers with high counts of events.

The second issue we explored, as described above, was whether the full model yielded better predictions than the reduced model. We chose the reduced model over the full model because although the O to E ratios were similar (***Tables 2-2*** and ***2-3***), the full model produced unstable coefficients for a handful of predictors. With the reduced model, there was only one predictor that was unstable and only in one outcome in one year (the first-stage logistic coefficient for respiratory arrest in the 2015 AV model).

2.7 Calculating Risk-Standardized Rates

After selecting a final regression model, we calculated market-level rates for both types of market areas (MMAs and HSAs). We summed the number of observed events (AHs or AVs) for each individual in the market area to obtain the total observed number of events. We summed the number of events that were predicted by the model for each individual in the market area to obtain the expected number of events. Dividing the market area total number of observed by the total number of expected events yielded an O to E ratio for each market area. Multiplying the O to E ratio by the mean market-level observed rate of events resulted in the risk-standardized rate.

3. Results

3.1 Final Sample After Exclusions

The sample exclusions and the count of beneficiaries in the final sample are shown in ***Table 3-1***. As shown in the table, the number of Medicare beneficiaries increased over the years, from more than 58 million in 2015 to more than 61 million in 2017. Interestingly, the number of beneficiaries excluded from our sample also increased, likely due to an increase in Medicare Advantage enrollment. The number of beneficiaries included in our final sample was fairly consistent over the 3 years, between 30 million and 31 million.

Table 3-1. Sample Exclusions and Final Beneficiary Sample, 2015 to 2017

Characteristic	2015		2016		2017	
	N	**Percentage of Total Beneficiaries**	***N***	**Percentage of Total Beneficiaries**	***N***	**Percentage of Total Beneficiaries**
Total Beneficiaries	58,292,453	100.00%	59,817,889	100.00%	61,260,656	100.00%
Denominator Drops[1]						
< 18 Years Old	2,378	0.00%	2,208	0.00%	2,009	0.00%
Did Not Have a Complete Year of Medicare Parts A & B Coverage	27,783,680	47.66%	28,830,782	48.20%	30,435,970	49.68%
Died During Year	2,220,899	3.81%	2,228,883	3.73%	2,295,137	3.75%
Missing Age, Gender, or Geography	7,035	0.01%	6,272	0.01%	4,756	0.01%
Characteristic	***N***	**Percentage of Total Beneficiaries**	***N***	**Percentage of Total Beneficiaries**	***N***	**Percentage of Total Beneficiaries**
Preliminary Sample of Beneficiaries After Above Denominator Drops	30,383,762	52.12%	30,856,116	51.58%	30,693,806	50.10%
Missing Market Areas						
Missing MMA	134,412	0.23%	134,637	0.23%	135,966	0.22%
Missing HSA	133,330	0.23%	133,641	0.22%	131,692	0.21%
Missing HCCs	7,006	0.01%	13,655	0.02%	4,101	0.01%
Outside 50 States + DC	129,713	0.22%	130,332	0.22%	129,161	0.21%
Final Beneficiary Sample	**30,238,611**	51.87%	**30,704,417**	51.33%	**30,550,167**	49.87%

[1]Categories are not mutually exclusive.

HCC = Hierarchical Condition Categories; HSA = hospital service area; MMA = MedPAC market area.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: BS 09).

3.2 Observed AH and AV Prevalence and Rates

The observed avoidable hospitalization (AH) and avoidable emergency department (ED) visits (AV) prevalence, measured in the number and percentage of beneficiaries who experienced at least one AH or AV in each year (2015 through 2017), is shown in ***Table 3-2***. The observed AH and AV rates, measured in the number of AHs or AVs per 1,000 beneficiaries in each year, are presented in ***Table 3-3***.

In each year, about 18% of the population experienced an inpatient or observation stay, while roughly 24% experienced an ED visit (***Table 3-2***). Because of beneficiaries with multiple stays and/or visits, the rate of inpatient or observation stays ranged from 277 to 280 per 1,000 beneficiaries, and the rate of ED visits ranged from 424 to 425 per 1,000 beneficiaries (***Table 3-3***). Because AHs and AVs make up a relatively modest proportion of all inpatient/observation stays and all ED visits, respectively, the percentage of all beneficiaries who experienced an AH or an AV, and the corresponding rates, were considerably lower. In each year, about 3% of all beneficiaries experienced an AH, while roughly 6% experienced an AV (***Table 3-2***). The rate of AHs noticeably dropped over the 3 years from 50 to 36 stays per 1,000 beneficiaries, while the rate of AV ranged from 75 to 77 visits per 1,000 beneficiaries (***Table 3-3***). It should be noted that part of this decline in AHs is due to changes during the study period in the medical coding of heart failure and hypertension. A number of new International Classification of Diseases, Version 10 (ICD-10) codes were added for these conditions (at the end of 2016 and 2017) but were not captured in our definition of AHs and AVs.

Detailed results on the frequency of AHs and AVs, by condition and year, are shown in **Appendix C** (note the particularly large drop in AHs due to heart failure in 2017, partly due to coding changes noted above). As explained above, we used a zero-inflated negative binomial model for risk adjustment. Full results using this model to predict AH or AV counts are shown in **Appendix D**, and full descriptive results on model covariates are presented in **Appendix E**.

Table 3-2. Observed AH and AV Prevalence, 2015 to 2017

Inpatient/Observation Stays and AHs	2015		2016		2017	
	Number of Beneficiaries with Each Type of Event	Percentage of Final Sample Beneficiaries (N = 30,238,611)	Number of Beneficiaries with Each Type of Event	Percentage of Final Sample Beneficiaries (N = 30,704,417)	Number of Beneficiaries with Each Type of Event	Percentage of Final Sample Beneficiaries (N = 30,550,167)
Any Inpatient or Observation Stay	5,397,194	17.85%	5,432,463	17.69%	5,391,293	17.65%
Any Inpatient Stay	4,669,715	15.44%	4,667,583	15.20%	4,631,092	15.16%
Any Observation Stay	1,225,739	4.05%	1,283,642	4.18%	1,278,678	4.19%
Any AH	1,049,966	3.47%	947,613	3.09%	794,136	2.60%
Any Acute AH	497,545	1.65%	446,716	1.45%	402,271	1.32%
Any Acute Inpatient AH	454,343	1.50%	398,532	1.30%	353,612	1.16%
Any Acute Observation AH	50,969	0.17%	56,143	0.18%	56,293	0.18%
Any Chronic AH	588,016	1.94%	529,472	1.72%	411,207	1.35%
Any Chronic Inpatient AH	514,265	1.70%	454,232	1.48%	346,567	1.13%
Any Chronic Observation AH	97,762	0.32%	98,006	0.32%	82,040	0.27%
ED Visits and AVs	**Number of Beneficiaries with Each Type of Event**	**Percentage of Final Sample Beneficiaries (N = 30,238,611)**	**Number of Beneficiaries with Each Type of Event**	**Percentage of Final Sample Beneficiaries (N = 30,704,417)**	**Number of Beneficiaries with Each Type of Event**	**Percentage of Final Sample Beneficiaries (N = 30,550,167)**
Any ED Visit	7,237,666	23.94%	7,375,799	24.02%	7,383,302	24.17%
Any AV	1,823,402	6.03%	1,801,963	5.87%	1,818,007	5.95%
Any Acute AV	1,365,346	4.52%	1,318,153	4.29%	1,346,613	4.41%
Any Chronic AV	546,175	1.81%	572,572	1.86%	559,352	1.83%

ED = emergency department; AH = avoidable hospitalization; AV = avoidable ED visit. Text indenting shown on the rows indicates subcategories, which may not sum to the category above them because of possible overlaps (some beneficiaries may have multiple types of events in a given year).

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: BS 09).

Table 3-3. Observed AH and AV Rates, 2015 to 2017

Inpatient/Observation Stays and AHs	2015		2016		2017	
	Number of Events	Rate per 1,000 Final Sample Beneficiaries	Number of Events	Rate per 1,000 Final Sample Beneficiaries	Number of Events	Rate per 1,000 Final Sample Beneficiaries
Inpatient/Observation Stays	8,452,599	279.53	8,506,454	277.04	8,452,993	276.69
Inpatient Stays	7,047,815	233.07	7,030,861	228.99	6,983,922	228.61
Observation Stays	1,404,784	46.46	1,475,593	48.06	1,469,071	48.09
AHs	1,497,787	49.53	1,328,217	43.26	1,087,196	35.59
Acute AHs	633,298	20.94	563,975	18.37	507,497	16.61
Acute Inpatient AHs	581,387	19.23	506,670	16.50	450,095	14.73
Acute Observation AHs	51,911	1.72	57,305	1.87	57,402	1.88
Chronic AHs	864,489	28.59	764,242	24.89	579,699	18.98
Chronic Inpatient AHs	759,747	25.13	658,998	21.46	491,619	16.09
Chronic Observation AHs	104,742	3.46	105,244	3.43	88,080	2.88
ED Visits and AVs	**Number of Events**	**Rate per 1,000 Sample Beneficiaries**	**Number of Events**	**Rate per 1,000 Sample Beneficiaries**	**Number of Events**	**Rate per 1,000 Sample Beneficiaries**
ED Visits	12,806,532	423.52	13,038,694	424.65	12,959,238	424.20
AVs	2,332,672	77.14	2,298,433	74.86	2,300,698	75.31
Acute AVs	1,657,309	54.81	1,584,961	51.62	1,605,651	52.56
Chronic AVs	675,363	22.33	713,472	23.24	695,047	22.75

ED = emergency department; AH = avoidable hospitalization; AV = avoidable ED visit. Text indenting shown on the rows indicates subcategories, which sum to the category above them (the types of events reported in this table are mutually exclusive).

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: BS 09).

3.3 Results by Beneficiary Characteristics

We next compared results nationally across categories of age, gender, race, and dual eligibility status. We aggregated the observed counts and the expected counts of AHs and AVs across all individuals in each category. This enabled us to calculate an observed to expected (O to E) ratio and hence a risk-standardized rate for each category.

As shown in ***Table 3-4*** (for AHs) and ***Table 3-5*** (for AVs) for the results based on the 2017 data, both the observed and expected AH and AV rates were above the national average for beneficiaries aged 65 years or older who were originally eligible for Medicare because of disability, African Americans, American Indians or Alaska Natives, and dually eligible beneficiaries; rates were lower than average for Asians or Pacific Islanders. Thus, for example, dually eligible beneficiaries both experienced more AH and AV events and tended to be clinically at higher risk for AHs and AVs. Note that for dually eligible beneficiaries, the observed rate more than doubles the rate for non-duals, but the risk-standardized rate is about 30% higher. This demonstrates the success of the model in "leveling the playing field" through risk adjustment. However, even after risk adjustment, differences remain between duals and non-duals in AH and AV rates. This may indicate opportunities for improved ambulatory care delivery to reduce AH and AV rates for duals. Results for 2015 and 2016 follow a similar pattern and are included in **Appendix F**.

Table 3-4. AH Outcomes by Select Beneficiary Characteristics, 2017

Characteristic	Number of Beneficiaries	Percentage of Beneficiaries	Percentage of Beneficiaries with at Least One AH Observed	Observed Rate of AHs per 1,000 Beneficiaries	Expected Rate of AHs per 1,000 Beneficiaries	O to E Ratio	Risk-Standardized Rate of AHs per 1,000 Beneficiaries
All Beneficiaries	30,550,167	100.00	2.60	35.59	35.58	1.00	35.59
Age/Eligibility Group							
18–64	5,166,532	16.91	3.13	47.64	47.35	1.01	35.80
65+ and not originally disabled	22,956,172	75.14	2.25	29.41	29.48	1.00	35.50
65+ and originally disabled	2,427,463	7.95	4.82	68.39	68.23	1.00	35.67
Gender							
Male	13,752,854	45.02	2.37	32.60	32.72	1.00	35.45
Female	16,797,313	54.98	2.79	38.03	37.92	1.00	35.69
Race/Ethnicity							
Non-Hispanic White	24,388,203	79.83	2.59	35.15	35.15	1.00	35.59
Black (or African American)	2,802,360	9.17	3.18	46.25	43.57	1.06	37.78
Hispanic	1,725,396	5.65	2.66	37.00	36.64	1.01	35.94
American Indian or Alaska Native	176,364	0.58	3.90	54.78	43.98	1.25	44.32
Asian or Pacific Islander	777,504	2.55	1.50	19.30	28.51	0.68	24.09
Other	233,467	0.76	1.88	24.81	30.57	0.81	28.89
Unknown	446,873	1.46	1.00	13.56	16.50	0.82	29.26
Dual Status							
Dual	4,613,237	15.10	4.78	71.05	58.48	1.21	43.23
Nondual	25,936,930	84.90	2.21	29.28	31.51	0.93	33.07

O to E = observed to expected; AH = avoidable hospitalization.
Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 09).

Table 3-5. AV Outcomes by Select Beneficiary Characteristics, 2017

Characteristic	Number of Beneficiaries	Percentage of Beneficiaries	Percentage of Beneficiaries with at Least One AV Observed	Observed Rate of AVs per 1,000 Beneficiaries	Expected Rate of AVs per 1,000 Beneficiaries	O to E Ratio	Risk-Standardized Rate of AVs per 1,000 Beneficiaries
All Beneficiaries	30,550,167	100.00	5.95	75.31	75.33	1.00	75.29
Age/Eligibility Group							
18–64	5,166,532	16.91	10.38	147.60	147.45	1.00	75.39
65+ and Not Originally Disabled	22,956,172	75.14	4.65	54.93	55.06	1.00	75.14
65+ and Originally Disabled	2,427,463	7.95	8.82	114.15	113.48	1.01	75.75
Gender							
Male	13,752,854	45.02	5.08	64.06	64.10	1.00	75.27
Female	16,797,313	54.98	6.67	84.52	84.52	1.00	75.31
Race/Ethnicity							
Non-Hispanic White	24,388,203	79.83	5.58	69.71	73.20	0.95	71.71
Black (or African American)	2,802,360	9.17	9.31	125.82	96.65	1.30	98.04
Hispanic	1,725,396	5.65	7.41	94.96	82.24	1.15	86.96
American Indian or Alaska Native	176,364	0.58	10.14	143.27	97.87	1.46	110.24
Asian or Pacific Islander	777,504	2.55	3.33	39.13	62.92	0.62	46.84
Other	233,467	0.76	4.31	52.47	67.82	0.77	58.27
Unknown	446,873	1.46	3.03	36.55	47.38	0.77	58.09
Dual Status							
Dual	4,613,237	15.10	11.18	157.90	125.15	1.26	95.02
Nondual	25,936,930	84.90	5.02	60.62	66.46	0.91	68.69

O to E = observed to expected; AV = avoidable emergency department (ED) visit.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 09).

3.4 Market-Level Results

Descriptive statistics of the market-level results for hospital service areas (HSAs) for 2017 are shown in ***Table 3-6*** and for MedPAC market areas (MMAs) in ***Table 3-7***. Results for 2015 and 2016 are shown in **Appendix F**.

Using the 2017 HSA results (***Table 3-6***) as an illustration, the percentage of beneficiaries with an AH ranged from 0% to 11.06% across all 3,436 HSAs. Among the HSAs, the mean and median percentages of beneficiaries with an AH were 2.97% and 2.82%, respectively. The observed AH rate per 1,000 beneficiaries ranged from 0 to 190.27, and the mean and median were 40.65 and 37.90, respectively. On average, the risk-standardized rates were slightly higher than the observed rates, with a mean and median of risk-standardized AH rates per 1,000 beneficiaries of 45.96 and 42.72, respectively.

