

Supplemental Material

Medicare Risk Adjustment

The Medicare Risk Adjustment formula was first implemented in 2004 by Centers for Medicare & Medicaid Services (CMS) to set capitation rates for Medicare Advantage plans and ensure that plans with higher risk beneficiaries (on average) are compensated more than plans with lower risks beneficiaries (on average).¹ The formula is built and calibrated using Traditional Medicare beneficiaries. Our risk adjustment estimates were based on the 2017 Medicare risk adjustment formula for beneficiaries who qualified for Medicare based on age and were not enrolled in Medicaid. We additionally included a control for county, the level at which premiums are set:

$$Y = \text{Age} \times \text{Sex} + \text{HCC} + \text{County} + \epsilon,$$

where Age \times Sex are eight age and documented sex categories and HCC are a set of Health Condition Categories. Unlike the Marketplaces formulas, the Medicare risk adjustment formula is prospective, meaning it uses diagnosis-based condition categories from the previous year to predict current year spending.

Data

To evaluate the Medicare risk adjustment formula, we sampled individuals age 65+ enrolled in Traditional Medicare for at least two years starting in either 2015, 2016, or 2017. Because the risk adjustment formula is prospective, we required these two years of enrollment in order to have a complete year of data for measuring HCCs and a

subsequent complete year of data for annual spending. Individual annual spending, measured in 2016, 2017, and 2018, was calculated as the total spending across the individual's outpatient, inpatient, and carrier claims in the given year. Diagnosis codes recorded in inpatient, outpatient, and carrier claims were mapped to HCC categories using the CMS-HCC software. The component variables in I to define groups in G were age categories (65-69, 70-79, 80-89, 90+), documented sex, and the same twelve chronic conditions (arthritis, asthma and other respiratory conditions, cancer, diabetes, heart disease, hypertension, kidney disease, hyperlipidemia, mental health and substance use disorders, nervous system conditions, osteoporosis, and viral infections). Similar to the Marketplaces formula, chronic conditions were defined using the individual diagnosis-based categories from the Agency for Healthcare Research and Quality Clinical Classification Software but measured in the prior year (see Table S1 for mapping). Age and documented sex information was acquired from the Master Beneficiary Summary File. We excluded individuals with any months of Medicaid eligibility in their starting year.

Results

The Medicare sample had more individuals with female documented sex than the Marketplaces sample (55% compared to 52%), and nearly half the sample was in their 70s (45.1% to 47.7%). As expected for an older sample, chronic conditions were much more prevalent than in the younger commercial sample: a majority of the conditions were found in at least 25% of the sample (hypertension and lipid disorders were the most common conditions with a prevalence of approximately 65%). Chronic viral infections

and nervous conditions were the rarest conditions and were only recorded in 0.4% and 6.8% of the sample, respectively. Recall that chronic conditions were recorded in the year prior, and the slight differences in prevalence for the 2016 sample (with 2015 diagnosis) may be due to the switch from ICD-9 to ICD-10 on October 1, 2015. Table S2 presents the sample statistics for the Medicare sample. The observed average residual for every chronic condition except chronic viral infections was trivial (all less than \$100, or less than 1% of the average annual spending of \$7,500). Chronic viral infections had an average undercompensation of -\$358 in 2016 and average overcompensation in both 2017 and 2018 (\$138 and \$184, respectively). In general, under- versus overcompensation did not appear uniformly across years (Table S3).