Table 3-6. HSA Market-Level Distributions of AH and AV Measures, 2017 (*N* = 3,436)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
	Number of Beneficiaries in the Market Area	8,891	14,952	66	842	1,783	4,068	9,968	20,846	215,148
AH	Percentage of FFS Medicare Beneficiaries with an AH	2.97	1.09	0.00	1.76	2.25	2.82	3.51	4.34	11.06
	Observed Rate of AHs per 1,000 Beneficiaries	40.65	16.89	0.00	22.73	29.55	37.90	48.28	60.82	190.27
	O to E Ratio for AHs	1.13	0.41	0.00	0.72	0.86	1.05	1.29	1.65	4.38
	Risk-Standardized Rate of AHs per 1,000 Beneficiaries	45.96	16.78	0.00	29.12	35.07	42.72	52.44	66.92	177.89
	Percentage of FFS Medicare Beneficiaries with an Acute AH	1.55	0.66	0.00	0.87	1.12	1.43	1.81	2.39	7.01
	Observed Rate of Acute AHs per 1,000 Beneficiaries	19.53	9.17	0.00	10.54	13.86	17.77	22.74	30.33	107.48
	Percentage of FFS Medicare Beneficiaries with a Chronic AH	1.51	0.63	0.00	0.81	1.08	1.42	1.83	2.27	6.64
	Observed Rate of Chronic AHs per 1,000 Beneficiaries	21.11	10.00	0.00	10.76	14.48	19.51	25.94	32.67	118.84
AV	Percentage of FFS Medicare Beneficiaries with an AV	7.11	2.49	0.65	4.21	5.33	6.87	8.57	10.34	39.02
	Observed Rate of AVs per 1,000 Beneficiaries	91.94	38.98	6.49	50.00	65.30	86.70	112.09	139.10	752.83
	O to E Ratio for AVs	1.20	0.46	0.13	0.72	0.89	1.14	1.43	1.74	9.62
	Risk-Standardized Rate of AVs per 1,000 Beneficiaries	110.11	42.33	11.97	65.75	81.76	104.50	131.74	160.21	884.66
	Percentage of FFS Medicare Beneficiaries with an Acute AV	5.20	1.86	0.65	3.06	3.90	4.98	6.23	7.65	18.77
	Observed Rate of Acute AVs per 1,000 Beneficiaries	62.71	25.49	6.49	34.80	45.40	59.07	75.75	94.61	288.51
	Percentage of FFS Medicare Beneficiaries with a Chronic AV	2.31	1.08	0.00	1.19	1.59	2.16	2.85	3.57	28.35
	Observed Rate of Chronic AVs per 1,000 Beneficiaries	29.23	16.27	0.00	13.85	19.23	26.62	36.42	46.91	472.73

FFS = fee-for-service; HSA = hospital service area; O to E = observed to expected; AH = avoidable hospitalization; AV = avoidable emergency department (ED) visit; SD = standard deviation.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 11).

Table 3-7. MMA Market-Level Distributions of AH and AV Measures, 2017 (*N* = 1,230)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
AH	Number of Beneficiaries in the Market Area	24,838	51,753	93	2,429	5,101	10,905	21,053	52,803	716,885
	Percentage of FFS Medicare Beneficiaries with an AH	2.87	0.91	0.00	1.81	2.27	2.78	3.39	3.95	6.92
	Observed Rate of AHs per 1,000 Beneficiaries	39.11	13.70	0.00	23.36	30.03	37.56	46.29	55.60	108.26
	O to E Ratio for AHs	1.09	0.33	0.00	0.74	0.87	1.04	1.24	1.50	2.85
	Risk-Standardized Rate of AHs per 1,000 Beneficiaries	42.62	12.74	0.00	29.09	34.14	40.70	48.60	58.56	111.32
	Percentage of FFS Medicare Beneficiaries with an Acute AH	1.46	0.53	0.00	0.89	1.11	1.38	1.71	2.11	4.60
	Observed Rate of Acute AHs per 1,000 Beneficiaries	18.42	7.16	0.00	10.86	13.75	17.35	21.46	26.88	59.33
	Percentage of FFS Medicare Beneficiaries with a Chronic AH	1.48	0.52	0.00	0.90	1.14	1.44	1.77	2.11	4.59
	Observed Rate of Chronic AHs per 1,000 Beneficiaries	20.69	8.03	0.00	11.67	15.26	19.83	24.84	30.22	81.82
AV	Percentage of FFS Medicare Beneficiaries with an AV	7.10	1.91	1.96	4.77	5.70	6.96	8.30	9.72	16.14
	Observed Rate of AVs per 1,000 Beneficiaries	91.89	29.43	21.66	57.89	70.88	88.70	108.71	129.10	339.22
	O to E Ratio for AVs	1.20	0.35	0.37	0.82	0.96	1.15	1.39	1.63	5.19
	Risk-Standardized Rate of AVs per 1,000 Beneficiaries	110.15	32.07	34.37	75.04	87.89	105.97	127.81	149.68	476.88
	Percentage of FFS Medicare Beneficiaries with an Acute AV	5.19	1.44	1.44	3.46	4.16	5.00	6.09	7.11	11.98
	Observed Rate of Acute AVs per 1,000 Beneficiaries	62.58	19.77	14.44	40.06	49.22	59.79	73.83	88.04	197.98
	Percentage of FFS Medicare Beneficiaries with a Chronic AV	2.32	0.77	0.00	1.41	1.75	2.24	2.79	3.34	8.30
	Observed Rate of Chronic AVs per 1,000 Beneficiaries	29.31	11.21	0.00	17.04	21.33	27.92	35.61	43.83	141.24

FFS = fee-for-service; MMA = MedPAC-defined market area; O to E = observed to expected; AH = avoidable hospitalization; AV = avoidable emergency department (ED) visit; SD = standard deviation.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 11).

In general, the percentage of beneficiaries with an AV and the rate of AVs were substantially higher than the corresponding AH percentage and rate. Furthermore, there was a large degree of variation across market areas for both AHs and AVs. For example, the interquartile ranges for the O to E ratios for AHs and AVs across HSAs in 2017 were 0.86 to 1.29 and 0.89 to 1.43, respectively (***Table 3-6***). Given that an O to E ratio of 1 indicates average quality, the interquartile range includes market areas with moderately better than expected and substantially worse than expected quality. Note that the full market-level results were delivered separately as Excel files to MedPAC.

For the present study, we did not require a minimum number of beneficiaries in a market area. It may be appropriate to require a minimum to increase the stability of the measures. In ***Table 3-8*** below, we list the number of market areas affected by requiring a minimum population size of 150 and 1,000, respectively.

Table 3-8. Number of Market Areas with Fewer than 150 and 1,000 Beneficiaries

	HSA			MMA		
***N* (Beneficiaries)**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
< 150	7	7	9	2	2	2
< 1,000	440	438	437	28	27	27

HSA = hospital service area; MMA = MedPAC market area.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 08).

3.5 Profile of Selected Market Areas

In ***Table 3-9*** below, we present descriptive statistics using 2017 data for five market areas that are particularly of interest to MedPAC (results for 2015 and 2016 are presented in **Appendix F**). These market area definitions are based on the MMAs for Boston, Massachusetts; Houston-The Woodlands-Sugar Land, Texas; Orlando-Kissimmee-Sanford, Florida; Minneapolis-St. Paul-Bloomington, Minnesota-Wisconsin; and Phoenix-Mesa-Scottsdale, Arizona. For simplicity, we refer to them as Boston, Houston, Minneapolis, Orlando, and Phoenix. Note that the AV rates in all five market areas were consistently lower than the national average. Among these five market areas, the AH rates were highest in Boston and lowest in Phoenix.

Table 3-9. AH and AV Measures for Five Illustrative MMA Market Areas and the National Average, 2017

		National Average	Boston	Houston	Minneapolis	Orlando	Phoenix
MMA Information	MMA Name	—	Boston, MA	Houston-The Woodlands-Sugar Land, TX	Minneapolis-St. Paul-Bloomington, MN-WI	Orlando-Kissimmee-Sanford, FL	Phoenix-Mesa-Scottsdale, AZ
	MMA Number	—	14454	26420	33461, 33462	36740	38060
	Number of Beneficiaries in the Market Area	24,838	208,101	348,906	158,442	206,914	333,696

(continued)

Table 3-9. AH and AV Measures for Five Illustrative MMA Market Areas and the National Average, 2017 (continued)

		National Average	Boston	Houston	Minneapolis	Orlando	Phoenix
AH	Percentage of FFS Medicare Beneficiaries with an AH	2.87	3.19	2.88	2.27	2.78	2.04
	Observed Rate of AHs per 1,000 Beneficiaries	39.11	45.62	39.41	30.86	39.05	26.16
	O to E Ratio for AHs	1.09	1.28	1.12	0.89	1.05	0.87
	Risk-Standardized Rate of AHs per 1,000 Beneficiaries	42.62	50.18	43.95	34.76	41.02	33.87
	Percentage of FFS Medicare Beneficiaries with an Acute AH	1.46	1.70	1.55	1.13	1.37	1.11
	Observed Rate of Acute AHs per 1,000 Beneficiaries	18.42	21.87	19.44	14.12	17.79	13.45
	Percentage of FFS Medicare Beneficiaries with a Chronic AH	1.48	1.57	1.41	1.19	1.48	0.98
	Observed Rate of Chronic AHs per 1,000 Beneficiaries	20.69	23.75	19.97	16.74	21.26	12.71
AV	Percentage of FFS Medicare Beneficiaries with an AV	7.10	5.07	5.35	5.58	4.53	5.03
	Observed Rate of AVs per 1,000 Beneficiaries	91.89	62.39	64.64	0.01	54.37	60.59
	O to E ratio for AVs	1.20	0.80	0.91	0.83	0.74	0.95
	Risk-Standardized Rate of AVs per 1,000 Beneficiaries	110.15	73.83	83.66	76.31	67.95	87.69
	Percentage of FFS Medicare Beneficiaries with an Acute AV	5.19	3.90	4.05	4.22	3.45	3.87
	Observed Rate of Acute AVs per 1,000 Beneficiaries	62.58	45.49	46.95	51.06	40.06	44.94
	Percentage of FFS Medicare Beneficiaries with a Chronic AV	2.32	1.37	1.50	1.61	1.23	1.35
	Observed Rate of Chronic AVs per 1,000 Beneficiaries	29.31	16.91	17.69	19.86	14.31	15.65

FFS = fee-for-service; MMA = MedPAC market area; O to E = observed to expected; AH = avoidable hospitalization; AV = avoidable emergency department (ED) visit. Dashes (—) indicate not applicable.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 08).

In ***Table 3-10*** below, we present descriptive statistics using 2017 data for an additional 10 market areas based on MMA. These market areas represent the 10th, 25th, 50th, 75th, and 90th percentiles among all MMAs based on their risk-standardized rates of AHs and AVs, respectively. For comparison, we also include the national average of all MMAs for each of the statistics presented, which is identical to what was presented in Table 3-9 above.

Table 3-10. AH and AV Measures for 10 MMA Market Areas at Selected Percentiles Based on Risk-Standardized Rates of AHs and AVs, Respectively, 2017

		National Average	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
AH	MMA Name	—	Rural IA	Wausau, WI	Rural PA	Rural IN	Rural AL
	MMA Number	—	IA552	48140	PA128	IN311	AL161
	Risk-Standardized Rate of AHs per 1,000 Beneficiaries	42.62	29.08	34.14	40.70	48.60	58.47
	Number of Beneficiaries in the Market Area	24,838	1,951	11,851	6,415	2,285	9,280
	Percentage of FFS Medicare Beneficiaries with an AH	2.87	1.59	2.28	2.63	3.63	3.86
	Observed Rate of AHs per 1,000 Beneficiaries	39.11	20.50	31.05	34.92	47.26	51.94
	O to E Ratio for AHs	1.09	0.74	0.87	1.04	1.24	1.50
	Percentage of FFS Medicare Beneficiaries with an Acute AH	1.46	0.92	1.32	1.33	1.44	2.07
	Observed Rate of Acute AHs per 1,000 Beneficiaries	18.42	11.28	17.55	16.06	17.07	24.25
	Percentage of FFS Medicare Beneficiaries with a Chronic AH	1.48	0.72	1.06	1.34	2.32	1.94
	Observed Rate of Chronic AHs per 1,000 Beneficiaries	20.69	9.23	13.50	18.86	30.20	27.69
AV	MMA Name	—	Minneapolis-St. Paul-Bloomington, MN-WI	Rural CA	Rural WI	Rural MN	Rural TN
	MMA Number	—	33461	CA753	WI278	MN626	TN217
	Risk-Standardized Rate of AVs per 1,000 Beneficiaries	110.15	75.04	87.89	105.96	127.81	149.44
	Number of Beneficiaries in the Market Area	24,838	148,891	20,063	5,361	2,127	626
	Percentage of FFS Medicare Beneficiaries with an AV	7.10	5.54	4.73	5.35	8.37	11.98
	Observed Rate of AVs per 1,000 Beneficiaries	91.89	70.63	56.72	66.78	117.07	153.35
	O to E ratio for AVs	1.20	0.82	0.96	1.15	1.39	1.63
	Percentage of FFS Medicare Beneficiaries with an Acute AV	5.19	4.21	3.58	3.30	6.58	8.31
	Observed Rate of Acute AVs per 1,000 Beneficiaries	62.58	51.04	40.87	37.68	85.57	94.25

(continued)

Table 3-10. AH and AV Measures for Five MMA Market Areas at Selected Percentiles Based on Risk-Standardized Rates of AHs and AVs, Respectively, 2017 (continued)

		National Average	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
AV (cont.)	Percentage of FFS Medicare Beneficiaries with a Chronic AV	2.32	1.59	1.31	2.26	2.21	4.63
	Observed Rate of Chronic AVs per 1,000 Beneficiaries	29.31	19.58	15.85	29.10	31.50	59.11

FFS = fee-for-service; MMA = MedPAC market area; O to E = observed to expected; AH = avoidable hospitalization; AV = avoidable emergency department (ED) visit. Dashes (—) indicate not applicable.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 08).

3.6 Correlations Between Measures

To explore the stability of these measures across years, we calculated correlations for O to E ratios for both AH and AV measures. We found strong correlations, in the range of approximately 0.7 to 0.9, between the O to E ratios from different years for both AHs and AVs (see ***Table 3-11***). Correlations are slightly stronger for MMAs than HSAs because MMAs are larger, and thus rates are more stable. Correlations are also stronger for consecutive years (2015 with 2016, and 2016 with 2017) than for non-consecutive (2015 with 2017). In addition, correlations across years are stronger for AVs than for AHs, which may be due to the overall decline in AH rates during the study period and the relative stability in AV rates over the same period.

Table 3-11. Market-Level Correlations Across Years for AH and AV Measures

			HSA		MMA	
	Years		Correlation Coefficient	*P* Value	Correlation Coefficient	*P* Value
O to E Ratio for AHs	2015	2016	0.77	< 0.0001	0.86	< 0.0001
	2015	2017	0.72	< 0.0001	0.79	< 0.0001
	2016	2017	0.78	< 0.0001	0.84	< 0.0001
O to E Ratio for AVs	2015	2016	0.90	< 0.0001	0.92	< 0.0001
	2015	2017	0.83	< 0.0001	0.84	< 0.0001
	2016	2017	0.89	< 0.0001	0.89	< 0.0001

HSA = hospital service area; MMA = MedPAC market area; O to E = observed to expected; AH = avoidable hospitalizations; AV = avoidable emergency department (ED) visit.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 11).

The correlations between O to E ratios for the AHs and AVs for the same years were positive but relatively weak (see ***Table 3-12***). Correlations were approximately 0.3 and were

slightly weaker in 2016. These correlations suggest that some of the same factors, including the quality of and access to primary care, which affect one measure, may also affect the other. However, it is not surprising that the relationship is not strong, because AHs and AVs can substitute for each other. In fact, a subsequent analysis (not shown here) showed that these correlations weakened and, in some cases, changed sign when we stratified by market area size.

Table 3-12. Market-Level Correlations Between AH and AV Measures, by Year

	HSA		MMA	
O to E Ratio for AHs vs. O to E Ratio for AVs	**Correlation Coefficient**	***P* Value**	**Correlation Coefficient**	***P* Value**
2015	0.30	< 0.0001	0.28	< 0.0001
2016	0.27	< 0.0001	0.22	< 0.0001
2017	0.29	< 0.0001	0.32	< 0.0001

HSA = hospital service area; MMA = MedPAC market area; O to E = observed to expected; AH = avoidable hospitalization; AV = avoidable emergency department (ED) visit.

Source: RTI analysis of 2015–2017 Master Beneficiary Summary File, Inpatient Claims, and Outpatient Claims (RTI programming reference: MS 11).