We found no groups that were consistently under- and overcompensated over the three-year observation period. In Figure S6, we display the top under- and overcompensated groups for each sample year when limiting the group size to 10,000 and maximum nodes to 8. The top identified groups are different in each year, with certain conditions appearing in some years and not others. For example, in 2017 groups with chronic kidney disease appeared in six out of the ten top undercompensated groups, but not consistently in other years. Some conditions appeared in both under- and overcompensated groups within and across years. For example, nerve disorders was a common condition in groups that were under- and overcompensated in 2017 and 2018. Six out of the ten top undercompensated groups in 2016 included beneficiaries with viral infections, but groups with this condition tended to be overcompensated in 2017 and 2018. Recall that chronic viral infections had the largest observed negative average residual in 2016 and largest positive residual in 2017 and 2018, thus, this result aligns

with those findings. Compared to the Marketplaces risk adjustment, the magnitude of the predicted average residual for undercompensation was smaller (about \$500 rather than thousands) and more evenly balanced between the under- and overcompensated groups. When we allowed the groups to be more complex and smaller in size, we identified very few groups that appeared in more than 1% of trees.

Supplement References

1. Pope GC, Kautter J, Ellis RP, et al. Risk adjustment of Medicare capitation payments using the CMS-HCC model. *Health Care Financ Rev.* 2004;25(4):119-141.

Table S1. Mapping Diagnosis Codes and Clinical Classification Software (CCS) to Chronic Conditions

<i>Chronic Condition</i>	<i>Short Name</i>	<i>Single Level CCS Diagnosis Categories</i>	<i>Multiple 2nd Level CCS Diagnosis Categories</i>	<i>ICD-10 Diagnosis Codes</i>
Arthritis (osteoarthritis & rheumatoid)	Arthritis	202,203		
Asthma, COPD, and Other Chronic Lung Diseases	Asthma	8.2-8.8	8.2-8.3	
Cancer	Cancer	11-45		
Diabetes	Diabetes	49, 50		
Diseases of the Heart	Heart	103		
Hypertension	Hypertension	98,99		
Chronic Kidney Disease	Kidney	158		
Disorders of Lipid Metabolism	Lipid	53		
Mental Health and Substance Use Disorders	Mental	650-663, 670		
Hereditary and Degenerative Nervous System	Nervous		6.2	
Osteoporosis	Osteoporosis	206		
Chronic Viral Infections (Viral HIV and Chronic Viral Hepatitis)	Viral	5		B18

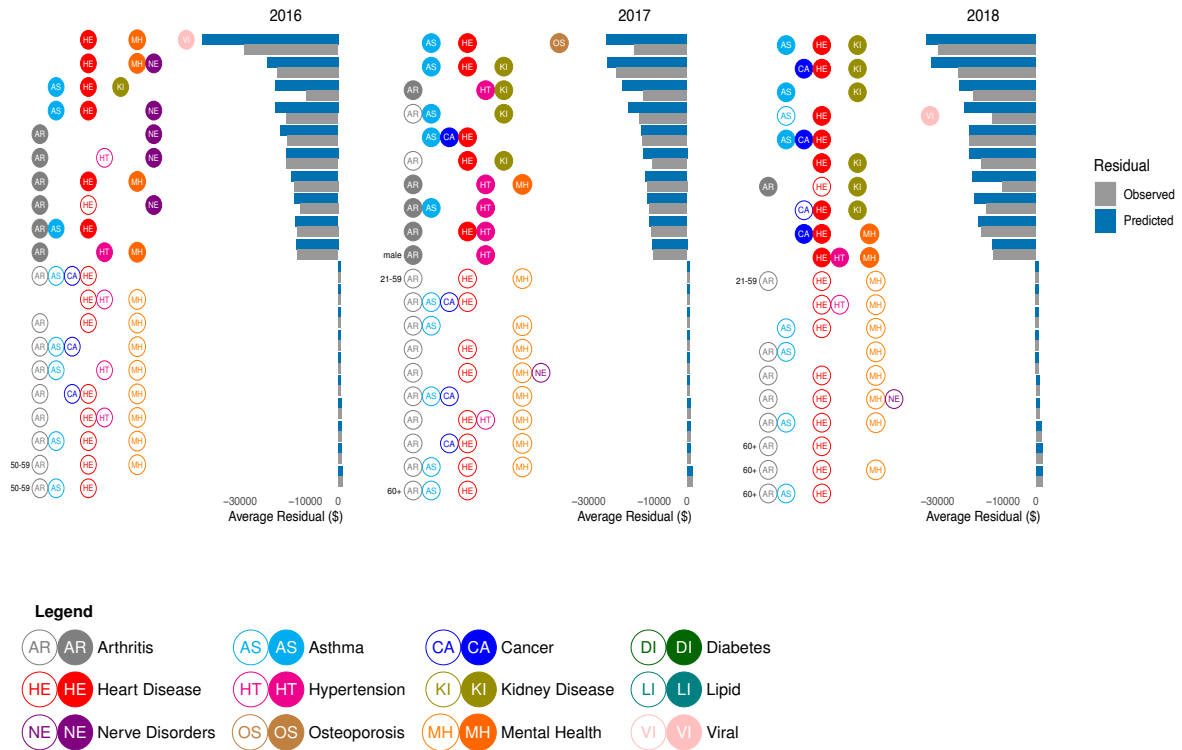
Table S2. Medicare Sample Characteristics (in Percents)

Variables	2016	2017	2018
Documented Sex, Female	55.2	55.1	55.0
Age			
65-69	27.9	27.6	26.6
70-79	45.1	46.2	47.6
80-89	22.1	21.3	21.0
90+	4.9	4.8	4.7
Arthritis	28.9	30.1	30.7
Asthma	37.4	37.4	38.8
Cancer	33.0	33.3	33.9
Diabetes	35.7	37.2	38.3
Heart Disease	45.6	45.3	45.8
Hypertension	68.6	68.5	68.3
Kidney Disease	11.6	12.2	12.8
Lipid Disorders	65.7	65.4	66.0
Mental Health	34.2	35.6	37.7
Nervous	6.8	7.3	7.5
Osteoporosis	11.1	10.8	11.0
Viral Infections	0.4	0.4	0.4
N	1,000,000	1,000,000	1,000,000

Table S3: Medicare Average Residual (\$) by Chronic Condition

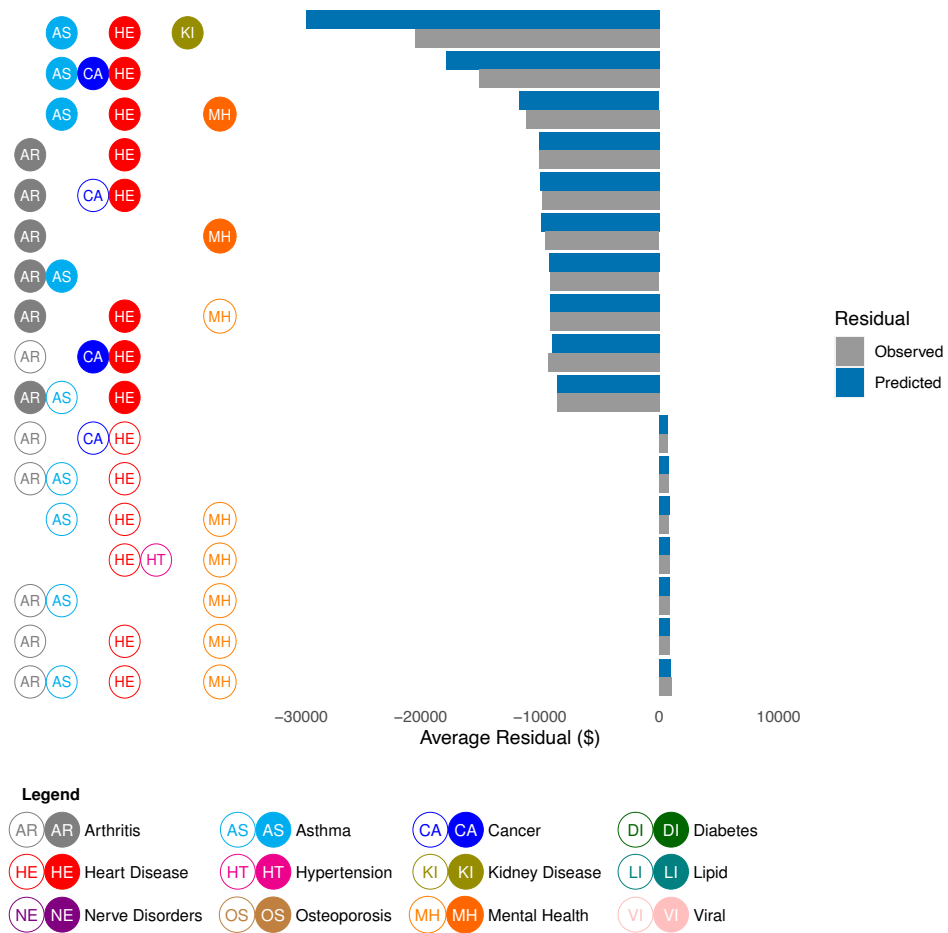
Chronic Condition	2016		2017		2018	
	<i>No</i>	<i>Yes</i>	<i>No</i>	<i>Yes</i>	<i>No</i>	<i>Yes</i>
Arthritis	-19	47	6	-14	4	-8
Asthma	6	-10	-6	10	8	-13
Cancer	17	-34	-11	23	-1	3
Diabetes	-11	20	-8	13	9	-14
Heart Disease	2	-2	12	-14	10	-11
Hypertension	12	-5	5	-2	22	-10
Kidney Disease	-5	40	11	-80	3	-21
Lipid Disorders	-16	8	-5	3	-8	4
Mental Health	10	-20	-8	15	7	-12
Nervous	-1	20	2	-26	-4	46
Osteoporosis	0	3	-12	96	-1	10
Viral Infections	1	-358	0	138	0	184