4. Discussion

We developed a risk-adjustment model that accounts for a rich set of individual-level risk factors for avoidable hospitalizations (AHs) and avoidable emergency department (ED) visits (AVs) in the population of fee-for-service (FFS) Medicare beneficiaries in each year from 2015 through 2017. These factors included beneficiary demographics (age and gender) and measures of comorbidities and disease severity based on the Centers for Medicare & Medicaid Services Hierarchical Condition Categories (HCCs). Using this model, we calculated risk-adjusted rates of AHs and AVs at the local market level and examined the variation in these rates across 1,230 MedPAC-defined market areas (MMAs) and 3,436 Dartmouth-defined hospital service areas (HSAs). The analysis summarized in this report is an extension of previous MedPAC work that tested preliminary measures of AHs and AVs with no or limited risk adjustment or measures that were overly complicated and proprietary (MedPAC, 2017, 2018).

The risk adjustment is intended to minimize any "unwarranted variations" in the rates of AHs and AVs that could be attributable to differences in the health status and disease severity of the underlying population in an area. However, our analysis reveals substantial variation in the risk-adjusted rates of AHs and AVs across local market areas delineated by two different definitions. This variation signals opportunities for improvement not only in the quality of care provided to patient, but also in the effectiveness and efficiency of the ambulatory care delivery systems in relatively poor-performing market areas where the observed AH or AV rates exceed their expected rates by a significant margin, relative to the national average. Indeed, research has suggested evidence that higher rates of preventive care are associated with lower rates of preventable hospitalizations and lower spending (*Health*Landscape, 2016), and the sharp decrease in recent years in primary care office visits was accompanied by an increase in ED visits (Chou, Venkatesh, Trueger, & Pitts, 2019). On the premise that the risk-adjusted rates of AHs and AVs are indicative of problems in the access to and quality of ambulatory care for patients, the variation in these rates across market areas can be employed for monitoring and evaluation of the relative performance of local ambulatory care delivery systems. Such variation can also be used to identify and explore "hot spots"—areas with relatively high AH or AV rates—for better targeted use of limited resources in health reform and quality improvement initiatives.

The strong correlation across the 3 years of analysis on the risk-adjusted AH rate and risk-adjusted AV rate, respectively, lends support to the consistency in both measures and their potential utility for quality monitoring and improvement purposes. In each year cross-sectionally, there is a positive but relatively weak correlation between the AH rate and AV rate, suggesting that areas with higher rates of AHs also tend to have higher rates of AVs. The lack of strong correlation between the two measures is not totally surprising, as they

capture different aspects of quality, and in some market areas, AHs and AVs may substitute for each other.

Nationally, we observed a considerable drop from 2015 to 2017 in the risk-adjusted rate of AHs and a relatively stable rate of AVs. The more-pronounced decrease in the rate of AHs could be driven by heightened Medicare policy efforts to cut excessive hospital readmissions, notably through the ongoing Hospital Readmissions Reduction Program that has been in effect since 2012. Hospital outpatient care has not been subject to similar scrutiny by Medicare policy. Thus, hospitals may not be incentivized as much to reduce AVs as they are to reduce AHs.

In addition, our analysis suggests the importance of social risk factors that are not currently included in our risk-adjustment model but may have contributed to differences in AH and AV rates among population subgroups. For instance, the risk-adjusted rates of both AHs and AVs are significantly higher for beneficiaries who are dually eligible for Medicare and Medicaid (who are low-income with relatively high needs and high costs as a group) than for Medicare-only beneficiaries. Whether to include the dual eligible status and other socioeconomic variables in a risk-adjustment model remains controversial (Joynt Maddox et al., 2019). MedPAC currently does not support the inclusion of such variables for risk adjustment and argues that doing so would mask disparities in clinical performance; instead, it recommends that for payment purposes, Medicare should account for social risk factors by directly adjusting payment using peer grouping (MedPAC, 2018).

One potential limitation of this analysis is that our risk-adjustment model did not control for market area–level characteristics that may also affect AH and AV rates, in addition to beneficiary-level risk factors already included in the model. Such characteristics could include area–level poverty rates (which may influence access to and quality of ambulatory care); health care supply-side factors, such as the number of hospital beds per capita (which may induce demand for and use of hospital care); and the number of primary care physicians per capita (which can affect the use of preventive care). The extent of Medicare managed care penetration in a market area may also be relevant because of its potential spillover effects on FFS Medicare delivery system. These factors may be considered in future work. However, similar to the question of whether individual-level social risk factors should be included in risk-adjustment models, the inclusion of market area–level characteristics can also be controversial, particularly if the risk-adjusted measures are intended to capture the quality of care at the market level.

Going forward, MedPAC may continue testing the risk-adjusted AH and AV measures and apply these measures to other populations and entities. These may include Medicare enrollees in Medicare Advantage (MA) plans, accountable care organizations, and groups of physicians or other providers participating in the Medicare program. One challenge with many of these entities, though, is the lack of complete and timely data needed to calculate

and calibrate these population-based quality measures. This is certainly the case with MA plans.

5. Conclusion

Avoidable hospitalizations (AHs) and avoidable emergency department (ED) visits (AVs) constitute important quality measures because a substantial portion of hospitalizations and ED visits can be prevented with adequate and better-quality ambulatory care. The market area–level, risk-adjusted rates of AHs and AVs developed from this analysis can be used as performance indicators of the ambulatory care systems in a given market. The considerable variation in both AH and AV rates across market areas suggests opportunities to improve the quality of care and the potential to use these measures to compare quality across local health care markets. These measures may be refined further by accommodating advances in risk-adjustment methods.

6. References

Agency for Healthcare Research and Quality (AHRQ). (2019). *Prevention quality indicators overview*. Retrieved from http://www.qualityindicators.ahrq.gov/modules/pqi_resources.aspx

Centers for Medicare & Medicaid Services. (2019). *Skilled nursing facility (SNF) quality reporting program measures and technical information.* Retrieved from https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/NursingHomeQualityInits/Skilled-Nursing-Facility-Quality-Reporting-Program/SNF-Quality-Reporting-Program-Measures-and-Technical-Information.html

Chou, S.-C., Venkatesh, A. K., Trueger, N. S., & Pitts, S. R. (2019). Primary care office visits for acute care dropped sharply in 2002–15, while ED visits increased modestly. *Health Affairs, 38*, 268–275. https://doi.org/10.1377/hlthaff.2018.05184

Corwin, G. S., Parker, D. M., & Brown, J. R. (2016). Site of treatment for non-urgent conditions by Medicare beneficiaries: is there a role for urgent care centers? *The American Journal of Medicine*, *129*(9), 966-973.

Dartmouth Atlas Project. (2019). *Understanding of the efficiency and effectiveness of the health care system.* Lebanon, NH: The Trustees of Dartmouth College. Retrieved from https://www.dartmouthatlas.org/

Davies, S., Schultz, E., Raven, M., Wang, N. E., Stocks, C. L., Delgado, M. K., & McDonald, K. M. (2017). Development and validation of the Agency for Healthcare Research and Quality measures of potentially preventable emergency department (ED) visits: The ED prevention quality indicators for general health conditions. *Health Service Research, 52*, 1667–1684. https://doi.org/10.1111/1475-6773.12687

Feng, Z., Wright, B., & Mor, V. (2012). Sharp rise in Medicare enrollees being held in hospitals for observation raises concerns about causes and consequences. *Health Affairs (Millwood), 31*, 1251–1259. https://doi.org/10.1377/hlthaff.2012.0129

Fingar, K. R., Barrett, M. L., Elixhauser, A., Stocks, C., & Steiner, C. A. (2015, November). *Trends in potentially preventable inpatient hospital admissions and emergency department visits* (HCUP Statistical Brief #195). Rockville, MD: Agency for Healthcare Research and Quality. Retrieved from http://www.hcup-us.ahrq.gov/reports/statbriefs/sb195-Potentially-Preventable-Hospitalizations.pdf

*Health*Landscape. (2016, March). *Geospatial research brief: Do regions with more preventive care have lower spending and fewer hospitalizations?* Retrieved from https://www.healthlandscape.org/GeospatialResearchBrief2016MAR.pdf

Ingber, M. J., Feng, Z., Khatutsky, G., Wang, J. M., Bercaw, L. E., Zheng, N. T., Vadnais, A., Coomer, N. M., & Segelman, M. (2017). Initiative to reduce avoidable hospitalizations among nursing facility residents shows promising results. *Health Affairs (Millwood)*, *36*, 441–450. https://doi.org/10.1377/hlthaff.2016.1310

Joynt Maddox, K. E., Reidhead, M., Hu, J., Kind, A. J. H., Zaslavsky, A. M., Nagasako, E. M., & Nerenz, D. R. (2019). Adjusting for social risk factors impacts performance and penalties in the hospital readmissions reduction program. *Health Services Research, 54*(2), 327-336. https://doi.org/10.1111/1475-6773.13133

Kramer, A. A., & Zimmerman, J. E. (2007). Assessing the calibration of mortality benchmarks in critical care: The Hosmer-Lemeshow test revisited. *Critical Care Medicine, 35*(9), 2052-2056. https://doi.org/10.1097/01.CCM.0000275267.64078.B0

MedPAC. (2017, March). *Report to the Congress: Medicare payment policy*. Retrieved from http://www.medpac.gov/docs/default-source/reports/mar17_entirereport.pdf

MedPAC. (2018, June). Applying the commission's principles for measuring quality: Population-based measures and hospital quality incentives (pp. 175–207). In *Report to the Congress: Medicare and the health care delivery system.* Retrieved from http://www.medpac.gov/docs/default-source/reports/jun18_medpacreporttocongress_sec.pdf?sfvrsn=0)

Moy, E., Chang, E., & Barrett, M. (2013). Potentially preventable hospitalizations—United States, 2001–2009. *Morbidity and Mortality Weekly Report*, *62*(03), 139–143. Retrieved from https://www.cdc.gov/mmwr/preview/mmwrhtml/su6203a23.htm?s_cid%3Dsu6203a23_x

National Committee for Quality Assurance (NCQA). (2018). *HEDIS 2019 Volume 2, Technical Specifications for Heath Plans*. Washington, DC: Author.

National Committee for Quality Assurance (NCQA). (2019). *Hospitalization for potentially preventable complications (HPC).* Retrieved from https://www.ncqa.org/hedis/measures/hospitalization-for-potentially-preventable-complications/

Silver, B. C., Rahman, M., Wright, B., Besdine, R., Gozalo, P., & Mor, V. (2018). Effects of Medicare medical reviews on ambiguous short-stay hospital admissions. *Health Services Research*, *53*, 4747–4766. https://doi.org/10.1111/1475-6773.13036

Walsh, E. G., Freiman, M. P., Haber, S., Bragg, A., Ouslander, J., & Wiener, J. M. (2010). *Cost drivers for dually eligible beneficiaries: Potentially avoidable hospitalizations from long-term and post-acute care settings* (Report for the Centers for Medicare & Medicaid Services). Waltham, MA: RTI International.

Walsh, E. G., Wiener, J. M., Haber, S., Bragg, A., Freiman, M., & Ouslander, J. G. (2012). Potentially avoidable hospitalizations of dually eligible Medicare and Medicaid beneficiaries from nursing facility and home- and community-based services waiver programs. *Journal of the American Geriatrics Society, 60*, 821–829. https://doi.org/10.1111/j.1532-5415.2012.03920.x

Weaver, C. G., Ravani, P., Oliver, M. J., Austin, P. C., & Quinn, R. R. (2015). Analyzing hospitalization data: Potential limitations of Poisson regression. *Nephrology Dialysis Transplantation, 30,* 1244–1249. https://doi.org/10.1093/ndt/gfv071

Wright, B., Jung, H.-Y., Feng, Z., & Mor, V. (2014). Hospital, patient, and local health system characteristics associated with the prevalence and duration of observation care. *Health Services Research*, *49*, 1088–1107. https://doi.org/10.1111/1475-6773.12166

Appendix A:
Dropped Model Covariates

Covariate (interactions among HCCs or HCCS with disability status)
End Stage Renal Disease Status and Under 65
Artificial Openings and Pressure Ulcer
Aspiration and Specified Bacterial Pneumonias and Pressure Ulcer
Cancer and Disorders of Immunity
CHF and COPD/Cystic Fibrosis
Congestive Heart Failure and Renal Failure
COPD/Cystic Fibrosis and Bacterial Pneumonia
COPD/Cystic Fibrosis and Cardiac/Respiratory Failure
Diabetes and Congestive Heart Failure
Disabled and Opportunistic Infections
Disabled and Chronic Pancreatitis
Disabled and Bone/Joint/Muscle Infections/Necrosis
Disabled and Severe Hematological Disorders
Disabled and Drug/Alcohol Psychosis
Disabled and Drug/Alcohol Dependence
Disabled and Multiple Sclerosis
Disabled and Congestive Heart Failure
Disabled and Cystic Fibrosis
Disabled and Chronic Ulcer of Skin, Except Pressure
Disabled and Complications of Specified Implanted Device or Graft
Disabled and Pressure Ulcer
Schizophrenia and Congestive Heart Failure
Schizophrenia and COPD/Cystic Fibrosis
Schizophrenia and Seizures
Sepsis and Artificial Openings
Sepsis and Bacterial Pneumonia
Sepsis and Cardiac/Respiratory Failure
Sepsis and Pressure Ulcer
Substance Abuse Disorder and Psychiatric Disorder
CHF and Specified Heart Arrhythmias

RTI programming reference: MS 02.

Appendix B:
Number and Percentage of Beneficiaries by AH and AV Count, 2015–2017

Table B.1. Number and Percentage of Beneficiaries by AH Count, 2015-2017

	2015		2016		2017	
Count of AHs	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
0	29,188,645	96.53	29,756,804	96.91	29,756,031	97.40
1	743,021	2.46	682,623	2.22	585,226	1.92
2	223,657	0.74	196,331	0.64	1,58844	0.52
3	53,603	0.18	44,761	0.15	3,2984	0.11
4	17,196	0.06	13,829	0.05	9,856	0.03
5	6,430	0.02	5,131	0.02	3,601	0.01
6	2,750	0.01	2,257	0.01	1,592	0.01
7	1,334	0.00	1,049	0.00	775	0.00
8	752	0.00	550	0.00	465	0.00
9	415	0.00	371	0.00	235	0.00
10	250	0.00	235	0.00	161	0.00
11	178	0.00	136	0.00	110	0.00
12	105	0.00	84	0.00	85	0.00
13	72	0.00	63	0.00	51	0.00
14	57	0.00	51	0.00	44	0.00
15	35	0.00	35	0.00	26	0.00
16	37	0.00	27	0.00	17	0.00
17	17	0.00	15	0.00	19	0.00
18	15	0.00	10	0.00	10	0.00
19	9	0.00	18	0.00	9	0.00
20	5	0.00	11	0.00	6	0.00
21	7	0.00	2	0.00	3	0.00
22	3	0.00	5	0.00	2	0.00
23	3	0.00	3	0.00	3	0.00
24	6	0.00	2	0.00	3	0.00
25	1	0.00	2	0.00	2	0.00
26	1	0.00	1	0.00	2	0.00
27	0	0.00	0	0.00	2	0.00

(continued)

Table B.1. Number and Percentage of Beneficiaries by AH Count, 2015-2017 (continued)

	2015		2016		2017	
Count of AHs	**Number of Beneficiaries**	**Percentage of Beneficiaries**	**Number of Beneficiaries**	**Percentage of Beneficiaries**	**Number of Beneficiaries**	**Percentage of Beneficiaries**
28	2	0.00	2	0.00	0	0.00
29	1	0.00	2	0.00	0	0.00
30	0	0.00	3	0.00	0	0.00
31	0	0.00	0	0.00	0	0.00
32	0	0.00	1	0.00	0	0.00
33	1	0.00	0	0.00	0	0.00
34	0	0.00	1	0.00	1	0.00
35	0	0.00	0	0.00	0	0.00
36	0	0.00	0	0.00	0	0.00
37	1	0.00	0	0.00	1	0.00
38	0	0.00	0	0.00	0	0.00
39	0	0.00	0	0.00	1	0.00
40	0	0.00	0	0.00	—	—
41	0	0.00	0	0.00	—	—
42	1	0.00	0	0.00	—	—
43	0	0.00	0	0.00	—	—
44	0	0.00	0	0.00	—	—
45	0	0.00	0	0.00	—	—
46	0	0.00	0	0.00	—	—
47	1	0.00	1	0.00	—	—
48	—	—	0	0.00	—	—
49	—	—	0	0.00	—	—
50	—	—	0	0.00	—	—
51	—	—	1	0.00	—	—
Sum	30,238,611	100.00	30,704,417	100.00	30,550,167	100.00

— No beneficiary with the indicated count of events.

RTI programing reference: MS 02. AH = avoidable hospitalization.

Table B.2. Number and Percentage of Beneficiaries by AV Count, 2015-2017

	2015		2016		2017	
Count of AVs	**Number of Beneficiaries**	**Percentage of Beneficiaries**	**Number of Beneficiaries**	**Percentage of Beneficiaries**	**Number of Beneficiaries**	**Percentage of Beneficiaries**
0	28,415,209	93.97	28,902,454	94.13	28,732,160	94.05
1	1,498,942	4.96	1485478	4.84	1,505,691	4.93
2	229,425	0.76	224376	0.73	224,282	0.73
3	57,157	0.19	55,344	0.18	53,599	0.18
4	19,131	0.06	18,775	0.06	17,783	0.06
5	8,278	0.03	7,862	0.03	7,314	0.02
6	4,089	0.01	3,850	0.01	3,593	0.01
7	2,198	0.01	2,189	0.01	1,944	0.01
8	1,341	0.00	1,290	0.00	1,140	0.00
9	850	0.00	780	0.00	721	0.00
10	546	0.00	526	0.00	500	0.00
11	371	0.00	330	0.00	350	0.00
12	240	0.00	277	0.00	238	0.00
13	178	0.00	186	0.00	166	0.00
14	128	0.00	145	0.00	158	0.00
15	120	0.00	104	0.00	111	0.00
16	76	0.00	87	0.00	74	0.00
17	63	0.00	57	0.00	49	0.00
18	49	0.00	50	0.00	48	0.00
19	38	0.00	42	0.00	39	0.00
20	25	0.00	30	0.00	26	0.00
21	27	0.00	31	0.00	19	0.00
22	24	0.00	25	0.00	25	0.00
23	10	0.00	15	0.00	18	0.00
24	12	0.00	11	0.00	16	0.00
25	13	0.00	17	0.00	11	0.00
26	4	0.00	5	0.00	16	0.00
27	1	0.00	12	0.00	13	0.00
28	6	0.00	11	0.00	2	0.00
29	9	0.00	9	0.00	8	0.00
30	3	0.00	2	0.00	1	0.00
31	4	0.00	4	0.00	4	0.00
32	4	0.00	10	0.00	3	0.00

(continued)

Table B.2. Number and Percentage of Beneficiaries by AV Count, 2015-2017 (continued)

	2015		2016		2017	
Count of AVs	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
33	2	0.00	5	0.00	6	0.00
34	6	0.00	3	0.00	1	0.00
35	2	0.00	2	0.00	2	0.00
36	2	0.00	4	0.00	6	0.00
37	2	0.00	3	0.00	2	0.00
38	6	0.00	1	0.00	1	0.00
39	1	0.00	1	0.00	3	0.00
40	3	0.00	1	0.00	4	0.00
41	1	0.00	0	0.00	4	0.00
42	0	0.00	1	0.00	0	0.00
43	2	0.00	2	0.00	0	0.00
44	1	0.00	1	0.00	2	0.00
45	1	0.00	1	0.00	1	0.00
46	1	0.00	0	0.00	1	0.00
47	4	0.00	3	0.00	0	0.00
48	2	0.00	0	0.00	1	0.00
49	0	0.00	0	0.00	3	0.00
50	1	0.00	1	0.00	1	0.00
51	0	0.00	1	0.00	0	0.00
52	1	0.00	0	0.00	1	0.00
53	0	0.00	0	0.00	1	0.00
54	0	0.00	0	0.00	0	0.00
55	0	0.00	0	0.00	0	0.00
56	1	0.00	0	0.00	0	0.00
57	0	0.00	1	0.00	1	0.00
58	0	0.00	0	0.00	0	0.00
59	0	0.00	0	0.00	1	0.00
60	0	0.00	1	0.00	0	0.00
61	0	0.00	0	0.00	1	0.00
62	1	0.00	0	0.00	0	0.00
63	—	—	0	0.00	0	0.00
64	—	—	0	0.00	0	0.00

(continued)

Table B.2. Number and Percentage of Beneficiaries by AV Count, 2015-2017 (continued)

	2015		2016		2017	
Count of AVs	**Number of Beneficiaries**	**Percentage of Beneficiaries**	**Number of Beneficiaries**	**Percentage of Beneficiaries**	**Number of Beneficiaries**	**Percentage of Beneficiaries**
65	—	—	0	0.00	0	0.00
66	—	—	0	0.00	0	0.00
67	—	—	0	0.00	0	0.00
68	—	—	0	0.00	0	0.00
69	—	—	0	0.00	0	0.00
70	—	—	1	0.00	0	0.00
71	—	—	—	—	0	0.00
72	—	—	—	—	1	0.00
73	—	—	—	—	0	0.00
74	—	—	—	—	0	0.00
75	—	—	—	—	0	0.00
76	—	—	—	—	0	0.00
77	—	—	—	—	0	0.00
78	—	—	—	—	0	0.00
79	—	—	—	—	0	0.00
80	—	—	—	—	0	0.00
81	—	—	—	—	0	0.00
82	—	—	—	—	0	0.00
83	—	—	—	—	0	0.00
84	—	—	—	—	0	0.00
85	—	—	—	—	0	0.00
86	—	—	—	—	0	0.00
87	—	—	—	—	1	0.00
Sum	30,238,611	100.00	30,704,417	100.00	30,550,167	100.00

— No beneficiary with the indicated count of events.

RTI programming reference: MS 02. AV = avoidable emergency department (ED) visit.

Appendix C:
Frequency of AHs and AVs, by Condition and Year

Table C.1. Frequency of AHs and AVs, by Condition and Year

Condition	2015				2016				2017			
	AH Counts	Percentage of Total	AV Counts	Percentage of Total	AH Counts	Percentage of Total	AV Counts	Percentage of Total	AH Counts	Percentage of Total	AV Counts	Percentage of Total
Diabetes Short-Term	52,356	3.5%	33,872	1.5%	80,121	6.0%	109,727	4.8%	76,284	7.0%	113,310	4.9%
Diabetes Long-Term	82,258	5.5%	54,813	2.3%	64,816	4.9%	25,460	1.1%	81,857	7.5%	31,874	1.4%
COPD	257,025	17.2%	218,938	9.4%	275,764	20.8%	228,347	9.9%	307,388	28.3%	235,121	10.2%
Asthma	56,472	3.8%	87,599	3.8%	26,580	2.0%	70,934	3.1%	26,083	2.4%	69,169	3.0%
Hypertension[1]	53,545	3.6%	203,848	8.7%	35,085	2.6%	205,502	8.9%	14,130	1.3%	195,226	8.5%
Heart Failure[1]	362,833	24.2%	76,293	3.3%	281,876	21.2%	73,502	3.2%	73,957	6.8%	50,347	2.2%
Bacterial Pneumonia	261,642	17.5%	131,491	5.6%	212,602	16.0%	129,505	5.6%	171,630	15.8%	132,808	5.8%
UTI	217,087	14.5%	446,022	19.1%	210,539	15.9%	464,154	20.2%	204,592	18.8%	463,305	20.1%
Cellulitis	145,508	9.7%	252,249	10.8%	132,758	10.0%	193,993	8.4%	123,707	11.4%	189,298	8.2%
Pressure Ulcers	9,061	0.6%	5,842	0.3%	8,076	0.6%	1,851	0.1%	7,568	0.7%	1,850	0.1%
URI/Otitis/ Rhinitis	—	—	367,290	15.7%	—	—	360,204	15.7%	—	—	376,543	16.4%
Influenza	—	—	32,967	1.4%	—	—	22,328	1.0%	—	—	58,278	2.5%
Non-Specific Back Pain	—	—	421,448	18.1%	—	—	412,926	18.0%	—	—	383,569	16.7%
Chronic	864,489	57.7%	675,363	29.0%	764,242	57.5%	713,472	31.0%	579,699	53.3%	695,047	30.2%
Acute	633,298	42.3%	1,657,309	71.0%	563,975	42.5%	1,584,961	69.0%	507,497	46.7%	1,605,651	69.8%
Total	1,497,787	100.0%	2,332,672	100.0%	1,328,217	100.0%	2,298,433	100.0%	1,087,196	100.0%	2,300,698	100.0%

[1] The decline in the frequency of AHs and AVs for hypertension and heart failure in 2016 and 2017, relative to 2015, is partly due to changes in the medical coding of these two conditions. A number of new ICD-10 codes were added for these two conditions (at the end of 2016 and 2017) but were not captured in our definition of AHs and AVs analyzed and reported here.

RTI programming reference: C ZF 02. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit. Dashes (–) = Not applicable to AHs.

Appendix D:
AH and AV Risk Adjustment Model Results, 2015–2017

Table D.1. ZINB Model Results Predicting the Count of AHs, 2015–2017

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Male Less Than 65 Years of Age	−0.405	<0.001	0.172	<0.001	−0.345	<0.001	0.234	<0.001	−0.319	<0.001	0.229	<0.001
Male Aged 65–69	0.024	0.050	−0.118	<0.001	0.037	0.004	−0.102	<0.001	−0.002	0.891	−0.146	<0.001
Male Aged 70–74	−0.107	<0.001	−0.119	<0.001	−0.111	<0.001	−0.133	<0.001	−0.138	<0.001	−0.162	<0.001
Male Aged 75–79	−0.448	<0.001	−0.124	<0.001	−0.430	<0.001	−0.127	<0.001	−0.465	<0.001	−0.148	<0.001
Male Aged 80–84	−0.901	<0.001	−0.100	<0.001	−0.892	<0.001	−0.121	<0.001	−0.940	<0.001	−0.148	<0.001
Male Aged 85–89	−1.495	<0.001	−0.096	<0.001	−1.483	<0.001	−0.128	<0.001	−1.447	<0.001	−0.129	<0.001
Male Aged 90–94	−2.052	<0.001	−0.038	0.003	−2.023	<0.001	−0.087	<0.001	−2.062	<0.001	−0.085	<0.001
Male Aged 95+	−2.506	<0.001	−0.044	0.070	−2.450	<0.001	−0.045	0.072	−2.641	<0.001	−0.078	0.004
Female Less Than 65 Years of Age	−0.506	<0.001	0.257	<0.001	−0.466	<0.001	0.295	<0.001	−0.453	<0.001	0.305	<0.001
Female Aged 70–74	−0.187	<0.001	0.004	0.631	−0.188	<0.001	0.006	0.530	−0.196	<0.001	0.003	0.750
Female Aged 75–79	−0.594	<0.001	−0.005	0.527	−0.581	<0.001	0.006	0.487	−0.591	<0.001	−0.005	0.582
Female Aged 80–84	−1.103	<0.001	<0.001	0.990	−1.097	<0.001	−0.001	0.873	−1.137	<0.001	−0.017	0.077
Female Aged 85–89	−1.671	<0.001	−0.005	0.579	−1.691	<0.001	−0.030	0.001	−1.724	<0.001	−0.029	0.004
Female Aged 90–94	−2.265	<0.001	−0.017	0.092	−2.277	<0.001	−0.028	0.008	−2.296	<0.001	−0.034	0.004
Female Aged 95+	−2.433	<0.001	−0.045	0.002	−2.459	<0.001	−0.070	<0.001	−2.541	<0.001	−0.062	<0.001
End Stage Renal Disease Status	−1.849	<0.001	0.339	<0.001	−1.600	<0.001	0.309	<0.001	−1.659	<0.001	0.190	<0.001
Aged and Originally Eligible Due to Disability	−0.688	<0.001	0.130	<0.001	−0.665	<0.001	0.135	<0.001	−0.652	<0.001	0.150	<0.001
HIV/Aids	−0.188	<0.001	−0.013	0.579	0.028	0.509	−0.029	0.261	−0.173	<0.001	−0.136	<0.001
Septicemia, Sepsis, Systemic Inflam Response Syndrome/Shock	−0.940	<0.001	−0.015	0.007	−0.814	<0.001	0.027	<0.001	−0.965	<0.001	0.094	<0.001
Opportunistic Infections	−0.303	<0.001	0.148	<0.001	−0.284	<0.001	0.180	<0.001	−0.325	<0.001	0.185	<0.001

(continued)

Table D.1. ZINB Model Results Predicting the Count of AHs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Metastatic Cancer and Acute Leukemia	−0.660	<0.001	−0.094	<0.001	−0.553	<0.001	−0.054	<0.001	−0.666	<0.001	−0.046	0.001
Lung and Other Severe Cancers	−0.500	<0.001	0.049	<0.001	−0.408	<0.001	0.048	<0.001	−0.440	<0.001	0.081	<0.001
Lymphoma and Other Cancers	−0.246	<0.001	<0.001	0.998	−0.233	<0.001	0.010	0.435	−0.307	<0.001	−0.018	0.187
Colorectal, Bladder, and Other Cancers	−0.065	<0.001	−0.028	0.003	−0.042	0.027	−0.021	0.036	−0.103	<0.001	−0.024	0.035
Breast, Prostate, and Other Cancers and Tumors	0.169	<0.001	−0.031	<0.001	0.148	<0.001	−0.026	<0.001	0.133	<0.001	−0.034	<0.001
Diabetes With Acute Complications	−1.367	<0.001	0.842	<0.001	−1.340	<0.001	0.825	<0.001	−1.475	<0.001	0.906	<0.001
Diabetes With Chronic Complications	−0.831	<0.001	0.201	<0.001	−0.807	<0.001	0.188	<0.001	−0.811	<0.001	0.172	<0.001
Diabetes Without Complication	−0.444	<0.001	0.075	<0.001	−0.422	<0.001	0.044	<0.001	−0.387	<0.001	0.015	0.016
Protein-Calorie Malnutrition	−0.673	<0.001	−0.044	<0.001	−0.559	<0.001	−0.021	0.003	−0.663	<0.001	0.001	0.884
Morbid Obesity	−0.386	<0.001	0.110	<0.001	−0.387	<0.001	0.099	<0.001	−0.345	<0.001	0.064	<0.001
Other Significant Endocrine and Metabolic Disorders	−0.050	<0.001	0.041	<0.001	−0.020	0.153	0.039	<0.001	−0.005	0.731	0.029	<0.001
End-Stage Liver Disease	−0.518	<0.001	−0.094	<0.001	−0.448	<0.001	−0.101	<0.001	−0.591	<0.001	−0.091	<0.001
Cirrhosis of Liver	−0.329	<0.001	−0.002	0.867	−0.312	<0.001	0.016	0.303	−0.283	<0.001	0.009	0.577
Chronic Hepatitis	−0.083	0.008	0.077	<0.001	−0.022	0.475	0.087	<0.001	−0.060	0.077	0.056	0.002
Intestinal Obstruction/Perforation	−0.122	<0.001	−0.057	<0.001	−0.144	<0.001	−0.064	<0.001	−0.181	<0.001	−0.040	<0.001
Chronic Pancreatitis	−0.190	<0.001	0.188	<0.001	−0.133	0.003	0.209	<0.001	−0.176	<0.001	0.221	<0.001
Inflammatory Bowel Disease	0.004	0.862	−0.009	0.482	0.058	0.025	0.038	0.006	−0.007	0.811	−0.005	0.743
Bone/Joint/Muscle Infections/Necrosis	−0.288	<0.001	0.103	<0.001	−0.277	<0.001	0.108	<0.001	−0.269	<0.001	0.194	<0.001
Rheumatoid Arthritis and Inflam Connective Tissue Disease	−0.193	<0.001	−0.003	0.652	−0.175	<0.001	0.004	0.453	−0.180	<0.001	0.012	0.054
Severe Hematological Disorders	−0.440	<0.001	0.079	<0.001	−0.292	<0.001	0.060	<0.001	−0.260	<0.001	0.023	0.194

(continued)