Figure S1. Top Under- and Overcompensated Groups in the Marketplaces Risk Adjustment by Year (minimum node size: 10,000, maximum nodes: 8)



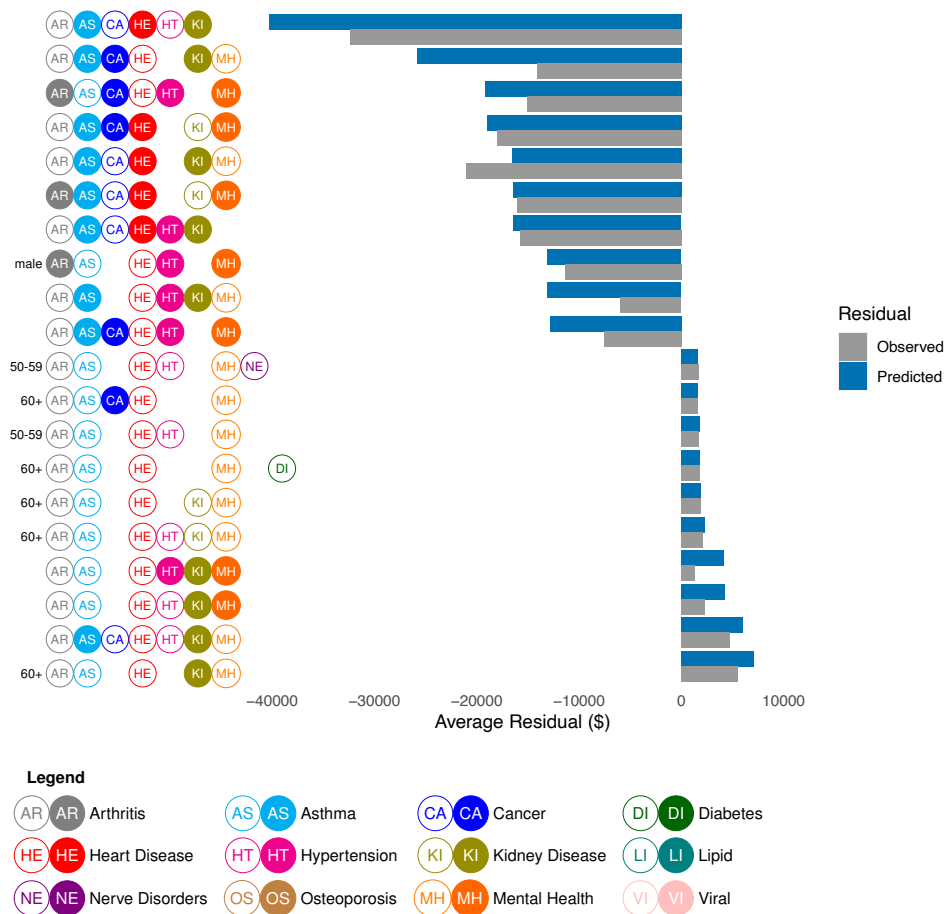
Note: Unfilled circles indicate the lack of a condition.