Table D.1. ZINB Model Results Predicting the Count of AHs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Disorders of Immunity	−0.242	<0.001	0.042	<0.001	−0.125	<0.001	−0.010	0.300	−0.094	<0.001	0.025	0.017
Coagulation Defects & Oth Specified Hematological Disordrs	−0.142	<0.001	−0.006	0.260	−0.135	<0.001	−0.015	0.008	−0.154	<0.001	−0.041	<0.001
Drug/Alcohol Psychosis	−0.392	<0.001	0.167	<0.001	−0.256	<0.001	0.186	<0.001	−0.429	<0.001	0.031	0.225
Drug/Alcohol Dependence	−0.114	<0.001	0.226	<0.001	−0.095	<0.001	0.235	<0.001	−0.144	<0.001	0.242	<0.001
Schizophrenia	−0.027	0.119	0.025	0.017	−0.083	<0.001	0.025	0.022	−0.139	<0.001	0.058	<0.001
Major Depressive, Bipolar, and Paranoid Disorders	−0.079	<0.001	0.059	<0.001	−0.113	<0.001	0.055	<0.001	−0.128	<0.001	0.079	<0.001
Quadriplegia	−1.134	<0.001	0.120	<0.001	−1.093	<0.001	0.098	<0.001	−1.240	<0.001	0.072	<0.001
Paraplegia	−1.025	<0.001	0.195	<0.001	−0.946	<0.001	0.234	<0.001	−1.206	<0.001	0.180	<0.001
Spinal Cord Disorders/Injuries	−0.258	<0.001	0.030	0.038	−0.233	<0.001	0.035	0.026	−0.273	<0.001	−0.019	0.268
Amyotrophic Lateral Sclerosis & Oth Motor Neuron Disease	−0.240	0.052	−0.131	0.019	−0.349	0.005	−0.104	0.066	−0.456	0.002	−0.139	0.030
Cerebral Palsy	−0.198	<0.001	−0.049	0.060	−0.255	<0.001	−0.058	0.028	−0.440	<0.001	−0.117	<0.001
Myasthenia Gravis/Myoneural Disorders, Inflammatory & Toxic Neuropathy	−0.167	<0.001	−0.004	0.732	−0.212	<0.001	0.005	0.667	−0.203	<0.001	0.018	0.194
Muscular Dystrophy	−0.285	0.004	−0.128	0.014	−0.354	<0.001	−0.131	0.012	−0.443	<0.001	−0.074	0.171
Multiple Sclerosis	−0.333	<0.001	−0.018	0.315	−0.442	<0.001	−0.029	0.109	−0.426	<0.001	0.007	0.708
Parkinsons and Huntingtons Diseases	−0.762	<0.001	0.017	0.074	−0.807	<0.001	0.029	0.003	−0.850	<0.001	0.077	<0.001
Seizure Disorders and Convulsions	−0.228	<0.001	0.015	0.021	−0.219	<0.001	0.038	<0.001	−0.251	<0.001	0.046	<0.001
Coma, Brain Compression/Anoxic Damage	−0.121	0.063	−0.242	<0.001	−0.105	0.097	−0.215	<0.001	−0.220	0.001	−0.196	<0.001

(continued)

Table D.1. ZINB Model Results Predicting the Count of AHs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Respirator Dependence/Tracheostomy Status	−0.449	<0.001	0.053	<0.001	−0.262	<0.001	0.068	<0.001	−0.390	<0.001	0.040	0.018
Respiratory Arrest	−0.637	0.001	0.244	<0.001	−0.582	0.002	0.249	<0.001	−0.469	0.012	0.331	<0.001
Cardio-Respiratory Failure and Shock	−0.967	<0.001	0.316	<0.001	−1.031	<0.001	0.328	<0.001	−1.218	<0.001	0.327	<0.001
Congestive Heart Failure	−0.794	<0.001	0.346	<0.001	−0.773	<0.001	0.303	<0.001	−0.561	<0.001	0.187	<0.001
Acute Myocardial Infarction	−0.184	<0.001	0.100	<0.001	−0.207	<0.001	0.079	<0.001	−0.137	<0.001	−0.002	0.840
Unstable Angina & Oth Acute Ischemic Heart Disease	−0.073	<0.001	0.156	<0.001	−0.085	<0.001	0.109	<0.001	−0.029	0.226	0.058	<0.001
Angina Pectoris	−0.003	0.842	0.058	<0.001	0.010	0.553	0.072	<0.001	−0.011	0.508	0.036	<0.001
Specified Heart Arrhythmias	−0.424	<0.001	0.143	<0.001	−0.420	<0.001	0.130	<0.001	−0.355	<0.001	0.053	<0.001
Cerebral Hemorrhage	−0.296	<0.001	−0.119	<0.001	−0.315	<0.001	−0.120	<0.001	−0.282	<0.001	−0.090	<0.001
Ischemic or Unspecified Stroke	−0.376	<0.001	0.004	0.560	−0.391	<0.001	−0.017	0.009	−0.389	<0.001	−0.005	0.528
Hemiplegia/Hemiparesis	−0.472	<0.001	−0.018	0.051	−0.434	<0.001	0.002	0.857	−0.520	<0.001	0.019	0.047
Monoplegia, Other Paralytic Syndromes	−0.394	<0.001	0.029	0.304	−0.231	0.001	0.022	0.465	−0.517	<0.001	<0.001	0.994
Atherosclerosis of Extremities W/Ulceration or Gangrene	−1.688	<0.001	0.207	<0.001	−1.588	<0.001	0.233	<0.001	−1.810	<0.001	0.352	<0.001
Vascular Disease With Complications	−0.385	<0.001	0.065	<0.001	−0.384	<0.001	0.053	<0.001	−0.428	<0.001	0.079	<0.001
Vascular Disease	−0.306	<0.001	0.025	<0.001	−0.313	<0.001	0.014	0.001	−0.331	<0.001	0.019	<0.001
Cystic Fibrosis	−0.646	<0.001	0.142	0.063	−0.564	0.001	0.175	0.031	−0.752	<0.001	0.104	0.239
Chronic Obstructive Pulmonary Disease	−1.449	<0.001	0.345	<0.001	−1.421	<0.001	0.358	<0.001	−1.527	<0.001	0.427	<0.001
Fibrosis of Lung and Other Chronic Lung Disorders	−0.633	<0.001	−0.003	0.836	−0.667	<0.001	−0.047	0.001	−0.803	<0.001	−0.045	0.006

(continued)

Table D.1. ZINB Model Results Predicting the Count of AHs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Aspiration and Specified Bacterial Pneumonias	−0.870	<0.001	0.038	<0.001	−0.779	<0.001	0.038	<0.001	−0.915	<0.001	0.079	<0.001
Pneumococcal Pneumonia, Empyema, Lung Abscess	−0.689	<0.001	0.104	<0.001	−0.713	<0.001	0.142	<0.001	−0.858	<0.001	0.218	<0.001
Proliferative Diabtic Retinopathy & Vitreous Hemorr	−0.430	<0.001	0.095	<0.001	−0.480	<0.001	0.103	<0.001	−0.536	<0.001	0.146	<0.001
Exudative Macular Degeneration	−0.031	0.102	0.032	0.001	−0.058	0.004	0.039	<0.001	−0.063	0.006	0.030	0.008
Dialysis Status	0.310	<0.001	−0.256	<0.001	0.577	<0.001	−0.357	<0.001	0.789	<0.001	−0.291	<0.001
Acute Renal Failure	−0.743	<0.001	0.148	<0.001	−0.689	<0.001	0.146	<0.001	−0.734	<0.001	0.066	<0.001
Chronic Kidney Disease, Stage 5	−0.385	<0.001	−0.174	<0.001	−0.091	0.031	−0.100	<0.001	0.034	0.535	−0.092	<0.001
Chronic Kidney Disease, Severe (Stage 4)	−0.718	<0.001	0.099	<0.001	−0.601	<0.001	0.071	<0.001	−0.642	<0.001	−0.041	0.005
Press Ulcer of Skn W/Necrosis Thr To Muscle,Tendon, Bone	−3.632	<0.001	0.121	<0.001	−2.701	<0.001	0.110	<0.001	−2.447	<0.001	0.177	<0.001
Pressure Ulcer of Skin With Full Thickness Skin Loss	−1.768	<0.001	0.012	0.360	−1.828	<0.001	0.052	<0.001	−1.740	<0.001	0.134	<0.001
Chronic Ulcer of Skin, Except Pressure	−0.919	<0.001	0.131	<0.001	−0.931	<0.001	0.152	<0.001	−1.122	<0.001	0.231	<0.001
Severe Skin Burn or Condition	−0.210	0.283	−0.127	0.075	−0.483	0.006	0.032	0.630	−0.397	0.040	−0.084	0.249
Severe Head Injury	−0.315	0.202	−0.466	<0.001	0.124	0.635	−0.214	0.041	−0.304	0.323	−0.237	0.037
Major Head Injury	−0.067	0.048	−0.024	0.111	−0.100	0.003	−0.013	0.395	−0.111	0.004	−0.024	0.150
Vertebral Fractures Without Spinal Cord Injury	−0.372	<0.001	0.103	<0.001	−0.332	<0.001	0.127	<0.001	−0.362	<0.001	0.142	<0.001
Hip Fracture/Dislocation	−0.286	<0.001	−0.077	<0.001	−0.334	<0.001	−0.082	<0.001	−0.398	<0.001	−0.073	<0.001

(continued)

Table D.1. ZINB Model Results Predicting the Count of AHs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Traumatic Amputations and Complications	−0.328	<0.001	−0.045	0.001	−0.354	<0.001	−0.059	<0.001	−0.439	<0.001	−0.084	<0.001
Complications of Specified Implanted Device or Graft	−0.083	<0.001	0.003	0.643	−0.107	<0.001	0.014	0.069	−0.123	<0.001	0.023	0.005
Major Organ Transplant or Replacement Status	−0.313	<0.001	−0.271	<0.001	0.085	0.139	−0.379	<0.001	−0.042	0.499	−0.401	<0.001
Artificial Openings for Feeding or Elimination	−0.649	<0.001	−0.066	<0.001	−0.698	<0.001	−0.081	<0.001	−0.785	<0.001	−0.053	<0.001
Amputation Status, Lower Limb/Amputation Complications	−0.770	<0.001	0.198	<0.001	−0.744	<0.001	0.211	<0.001	−0.807	<0.001	0.271	<0.001
Constant	2.623	<0.001	−2.095	<0.001	2.633	<0.001	−2.213	<0.001	2.617	<0.001	−2.400	<0.001
Ln(α)	1.052	<0.001			1.123	<0.001			1.300	<0.001		
Dispersion Parameter (α)	2.863				3.073				3.669			

RTI programming reference: MS 02. The age-sex category *Female 65-69* served as the reference group for this analysis. AH = avoidable hospitalization. ZINB = Zero-Inflated Negative Binomial.

Table D.2. ZINB Model Results Predicting the Count of AVs, 2015–2017

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Male less than 65 years of age	−0.596	<0.001	0.533	<0.001	−0.518	<0.001	0.528	<0.001	−0.453	<0.001	0.487	<0.001
Male aged 65–69	0.233	<0.001	−0.209	<0.001	0.244	<0.001	−0.213	<0.001	0.194	<0.001	−0.225	<0.001
Male aged 70–74	0.134	<0.001	−0.238	<0.001	0.135	<0.001	−0.254	<0.001	0.061	<0.001	−0.278	<0.001
Male aged 75–79	−0.131	<0.001	−0.236	<0.001	−0.106	<0.001	−0.232	<0.001	−0.137	<0.001	−0.229	<0.001
Male aged 80–84	−0.436	<0.001	−0.192	<0.001	−0.421	<0.001	−0.200	<0.001	−0.482	<0.001	−0.194	<0.001
Male aged 85–89	−0.863	<0.001	−0.167	<0.001	−0.798	<0.001	−0.176	<0.001	−0.888	<0.001	−0.160	<0.001
Male aged 90–94	−1.279	<0.001	−0.139	<0.001	−1.209	<0.001	−0.140	<0.001	−1.251	<0.001	−0.106	<0.001
Male aged 95+	−1.340	<0.001	−0.119	<0.001	−1.313	<0.001	−0.116	<0.001	−1.319	<0.001	−0.104	<0.001
Female less than 65 years of age	−1.213	<0.001	0.731	<0.001	−1.181	<0.001	0.722	<0.001	−1.113	<0.001	0.687	<0.001
Female aged 70–74	−0.093	<0.001	−0.006	0.334	−0.080	<0.001	0.001	0.902	−0.086	<0.001	<0.001	0.970
Female aged 75–79	−0.406	<0.001	0.006	0.335	−0.415	<0.001	0.011	0.082	−0.397	<0.001	0.026	<0.001
Female aged 80–84	−0.835	<0.001	0.012	0.061	−0.824	<0.001	0.024	<0.001	−0.823	<0.001	0.047	<0.001
Female aged 85–89	−1.339	<0.001	−0.004	0.551	−1.322	<0.001	0.015	0.034	−1.304	<0.001	0.046	<0.001
Female aged 90–94	−1.958	<0.001	−0.048	<0.001	−1.854	<0.001	−0.030	0.001	−1.984	<0.001	−0.008	0.327
Female aged 95+	−1.519	<0.001	−0.099	<0.001	−1.504	<0.001	−0.094	<0.001	−1.615	<0.001	−0.071	<0.001
Final End Stage Renal Disease	−2.339	<0.001	0.030	0.006	−1.316	<0.001	−0.082	<0.001	−1.245	<0.001	−0.096	<0.001
Final disabled status	−0.675	<0.001	0.299	<0.001	−0.653	<0.001	0.304	<0.001	−0.659	<0.001	0.298	<0.001
HIV/AIDS	−0.634	<0.001	0.054	<0.001	−0.417	<0.001	0.014	0.318	−0.492	<0.001	0.025	0.086
Septicemia, Sepsis, Systemic Inflam Response Syndrome/Shock	−3.299	<0.001	0.083	<0.001	−3.504	<0.001	0.088	<0.001	−3.146	<0.001	0.115	<0.001
Opportunistic Infections	−0.185	0.015	0.093	<0.001	−0.346	<0.001	0.081	<0.001	−0.435	<0.001	0.073	<0.001
Metastatic Cancer And Acute Leukemia	−0.828	<0.001	−0.162	<0.001	−0.709	<0.001	−0.172	<0.001	−0.587	<0.001	−0.157	<0.001

(continued)

Table D.2. ZINB Model Results Predicting the Count of AVs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Lung And Other Severe Cancers	−0.576	<0.001	−0.066	<0.001	−0.382	<0.001	−0.052	<0.001	−0.408	<0.001	−0.062	<0.001
Lymphoma And Other Cancers	−0.286	<0.001	−0.072	<0.001	−0.207	<0.001	−0.083	<0.001	−0.264	<0.001	−0.084	<0.001
Colorectal, Bladder, And Other Cancers	−0.242	<0.001	−0.051	<0.001	−0.168	<0.001	−0.044	<0.001	−0.225	<0.001	−0.054	<0.001
Breast, Prostate, And Other Cancers And Tumors	−0.039	0.009	−0.072	<0.001	0.022	0.140	−0.071	<0.001	0.007	0.640	−0.070	<0.001
Diabetes With Acute Complications	−0.546	<0.001	0.591	<0.001	−0.347	<0.001	0.732	<0.001	−0.302	<0.001	0.769	<0.001
Diabetes With Chronic Complications	−0.721	<0.001	0.199	<0.001	−0.678	<0.001	0.250	<0.001	−0.686	<0.001	0.248	<0.001
Diabetes Without Complication	−0.418	<0.001	0.094	<0.001	−0.419	<0.001	0.096	<0.001	−0.412	<0.001	0.071	<0.001
Protein-Calorie Malnutrition	−0.962	<0.001	−0.058	<0.001	−0.829	<0.001	−0.055	<0.001	−0.892	<0.001	−0.041	<0.001
Morbid Obesity	−0.635	<0.001	0.140	<0.001	−0.588	<0.001	0.121	<0.001	−0.554	<0.001	0.104	<0.001
Other Significant Endocrine And Metabolic Disorders	−0.186	<0.001	0.010	0.048	−0.176	<0.001	0.013	0.009	−0.151	<0.001	0.017	<0.001
End-Stage Liver Disease	−0.927	<0.001	−0.103	<0.001	−0.961	<0.001	−0.074	<0.001	−0.739	<0.001	−0.053	<0.001
Cirrhosis Of Liver	−0.541	<0.001	−0.043	<0.001	−0.527	<0.001	0.005	0.668	−0.407	<0.001	0.007	0.558
Chronic Hepatitis	−0.339	<0.001	0.143	<0.001	−0.376	<0.001	0.133	<0.001	−0.467	<0.001	0.098	<0.001
Intestinal Obstruction/Perforation	−0.788	<0.001	0.071	<0.001	−0.745	<0.001	0.056	<0.001	−0.797	<0.001	0.069	<0.001
Chronic Pancreatitis	−0.536	<0.001	0.188	<0.001	−0.340	<0.001	0.271	<0.001	−0.449	<0.001	0.251	<0.001
Inflammatory Bowel Disease	−0.121	0.001	0.020	0.036	−0.084	0.014	0.020	0.035	−0.152	<0.001	0.011	0.243
Bone/Joint/Muscle Infections/Necrosis	−0.384	<0.001	0.004	0.648	−0.309	<0.001	−0.008	0.293	−0.412	<0.001	0.016	0.041
Rheumatoid Arthritis And Inflam Connective Tissue Disease	−0.352	<0.001	0.059	<0.001	−0.359	<0.001	0.063	<0.001	−0.372	<0.001	0.083	<0.001
Severe Hematological Disorders	−0.576	<0.001	0.024	0.054	−0.699	<0.001	−0.028	0.027	−0.580	<0.001	0.006	0.608
Disorders Of Immunity	−0.262	<0.001	0.004	0.580	−0.234	<0.001	−0.014	0.063	−0.214	<0.001	−0.006	0.427

(continued)

Table D.2. ZINB Model Results Predicting the Count of AVs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Coagulation Defects & Oth Specified Hematological Disordrs	−0.206	<0.001	−0.008	0.086	−0.248	<0.001	−0.019	<0.001	−0.336	<0.001	−0.029	<0.001
Drug/Alcohol Psychosis	−1.292	<0.001	0.437	<0.001	−1.114	<0.001	0.401	<0.001	−1.320	<0.001	0.145	<0.001
Drug/Alcohol Dependence	−0.550	<0.001	0.368	<0.001	−0.522	<0.001	0.342	<0.001	−0.507	<0.001	0.344	<0.001
Schizophrenia	0.222	<0.001	0.248	<0.001	0.213	<0.001	0.266	<0.001	0.284	<0.001	0.299	<0.001
Major Depressive, Bipolar, And Paranoid Disorders	−0.425	<0.001	0.166	<0.001	−0.430	<0.001	0.153	<0.001	−0.398	<0.001	0.139	<0.001
Quadriplegia	−0.584	<0.001	0.209	<0.001	−0.665	<0.001	0.119	<0.001	−0.744	<0.001	0.123	<0.001
Paraplegia	−0.624	<0.001	0.303	<0.001	−0.575	<0.001	0.280	<0.001	−0.425	<0.001	0.296	<0.001
Spinal Cord Disorders/Injuries	−0.285	<0.001	0.126	<0.001	−0.288	<0.001	0.120	<0.001	−0.281	<0.001	0.127	<0.001
Amyotrophic Lateral Sclerosis & Oth Motor Neuron Disease	−0.289	0.135	−0.146	0.001	−0.394	0.055	−0.190	<0.001	−0.212	0.285	−0.140	0.002
Cerebral Palsy	0.244	<0.001	−0.039	0.024	0.277	<0.001	−0.031	0.070	0.302	<0.001	0.020	0.228
Myasthenia Gravis/Myoneural Disorders, Inflammatory & Toxic Neuropathy	−0.481	<0.001	−0.063	<0.001	−0.437	<0.001	−0.041	<0.001	−0.375	<0.001	−0.036	<0.001
Muscular Dystrophy	−0.201	0.175	−0.080	0.030	−0.182	0.216	−0.122	0.001	−0.156	0.275	−0.108	0.003
Multiple Sclerosis	0.114	0.009	−0.095	<0.001	0.073	0.097	−0.099	<0.001	0.158	<0.001	−0.077	<0.001
Parkinsons And Huntingtons Diseases	−0.673	<0.001	0.025	0.002	−0.654	<0.001	0.060	<0.001	−0.698	<0.001	0.045	<0.001
Seizure Disorders And Convulsions	−0.158	<0.001	0.099	<0.001	−0.164	<0.001	0.105	<0.001	−0.203	<0.001	0.097	<0.001
Coma, Brain Compression/Anoxic Damage	−0.282	0.026	−0.157	<0.001	−0.573	<0.001	−0.143	<0.001	−0.779	<0.001	−0.115	<0.001
Respirator Dependence/Tracheostomy Status	−1.518	<0.001	−0.112	<0.001	−1.419	<0.001	−0.103	<0.001	−0.969	<0.001	−0.086	<0.001

(continued)

Table D.2. ZINB Model Results Predicting the Count of AVs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Respiratory Arrest	−11.780	0.983	0.098	0.004	−2.308	0.184	0.090	0.015	−0.863	0.109	0.220	<0.001
Cardio-Respiratory Failure And Shock	−1.187	<0.001	0.164	<0.001	−1.362	<0.001	0.184	<0.001	−1.774	<0.001	0.186	<0.001
Congestive Heart Failure	−0.514	<0.001	0.167	<0.001	−0.516	<0.001	0.157	<0.001	−0.515	<0.001	0.129	<0.001
Acute Myocardial Infarction	−0.819	<0.001	0.075	<0.001	−0.720	<0.001	0.088	<0.001	−0.662	<0.001	0.078	<0.001
Unstable Angina & Oth Acute Ischemic Heart Disease	−0.468	<0.001	0.141	<0.001	−0.528	<0.001	0.135	<0.001	−0.659	<0.001	0.122	<0.001
Angina Pectoris	−0.350	<0.001	0.079	<0.001	−0.403	<0.001	0.083	<0.001	−0.398	<0.001	0.086	<0.001
Specified Heart Arrhythmias	−0.508	<0.001	0.018	<0.001	−0.517	<0.001	0.017	<0.001	−0.561	<0.001	0.008	0.012
Cerebral Hemorrhage	−0.462	<0.001	−0.092	<0.001	−0.581	<0.001	−0.095	<0.001	−0.546	<0.001	−0.118	<0.001
Ischemic Or Unspecified Stroke	−0.589	<0.001	0.005	0.313	−0.661	<0.001	0.008	0.150	−0.605	<0.001	0.028	<0.001
Hemiplegia/Hemiparesis	−0.287	<0.001	−0.022	0.006	−0.289	<0.001	0.002	0.762	−0.284	<0.001	0.024	0.001
Monoplegia, Other Paralytic Syndromes	−0.417	0.001	0.035	0.139	−0.414	0.001	0.003	0.914	−0.426	0.001	0.024	0.307
Atherosclerosis Of Extremities W/Ulceration Or Gangrene	−1.522	<0.001	−0.068	<0.001	−1.213	<0.001	−0.065	<0.001	−1.182	<0.001	−0.022	0.029
Vascular Disease With Complications	−0.820	<0.001	−0.013	0.026	−0.721	<0.001	−0.019	0.002	−0.740	<0.001	0.002	0.705
Vascular Disease	−0.505	<0.001	−0.043	<0.001	−0.512	<0.001	−0.053	<0.001	−0.512	<0.001	−0.043	<0.001
Cystic Fibrosis	0.120	0.631	0.073	0.224	−0.087	0.746	0.149	0.009	−0.694	0.073	−0.013	0.823
Chronic Obstructive Pulmonary Disease	−0.996	<0.001	0.478	<0.001	−0.968	<0.001	0.478	<0.001	−0.983	<0.001	0.484	<0.001
Fibrosis Of Lung And Other Chronic Lung Disorders	−0.570	<0.001	0.047	<0.001	−0.598	<0.001	0.051	<0.001	−0.698	<0.001	0.038	<0.001
Aspiration And Specified Bacterial Pneumonias	−2.681	<0.001	0.003	0.718	−2.923	<0.001	0.011	0.134	−2.998	<0.001	0.023	0.001

(continued)

Table D.2. ZINB Model Results Predicting the Count of AVs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Pneumococcal Pneumonia, Empyema, Lung Abscess	−0.900	<0.001	0.121	<0.001	−0.911	<0.001	0.136	<0.001	−1.178	<0.001	0.214	<0.001
Proliferative Diabtic Retinopathy & Vitreous Hemorr	−0.198	<0.001	0.056	<0.001	−0.237	<0.001	0.058	<0.001	−0.286	<0.001	0.105	<0.001
Exudative Macular Degeneration	−0.066	0.034	0.015	0.074	−0.042	0.174	0.028	0.001	−0.049	0.113	0.040	<0.001
Dialysis Status	−1.720	<0.001	−0.069	<0.001	0.121	0.209	−0.211	<0.001	0.140	0.141	−0.235	<0.001
Acute Renal Failure	−1.545	<0.001	0.074	<0.001	−1.549	<0.001	0.075	<0.001	−1.631	<0.001	0.063	<0.001
Chronic Kidney Disease, Stage 5	−1.075	<0.001	−0.177	<0.001	−0.657	<0.001	−0.176	<0.001	−0.427	<0.001	−0.145	<0.001
Chronic Kidney Disease, Severe (Stage 4)	−0.520	<0.001	0.065	<0.001	−0.472	<0.001	0.029	0.012	−0.592	<0.001	0.003	0.810
Press Ulcer Of Skn W/Necrosis Thr To Muscle,Tendon, Bone	−1.295	0.004	0.064	0.001	−1.069	0.004	−0.021	0.258	−0.971	0.003	−0.060	0.001
Pressure Ulcer Of Skin With Full Thickness Skin Loss	−1.632	<0.001	−0.062	<0.001	−1.718	<0.001	−0.063	<0.001	−1.514	<0.001	−0.074	<0.001
Chronic Ulcer Of Skin, Except Pressure	−0.514	<0.001	0.066	<0.001	−0.495	<0.001	0.079	<0.001	−0.500	<0.001	0.101	<0.001
Severe Skin Burn Or Condition	−0.935	0.042	−0.029	0.606	−0.608	0.064	0.087	0.092	−0.528	0.100	0.025	0.631
Severe Head Injury	−0.127	0.735	−0.238	0.001	0.190	0.569	−0.148	0.055	0.180	0.606	−0.057	0.478
Major Head Injury	−0.206	<0.001	−0.013	0.284	−0.219	<0.001	0.009	0.432	−0.273	<0.001	0.064	<0.001
Vertebral Fractures Without Spinal Cord Injury	−0.489	<0.001	0.228	<0.001	−0.487	<0.001	0.211	<0.001	−0.552	<0.001	0.212	<0.001
Hip Fracture/Dislocation	−0.354	<0.001	−0.092	<0.001	−0.366	<0.001	−0.093	<0.001	−0.368	<0.001	−0.097	<0.001
Traumatic Amputations And Complications	−0.876	<0.001	0.009	0.475	−0.806	<0.001	0.003	0.810	−0.775	<0.001	−0.049	0.002

(continued)

Table D.2. ZINB Model Results Predicting the Count of AVs, 2015–2017 (continued)

	2015				2016				2017			
	First Stage		Second Stage		First Stage		Second Stage		First Stage		Second Stage	
N Beneficiaries	30,238,611				30,704,417				30,550,167			
Covariate	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Complications Of Specified Implanted Device Or Graft	−0.494	<0.001	0.164	<0.001	−0.420	<0.001	0.176	<0.001	−0.474	<0.001	0.176	<0.001
Major Organ Transplant Or Replacement Status	−0.362	0.001	−0.315	<0.001	−0.157	0.138	−0.412	<0.001	−0.325	0.004	−0.401	<0.001
Artificial Openings For Feeding Or Elimination	−1.065	<0.001	0.085	<0.001	−1.035	<0.001	0.086	<0.001	−1.073	<0.001	0.065	<0.001
Amputation Status, Lower Limb/Amputation Complications	−0.705	<0.001	0.143	<0.001	−0.517	<0.001	0.153	<0.001	−0.486	<0.001	0.153	<0.001
Constant	0.599	<0.001	−2.468	<0.001	0.584	<0.001	−2.504	<0.001	0.547	<0.001	−2.502	<0.001
Ln(A)	1.017	<0.001			1.027	<0.001			0.997	<0.001		
Dispersion Parameter (A)	2.766				2.794				2.711			

RTI programming reference: MS 02. The age-sex category *Female 65-69* served as the reference group for this analysis. AV = avoidable emergency department (ED) visit. ZINB = Zero-Inflated Negative Binomial.

Appendix E:
Descriptive Statistics for Model Covariates, 2015–2017

Table E.1. Descriptive Statistics for Model Covariates, 2015–2017

Covariate	2015		2016		2017	
	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
Total Beneficiaries (N)	30,238,611	100.00%	30,704,417	100.00%	30,550,167	100.00%
Male Less Than 65 Years of Age	2,822,156	9.33%	2,778,089	9.05%	2,671,482	8.74%
Male Aged 65–69	3,627,879	12.00%	3,797,291	12.37%	3,795,636	12.42%
Male Aged 70–74	2,756,712	9.12%	2,811,766	9.16%	2,920,551	9.56%
Male Aged 75–79	1,960,599	6.48%	1,991,782	6.49%	2,000,726	6.55%
Male Aged 80–84	1,306,399	4.32%	1,307,673	4.26%	1,289,629	4.22%
Male Aged 85–89	753,106	2.49%	759,269	2.47%	737,678	2.41%
Male Aged 90–94	278,985	0.92%	282,902	0.92%	277,718	0.91%
Male Aged 95+	53,476	0.18%	57,168	0.19%	59,434	0.19%
Female Less Than 65 Years of Age	2,623,065	8.67%	2,599,127	8.46%	2,495,050	8.17%
Female Aged 65–69	4,163,308	13.77%	4,371,348	14.24%	4,375,270	14.32%
Female Aged 70–74	3,273,185	10.82%	3,331,581	10.85%	3,441,666	11.27%
Female Aged 75–79	2,497,105	8.26%	2,528,268	8.23%	2,529,239	8.28%
Female Aged 80–84	1,893,756	6.26%	1,872,131	6.10%	1,822,954	5.97%
Female Aged 85–89	1,355,955	4.48%	1,336,176	4.35%	1,273,212	4.17%
Female Aged 90–94	667,362	2.21%	666,817	2.17%	644,039	2.11%
Female Aged 95+	205,563	0.68%	213,029	0.69%	215,883	0.71%
End Stage Renal Disease Status	340,881	1.13%	344,163	1.12%	347,099	1.14%
Aged and Originally Eligible Due To Disability	2,345,822	7.76%	2,417,806	7.87%	2,449,677	8.02%
HIV/AIDs	102,043	0.34%	103,115	0.34%	102,017	0.33%
Septicemia, Sepsis, Systemic Inflam Response Syndrome/Shock	545,198	1.80%	612,984	2.00%	625,921	2.05%

(continued)

Table E.1. Descriptive Statistics for Model Covariates, 2015–2017 (continued)

Covariate	2015		2016		2017	
	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
Opportunistic Infections	82,623	0.27%	90,736	0.30%	96,723	0.32%
Metastatic Cancer and Acute Leukemia	229,758	0.76%	248,821	0.81%	258,396	0.85%
Lung and Other Severe Cancers	291,307	0.96%	301,955	0.98%	298,850	0.98%
Lymphoma and Other Cancers	390,541	1.29%	400,740	1.31%	394,410	1.29%
Colorectal, Bladder, and Other Cancers	585,843	1.94%	593,733	1.93%	570,079	1.87%
Breast, Prostate, and Other Cancers and Tumors	1,747,877	5.78%	1,790,775	5.83%	1,753,946	5.74%
Diabetes With Acute Complications	86,289	0.29%	102,316	0.33%	99,551	0.33%
Diabetes With Chronic Complications	2,842,544	9.40%	3,571,557	11.63%	4,224,354	13.83%
Diabetes Without Complication	4,286,607	14.18%	3,688,507	12.01%	2,995,618	9.81%
Protein-Calorie Malnutrition	332,422	1.10%	352,845	1.15%	360,370	1.18%
Morbid Obesity	1,034,407	3.42%	1,225,050	3.99%	1,434,860	4.70%
Other Significant Endocrine and Metabolic Disorders	850,527	2.81%	930,643	3.03%	960,513	3.14%
End-Stage Liver Disease	90,302	0.30%	97,226	0.32%	99,397	0.33%
Cirrhosis of Liver	122,599	0.41%	132,516	0.43%	133,738	0.44%
Chronic Hepatitis	138,891	0.46%	157,330	0.51%	162,772	0.53%
Intestinal Obstruction/Perforation	382,640	1.27%	385,058	1.25%	365,712	1.20%
Chronic Pancreatitis	62,121	0.21%	65,188	0.21%	67,728	0.22%
Inflammatory Bowel Disease	256,425	0.85%	272,315	0.89%	281,973	0.92%
Bone/Joint/Muscle Infections/ Necrosis	255,032	0.84%	264,606	0.86%	254,509	0.83%

(continued)

Table E.1. Descriptive Statistics for Model Covariates, 2015–2017 (continued)

Covariate	2015		2016		2017	
	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
Rheumatoid Arthritis and Inflam Connective Tissue Disease	1,617,627	5.35%	1,753,681	5.71%	1,893,691	6.20%
Severe Hematological Disorders	117,597	0.39%	120,327	0.39%	117,320	0.38%
Disorders of Immunity	329,742	1.09%	365,737	1.19%	382,918	1.25%
Coagulation Defects & Oth Specified Hematological Disordrs	1,084,070	3.59%	1,161,440	3.78%	1,198,569	3.92%
Drug/Alcohol Psychosis	161,424	0.53%	142,792	0.47%	41,751	0.14%
Drug/Alcohol Dependence	461,956	1.53%	582,779	1.90%	763,204	2.50%
Schizophrenia	489,089	1.62%	503,392	1.64%	497,242	1.63%
Major Depressive, Bipolar, and Paranoid Disorders	1,725,338	5.71%	1,927,392	6.28%	2,197,130	7.19%
Quadriplegia	51,888	0.17%	56,872	0.19%	58,128	0.19%
Paraplegia	54,525	0.18%	56,571	0.18%	57,519	0.19%
Spinal Cord Disorders/Injuries	164,454	0.54%	172,075	0.56%	172,302	0.56%
Amyotrophic Lateral Sclerosis & Oth Motor Neuron Disease	12,556	0.04%	12,931	0.04%	11,788	0.04%
Cerebral Palsy	87,892	0.29%	92,615	0.30%	96,297	0.32%
Myasthenia Gravis/Myoneural Disorders, Inflammatory & Toxic Neuropathy	223,748	0.74%	242,853	0.79%	232,064	0.76%
Muscular Dystrophy	16,477	0.05%	17,541	0.06%	17,699	0.06%
Multiple Sclerosis	156,685	0.52%	161,985	0.53%	162,998	0.53%
Parkinson's and Huntington's Diseases	371,886	1.23%	386,457	1.26%	394,285	1.29%
Seizure Disorders and Convulsions	853,747	2.82%	866,901	2.82%	847,969	2.78%

(continued)

Table E.1. Descriptive Statistics for Model Covariates, 2015–2017 (continued)

Covariate	2015		2016		2017	
	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
Coma, Brain Compression/Anoxic Damage	50,508	0.17%	56,359	0.18%	66,236	0.22%
Respirator Dependence/Tracheostomy Status	53,338	0.18%	57,188	0.19%	60,273	0.20%
Respiratory Arrest	6,532	0.02%	6,292	0.02%	6,535	0.02%
Cardio-Respiratory Failure and Shock	672,342	2.22%	737,275	2.40%	760,688	2.49%
Congestive Heart Failure	2,973,698	9.83%	3,035,528	9.89%	3,007,046	9.84%
Acute Myocardial Infarction	258,565	0.86%	316,120	1.03%	439,364	1.44%
Unstable Angina & Oth Acute Ischemic Heart Disease	477,199	1.58%	455,083	1.48%	365,256	1.20%
Angina Pectoris	570,837	1.89%	660,973	2.15%	769,316	2.52%
Specified Heart Arrhythmias	3,640,657	12.04%	3,742,026	12.19%	3,734,428	12.22%
Cerebral Hemorrhage	126,878	0.42%	135,429	0.44%	134,603	0.44%
Ischemic or Unspecified Stroke	878,648	2.91%	872,760	2.84%	751,055	2.46%
Hemiplegia/Hemiparesis	302,911	1.00%	333,268	1.09%	382,218	1.25%
Monoplegia, Other Paralytic Syndromes	31,850	0.11%	34,027	0.11%	34,555	0.11%
Atherosclerosis of Extremities W/Ulceration or Gangrene	123,462	0.41%	136,136	0.44%	141,789	0.46%
Vascular Disease With Complications	539,267	1.78%	563,099	1.83%	546,868	1.79%
Vascular Disease	3,606,009	11.93%	3,792,921	12.35%	3,802,396	12.45%
Cystic Fibrosis	4,903	0.02%	4,976	0.02%	4,584	0.02%
Chronic Obstructive Pulmonary Disease	3,457,163	11.43%	3,515,816	11.45%	3,437,592	11.25%

(continued)

Table E.1. Descriptive Statistics for Model Covariates, 2015–2017 (continued)

Covariate	2015		2016		2017	
	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
Fibrosis of Lung and Other Chronic Lung Disorders	244,852	0.81%	257,004	0.84%	242,423	0.79%
Aspiration and Specified Bacterial Pneumonias	197,249	0.65%	209,560	0.68%	210,884	0.69%
Pneumococcal Pneumonia, Empyema, Lung Abscess	63,070	0.21%	74,439	0.24%	107,767	0.35%
Proliferative Diabtic Retinopathy & Vitreous Hemorr	228,429	0.76%	237,894	0.77%	235,641	0.77%
Exudative Macular Degeneration	497,456	1.65%	509,281	1.66%	502,596	1.65%
Dialysis Status	234,036	0.77%	259,665	0.85%	268,395	0.88%
Acute Renal Failure	948,774	3.14%	1,023,138	3.33%	1,052,990	3.45%
Chronic Kidney Disease, Stage 5	134,676	0.45%	113,402	0.37%	90,451	0.30%
Chronic Kidney Disease, Severe (Stage 4)	178,594	0.59%	193,589	0.63%	205,828	0.67%
Press Ulcer of Skn W/Necrosis Thr To Muscle, Tendon, Bone	28,837	0.10%	33,829	0.11%	38,327	0.13%
Pressure Ulcer of Skin With Full Thickness Skin Loss	63,585	0.21%	82,698	0.27%	105,621	0.35%
Chronic Ulcer of Skin, Except Pressure	620,098	2.05%	594,006	1.93%	511,721	1.68%
Severe Skin Burn or Condition	4,188	0.01%	4,933	0.02%	5,176	0.02%
Severe Head Injury	3,472	0.01%	3,405	0.01%	2,601	0.01%
Major Head Injury	160,076	0.53%	167,859	0.55%	164,155	0.54%
Vertebral Fractures Without Spinal Cord Injury	310,268	1.03%	317,625	1.03%	277,191	0.91%

(continued)

Table E.1. Descriptive Statistics for Model Covariates, 2015–2017 (continued)

Covariate	2015		2016		2017	
	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries	Number of Beneficiaries	Percentage of Beneficiaries
Hip Fracture/Dislocation	310,194	1.03%	307,920	1.00%	259,356	0.85%
Traumatic Amputations and Complications	86,269	0.29%	85,644	0.28%	50,511	0.17%
Complications of Specified Implanted Device or Graft	480,292	1.59%	525,890	1.71%	543,638	1.78%
Major Organ Transplant or Replacement Status	70,941	0.23%	76,596	0.25%	81,728	0.27%
Artificial Openings for Feeding or Elimination	211,025	0.70%	221,496	0.72%	225,939	0.74%
Amputation Status, Lower Limb/Amputation Complications	97,109	0.32%	106,227	0.35%	114,277	0.37%

RTI programming reference: MS 08. The age-sex category *Female 65–69* was used as the reference group in regression analysis.

Appendix F:
Selected AH and AV Results, 2015–2016

Table F.1. Market Level (HSA) Distributions of Potentially Preventable Hospital Admissions and Emergency Department Visits Measures, 2015 (*N* = 3,436)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
HSA	Number of Beneficiaries in the market area	8,801	14,770	66	854	1,777	4,069	9,790	20,462	212,360
AH	Percent of FFS Medicare Beneficiaries with an AH	3.78	1.22	0.00	2.37	2.97	3.66	4.42	5.30	11.99
	Observed Rate of AHs per 1,000 beneficiaries	53.51	19.87	0.00	31.17	40.46	50.97	63.31	77.87	198.95
	O to E ratio for AHs	1.09	0.34	0.00	0.74	0.86	1.03	1.24	1.51	4.26
	Risk-Standardized Rate of AHs per 1,000 beneficiaries	58.23	18.44	0.00	39.33	46.20	55.26	66.16	81.06	228.16
	Percent of FFS Medicare Beneficiaries with an Acute AH	1.90	0.74	0.00	1.14	1.42	1.77	2.21	2.83	7.52
	Observed Rate of Acute AHs per 1,000 beneficiaries	24.22	10.24	0.00	13.86	17.71	22.39	28.35	36.52	104.17
	Percent of FFS Medicare Beneficiaries with a Chronic AH	2.02	0.74	0.00	1.17	1.53	1.96	2.41	2.91	6.74
	Observed Rate of Chronic AHs per 1,000 beneficiaries	29.29	12.33	0.00	15.54	21.13	27.93	35.46	43.68	133.50

(continued)

Table F.1. Market Level (HSA) Distributions of Potentially Preventable Hospital Admissions and Emergency Department Visits Measures, 2015 (*N* = 3,436) (continued)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
AV	Percent of FFS Medicare Beneficiaries with an AV	7.19	2.48	0.00	4.20	5.42	6.95	8.70	10.43	25.19
	Observed Rate of AVs per 1,000 beneficiaries	94.01	38.39	0.00	49.84	67.37	88.89	114.96	142.86	477.78
	O to E ratio for AVs	1.21	0.45	0.00	0.70	0.90	1.15	1.45	1.77	5.68
	Risk-Standardized Rate of AVs per 1,000 beneficiaries	113.77	41.96	0.00	66.25	84.31	107.90	136.62	166.67	533.91
	Percent of FFS Medicare Beneficiaries with an Acute AV	5.31	1.87	0.00	3.09	3.98	5.08	6.41	7.74	17.78
	Observed Rate of Acute AVs per 1,000 beneficiaries	64.93	25.75	0.00	35.31	47.23	61.01	78.71	98.17	225.07
	Percent of FFS Medicare Beneficiaries with a Chronic AV	2.30	1.01	0.00	1.14	1.55	2.15	2.88	3.64	12.22
	Observed Rate of Chronic AVs per 1,000 beneficiaries	29.08	14.93	0.00	13.27	18.62	26.33	36.73	47.88	270.37

RTI programming reference: MS 11. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit.

Table F.2. Market Level (MMA) Distributions of Beneficiaries with Potentially Preventable Hospital Admissions and Emergency Department Visits Measures, 2015 (*N* = 1,230)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
MMA	Number of Beneficiaries in the market area	24,584	51,276	117	2,459	5,027	11,020	20,903	52,046	726,944
AH	Percent of FFS Medicare Beneficiaries with an AH	3.66	0.99	0.96	2.44	3.02	3.63	4.27	4.86	8.45
	Observed Rate of AHs per 1,000 beneficiaries	51.54	15.80	11.48	32.28	41.22	50.78	60.19	71.19	126.27
	O to E ratio for AHs	1.05	0.25	0.43	0.76	0.89	1.02	1.19	1.38	2.26
	Risk-Standardized Rate of AHs per 1,000 beneficiaries	54.35	13.11	21.98	39.26	45.70	52.82	61.17	71.16	116.71
	Percent of FFS Medicare Beneficiaries with an Acute AH	1.81	0.56	0.50	1.16	1.41	1.75	2.10	2.54	4.87
	Observed Rate of Acute AHs per 1,000 beneficiaries	22.88	7.54	5.74	14.11	17.46	22.04	26.79	32.63	62.55
	Percent of FFS Medicare Beneficiaries with a Chronic AH	1.98	0.62	0.41	1.21	1.57	1.95	2.36	2.69	4.97
	Observed Rate of Chronic AHs per 1,000 beneficiaries	28.67	10.11	4.65	16.19	21.90	27.91	34.17	40.68	86.85

(continued)

Table F.2. Market Level (MMA) Distributions of Beneficiaries with Potentially Preventable Hospital Admissions and Emergency Department Visits Measures, 2015 (*N* = 1,230) (continued)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
AV	Percent of FFS Medicare Beneficiaries with an AV	7.16	1.89	2.53	4.85	5.82	7.06	8.45	9.63	13.61
	Observed Rate of AVs per 1,000 beneficiaries	93.39	28.62	28.13	59.34	72.76	90.76	111.64	130.07	210.23
	O to E ratio for AVs	1.21	0.32	0.45	0.82	0.97	1.17	1.40	1.64	2.53
	Risk-Standardized Rate of AVs per 1,000 beneficiaries	112.57	30.23	42.45	76.14	90.13	109.39	130.35	153.34	236.20
	Percent of FFS Medicare Beneficiaries with an Acute AV	5.28	1.43	1.54	3.62	4.27	5.14	6.18	7.16	11.48
	Observed Rate of Acute AVs per 1,000 beneficiaries	64.62	19.67	15.44	41.81	50.59	61.81	76.81	90.23	152.72
	Percent of FFS Medicare Beneficiaries with a Chronic AV	2.29	0.76	0.56	1.37	1.73	2.20	2.78	3.31	5.18
	Observed Rate of Chronic AVs per 1,000 beneficiaries	28.77	10.68	5.63	16.33	20.81	27.39	35.32	42.72	85.23

RTI programming reference: MS 11. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit. MMA = MedPAC market area.

Table F.3. Market Level (HSA) Distributions of Potentially Preventable Hospital Admissions and Emergency Department Visits Measures, 2016 (*N* = 3,436)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
HSA	Number of Beneficiaries in the market area	8,936	15,049	63	852	1,798	4,084	9,949	20,753	219,097
AH	Percent of FFS Medicare Beneficiaries with an AH	3.39	1.12	0.48	2.12	2.66	3.27	3.98	4.73	11.69
	Observed Rate of AHs per 1,000 beneficiaries	47.36	18.05	6.96	27.67	35.86	45.01	55.98	68.79	214.77
	O to E ratio for AHs	1.10	0.36	0.22	0.73	0.87	1.03	1.25	1.54	4.28
	Risk-Standardized Rate of AHs per 1,000 beneficiaries	52.16	17.27	10.56	34.56	41.23	48.90	59.31	72.92	202.64
	Percent of FFS Medicare Beneficiaries with an Acute AH	1.70	0.70	0.00	0.99	1.25	1.57	1.98	2.51	7.50
	Observed Rate of Acute AHs per 1,000 beneficiaries	21.50	9.65	0.00	11.90	15.46	19.64	25.13	32.49	109.90
	Percent of FFS Medicare Beneficiaries with a Chronic AH	1.81	0.67	0.21	1.04	1.37	1.74	2.18	2.61	6.71
	Observed Rate of Chronic AHs per 1,000 beneficiaries	25.86	11.03	2.14	13.59	18.58	24.44	31.37	38.54	137.23

(continued)

Table F.3. Market Level (HSA) Distributions of Potentially Preventable Hospital Admissions and Emergency Department Visits Measures, 2016 (*N* = 3,436) (continued)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
AV	Percent of FFS Medicare Beneficiaries with an AV	6.98	2.39	0.88	4.10	5.28	6.75	8.44	10.08	24.46
	Observed Rate of AVs per 1,000 beneficiaries	91.03	37.06	10.32	48.58	65.38	86.00	111.48	137.85	478.42
	O to E ratio for AVs	1.20	0.44	0.13	0.71	0.89	1.15	1.44	1.75	6.18
	Risk-Standardized Rate of AVs per 1,000 beneficiaries	109.66	40.45	12.15	64.91	81.41	104.42	131.27	159.33	562.37
	Percent of FFS Medicare Beneficiaries with an Acute AV	5.04	1.79	0.65	2.93	3.81	4.84	6.07	7.32	16.91
	Observed Rate of Acute AVs per 1,000 beneficiaries	61.23	24.51	6.72	33.58	44.56	57.97	74.57	92.09	262.59
	Percent of FFS Medicare Beneficiaries with a Chronic AV	2.35	1.02	0.00	1.19	1.60	2.23	2.93	3.66	13.51
	Observed Rate of Chronic AVs per 1,000 beneficiaries	29.80	14.74	0.00	13.89	19.15	27.30	37.32	48.35	215.83

RTI programming reference: MS 11. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit.

Table F.4. Market Level (MMA) Distributions of AH and AV Measures, 2016 (*N* = 1,230)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
MMA	Number of Beneficiaries in the market area	24,963	52,334	105	2,437	5,078	10,948	21,022	53,108	738,418
AH	Percent of FFS Medicare Beneficiaries with an AH	3.28	0.93	0.56	2.14	2.68	3.23	3.79	4.42	8.06
	Observed Rate of AHs per 1,000 beneficiaries	45.60	14.57	5.59	28.26	35.98	44.69	53.28	62.88	128.23
	O to E ratio for AHs	1.06	0.27	0.21	0.77	0.88	1.03	1.20	1.41	2.41
	Risk-Standardized Rate of AHs per 1,000 beneficiaries	48.49	12.44	9.42	35.02	40.18	46.85	54.70	64.34	110.02
	Percent of FFS Medicare Beneficiaries with an Acute AH	1.61	0.54	0.39	1.01	1.26	1.53	1.88	2.34	4.81
	Observed Rate of Acute AHs per 1,000 beneficiaries	20.36	7.34	3.88	12.29	15.56	19.13	23.58	29.89	63.60
	Percent of FFS Medicare Beneficiaries with a Chronic AH	1.78	0.57	0.00	1.09	1.40	1.74	2.10	2.48	5.23
	Observed Rate of Chronic AHs per 1,000 beneficiaries	25.24	9.00	0.00	14.53	19.27	24.60	30.29	36.06	79.62

(continued)

Table F.4. Market Level (MMA) Distributions of AH and AV Measures, 2016 (*N* = 1,230) (continued)

		Mean	SD	Min	10th	25th	50th	75th	90th	Max
AV	Percent of FFS Medicare Beneficiaries with an AV	6.97	1.85	2.67	4.75	5.60	6.81	8.18	9.45	13.71
	Observed Rate of AVs per 1,000 beneficiaries	90.76	27.85	27.13	58.30	70.52	87.25	107.98	127.00	197.76
	O to E ratio for AVs	1.20	0.33	0.47	0.82	0.97	1.16	1.39	1.64	2.90
	Risk-Standardized Rate of AVs per 1,000 beneficiaries	109.20	29.69	43.00	74.18	87.80	105.66	125.87	148.42	263.00
	Percent of FFS Medicare Beneficiaries with an Acute AV	5.03	1.39	1.91	3.39	4.05	4.91	5.89	6.82	11.43
	Observed Rate of Acute AVs per 1,000 beneficiaries	61.02	18.75	21.33	39.13	47.81	59.14	72.36	85.21	142.43
	Percent of FFS Medicare Beneficiaries with a Chronic AV	2.35	0.76	0.39	1.43	1.79	2.27	2.85	3.35	5.95
	Observed Rate of Chronic AVs per 1,000 beneficiaries	29.74	10.80	3.88	17.05	21.62	28.33	36.52	44.45	80.91

RTI programming reference: MS 11. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit. MMA = MedPAC market area.

Table F.5. AH and AV Rates for Five Market Areas (MMA) of Interest and National Average, 2015

		National Average	Boston	Houston	Minneapolis	Orlando	Phoenix
MMA Information	MMA Name	—	Boston, MA	Houston-The Woodlands-Sugar Land, TX	Minneapolis-St. Paul-Bloomington, MN-WI	Orlando-Kissimmee-Sanford, FL	Phoenix-Mesa-Scottsdale, AZ
	MMA Number	—	14454	26420	33461 & 33462	36740	38060
	Number of Beneficiaries in the market area	24,584	207,462	344,337	163,646	207,246	305,833
AH	Percent of FFS Medicare Beneficiaries with an AH	3.66	4.08	4.09	2.94	3.76	2.72
	Observed Rate of AHs per 1,000 beneficiaries	51.54	60.11	58.83	41.17	55.06	36.34
	O to E ratio for AHs	1.05	1.20	1.16	0.91	1.05	0.86
	Risk-Standardized Rate of AHs per 1,000 beneficiaries	54.35	61.87	59.99	46.76	54.16	44.42
	Percent of FFS Medicare Beneficiaries with an Acute AH	1.81	1.96	1.99	1.37	1.69	1.39
	Observed Rate of Acute AHs per 1,000 beneficiaries	22.88	25.27	25.44	17.10	22.00	17.22
	Percent of FFS Medicare Beneficiaries with a Chronic AH	1.98	2.27	2.25	1.65	2.20	1.42
	Observed Rate of Chronic AHs per 1,000 beneficiaries	28.67	34.84	33.39	24.07	33.06	19.12

(continued)

Table F.5. AH and AV Rates for Five Market Areas (MMA) of Interest and National Average, 2015 (continued)

		National Average	Boston	Houston	Minneapolis	Orlando	Phoenix
AV	Percent of FFS Medicare Beneficiaries with an AV	7.16	5.30	4.98	5.40	4.35	4.88
	Observed Rate of AVs per 1,000 beneficiaries	93.39	66.26	60.26	0.00	52.59	59.07
	O to E ratio for AVs	1.21	0.83	0.82	0.80	0.70	0.91
	Risk-Standardized Rate of AVs per 1,000 beneficiaries	112.57	77.40	76.44	74.26	65.69	84.89
	Percent of FFS Medicare Beneficiaries with an Acute AV	5.28	4.15	3.73	4.10	3.23	3.75
	Observed Rate of Acute AVs per 1,000 beneficiaries	64.62	49.77	43.48	51.09	37.76	43.98
	Percent of FFS Medicare Beneficiaries with a Chronic AV	2.29	1.34	1.42	1.51	1.27	1.30
	Observed Rate of Chronic AVs per 1,000 beneficiaries	28.77	16.49	16.78	18.23	14.83	15.09

RTI programming reference: MS 08. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit. MMA = MedPAC market area.

Table F.6. AH and AV Rates for Five Market Areas (MMA) of Interest and National Average, 2016

		National Average	Boston	Houston	Minneapolis	Orlando	Phoenix
MMA Information	MMA Name	—	Boston, MA	Houston-The Woodlands-Sugar Land, TX	Minneapolis-St. Paul-Bloomington, MN-WI	Phoenix-Mesa-Scottsdale, AZ	Phoenix-Mesa-Scottsdale, AZ
	MMA Number	—	14454	26420	33461 & 33462	38060	38060
	Number of Beneficiaries in the market area	24,963	209,329	354,314	161,595	319,682	319,682
AH	Percent of FFS Medicare Beneficiaries with an AH	3.28	3.65	3.54	2.86	2.42	2.42
	Observed Rate of AHs per 1,000 beneficiaries	45.60	53.27	49.67	39.97	31.70	31.70
	O to E ratio for AHs	1.06	1.21	1.14	0.99	0.87	0.87
	Risk-Standardized Rate of AHs per 1,000 beneficiaries	48.49	55.33	51.81	45.35	39.59	39.59
	Percent of FFS Medicare Beneficiaries with an Acute AH	1.61	1.80	1.69	1.34	1.22	1.22
	Observed Rate of Acute AHs per 1,000 beneficiaries	20.36	23.25	21.37	16.69	14.78	14.78
	Percent of FFS Medicare Beneficiaries with a Chronic AH	1.78	1.97	1.96	1.60	1.27	1.27
	Observed Rate of Chronic AHs per 1,000 beneficiaries	25.24	30.02	28.30	23.28	16.92	16.92

(continued)

Table F.6. AH and AV Rates for Five Market Areas (MMA) of Interest and National Average, 2016 (continued)

		National Average	Boston	Houston	Minneapolis	Orlando	Phoenix
AV	Percent of FFS Medicare Beneficiaries with an AV	6.97	4.94	4.98	10.61	4.90	4.90
	Observed Rate of AVs per 1,000 beneficiaries	90.76	61.08	60.78	0.01	58.30	58.30
	O to E ratio for AVs	1.20	0.79	0.86	0.82	0.93	0.93
	Risk-Standardized Rate of AVs per 1,000 beneficiaries	109.20	71.39	77.67	74.82	84.34	84.34
	Percent of FFS Medicare Beneficiaries with an Acute AV	5.03	3.73	3.67	4.12	3.72	3.72
	Observed Rate of Acute AVs per 1,000 beneficiaries	61.02	44.25	42.83	50.47	42.88	42.88
	Percent of FFS Medicare Beneficiaries with a Chronic AV	2.35	1.40	1.51	1.53	1.34	1.34
	Observed Rate of Chronic AVs per 1,000 beneficiaries	29.74	16.83	17.94	19.33	15.42	15.42

RTI programming reference: MS 08. AH = avoidable hospitalization. AV = avoidable emergency department (ED) Visit. MMA = MedPAC market area.

Table F.7. AH Outcomes by Select Beneficiary Characteristics, 2015

Characteristic	Total Beneficiaries	Percentage of Beneficiaries	Percentage of Beneficiaries With at Least One AH Observed	Observed Rate of AHs per 1,000 Beneficiaries	Expected Rate of AHs per 1,000 Beneficiaries	O to E Ratio	Risk-Standardized Rate of AH per 1,000 Beneficiaries
All Beneficiaries	30,238,611	100.00	3.47	49.53	49.51	1.00	49.55
Age/Eligibility Group							
18–64	5,445,221	18.01	3.83	59.73	59.41	1.01	49.80
65+ and not originally disabled	22,469,751	74.31	3.09	42.47	42.55	1.00	49.43
65+ and originally disabled	2,323,639	7.68	6.3	93.97	93.61	1.00	49.73
Gender							
Male	13,559,312	44.84	3.21	46.02	46.18	1.00	49.36
Female	16,679,299	55.16	3.69	52.39	52.22	1.00	49.69
Race/Ethnicity							
Non-Hispanic White	24,308,518	80.39	3.41	47.94	48.67	0.98	48.79
Black (Or African American)	2,851,283	9.43	4.56	70.44	61.30	1.15	56.91
Hispanic	1,666,253	5.51	3.56	51.42	50.75	1.01	50.19
American Indian/Alaska Native	168,512	0.56	4.88	70.07	58.47	1.20	59.36
Asian/Pacific Islander	713,360	2.36	2.16	29.35	39.99	0.73	36.35
Other	228,476	0.76	2.38	33.76	41.60	0.81	40.20
Unknown	302,209	1.00	1.29	18.06	41.60	0.43	21.50
Dual Status							
Dual	4,649,603	15.38	6.06	93.99	77.08	1.22	60.40
Nondual	25,589,008	84.62	3.00	41.45	44.50	0.93	46.14

RTI programming reference: MS 09. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit.

Table F.8. AV Outcomes by Select Beneficiary Characteristics, 2015

Characteristic	Total Beneficiaries	Percentage of Beneficiaries	Percentage of Beneficiaries With at Least One AV Observed	Observed Rate of AVs per 1,000 Beneficiaries	Expected Rate of AVs per 1,000 Beneficiaries	O to E Ratio	Risk-Standardized Rate of AV per 1,000 Beneficiaries
All Beneficiaries	30,238,611	-	6.03	77.14	77.17	1.00	77.11
Age/Eligibility Group							
18–64	5,445,221	18.01	10.86	156.78	156.85	1.00	77.11
65+ and not originally disabled	22,469,751	74.31	4.58	54.19	54.31	1.00	76.97
65+ and originally disabled	2,323,639	7.68	8.7	112.45	111.53	1.01	77.78
Gender							
Male	13,559,312	44.84	5.19	66.40	66.48	1.00	77.05
Female	16,679,299	55.16	6.71	85.87	85.86	1.00	77.15
Race/Ethnicity							
Non-Hispanic White	24,308,518	80.39	5.62	70.86	74.43	0.95	73.44
Black (Or African American)	2,851,283	9.43	9.62	131.67	101.36	1.30	100.21
Hispanic	1,666,253	5.51	7.38	95.37	85.28	1.12	86.26
American Indian/Alaska Native	168,512	0.56	10.54	151.63	100.96	1.50	115.86
Asian/Pacific Islander	713,360	2.36	3.24	38.26	63.69	0.60	46.34
Other	228,476	0.76	4.21	51.11	69.63	0.73	56.63
Unknown	302,209	1.00	3.05	37.81	49.31	0.77	59.15
Dual Status							
Dual	4,649,603	15.38	11.64	166.25	129.41	1.28	99.10
Nondual	25,589,008	84.62	5.01	60.95	67.68	0.90	69.47

RTI programming reference: MS 09. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit.

Table F.9. AH Outcomes by Select Beneficiary Characteristics, 2016

Characteristic	Total Beneficiaries	Percentage of Total Beneficiaries	Percentage of Beneficiaries With at Least One AH Observed	Observed Rate of AHs per 1,000 Beneficiaries	Expected Rate of AHs per 1,000 Beneficiaries	O to E Ratio	Risk-Standardized Rate of AH per 1,000 Beneficiaries
All Beneficiaries	30,704,417	100.00	3.09	43.26	43.23	1.00	43.29
Age/Eligibility Group							
18–64	5,377,216	17.51	3.49	54.06	53.76	1.01	43.50
65+ and not originally disabled	22,932,099	74.69	2.73	36.62	36.71	1.00	43.16
65+ and originally disabled	2,395,102	7.80	5.63	82.52	82.05	1.01	43.50
Gender							
Male	13,785,940	44.90	2.84	39.98	40.11	1.00	43.12
Female	16,918,477	55.10	3.29	45.93	45.77	1.00	43.41
Race/Ethnicity							
Non-Hispanic White	24,571,629	80.03	3.04	42.14	42.64	0.99	42.74
Black (Or African American)	2,870,984	9.35	4.00	60.26	53.04	1.14	49.15
Hispanic	1,724,497	5.62	3.16	45.18	44.17	1.02	44.25
American Indian/Alaska Native	172,433	0.56	4.40	62.13	51.49	1.21	52.20
Asian/Pacific Islander	754,945	2.46	1.84	24.52	34.82	0.70	30.46
Other	232,885	0.76	2.12	29.01	36.75	0.79	34.14
Unknown	377,044	1.23	1.13	15.80	19.60	0.81	34.87
Dual Status							
Dual	4,669,279	15.21	5.49	83.65	68.76	1.22	52.62
Nondual	26,035,138	84.79	2.66	36.02	38.65	0.93	40.31

RTI programming reference: MS 09. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit.

Table F.10. AV Outcomes by Select Beneficiary Characteristics, 2016

Characteristic	Total Beneficiaries	Percentage of Total Beneficiaries	Percentage of Beneficiaries With at Least One AV Observed	Observed Rate of AVs per 1,000 Beneficiaries	Expected Rate of AVs per 1,000 Beneficiaries	O to E Ratio	Risk-Standardized Rate of AV per 1,000 Beneficiaries
All Beneficiaries	30,704,417	100.00	5.87	74.86	74.87	1.00	74.84
Age/Eligibility Group							
18–64	5,377,216	17.51	10.51	151.13	151.00	1.00	74.92
65+ and not originally disabled	22,932,099	74.69	4.49	53.13	53.28	1.00	74.65
65+ and originally disabled	2,395,102	7.80	8.60	111.64	110.71	1.01	75.49
Gender							
Male	13,785,940	44.90	5.00	63.74	63.79	1.00	74.80
Female	16,918,477	55.10	6.58	83.92	83.90	1.00	74.87
Race/Ethnicity							
Non-Hispanic White	24,571,629	80.03	5.48	68.83	72.45	0.95	71.11
Black (Or African American)	2,870,984	9.35	9.32	127.20	97.33	1.31	97.83
Hispanic	1,724,497	5.62	7.35	94.67	82.42	1.15	85.98
American Indian/ Alaska Native	172,433	0.56	10.09	144.60	97.75	1.48	110.73
Asian/Pacific Islander	754,945	2.46	3.20	37.83	61.94	0.61	45.72
Other	232,885	0.76	4.18	51.06	67.40	0.76	56.71
Unknown	377,044	1.23	2.91	35.63	46.90	0.76	56.87
Dual Status							
Dual	4,669,279	15.21	11.24	160.09	125.78	1.27	95.27
Nondual	26,035,138	84.79	4.91	59.57	65.74	0.91	67.83

RTI programming reference: MS 09. AH = avoidable hospitalization. AV = avoidable emergency department (ED) visit.