Figure S2. Top Under- and Overcompensated Groups in the Marketplaces Risk Adjustment, Observed vs Predicted Residuals (minimum node size: 10,000, maximum nodes: 8)



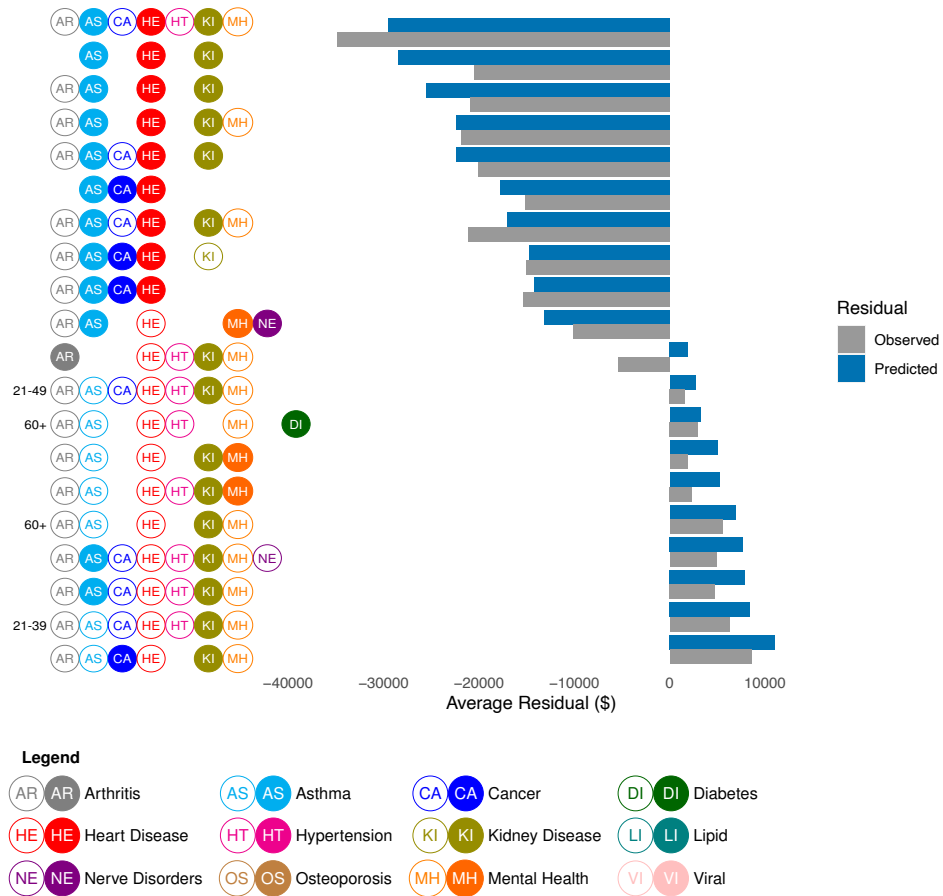
Note: Unfilled circles indicate the lack of a condition.

Figure S3. Top Under- and Overcompensated Groups in the Marketplaces Risk Adjustment, Observed vs Predicted Residuals (minimum node size: 100, maximum nodes: 64)



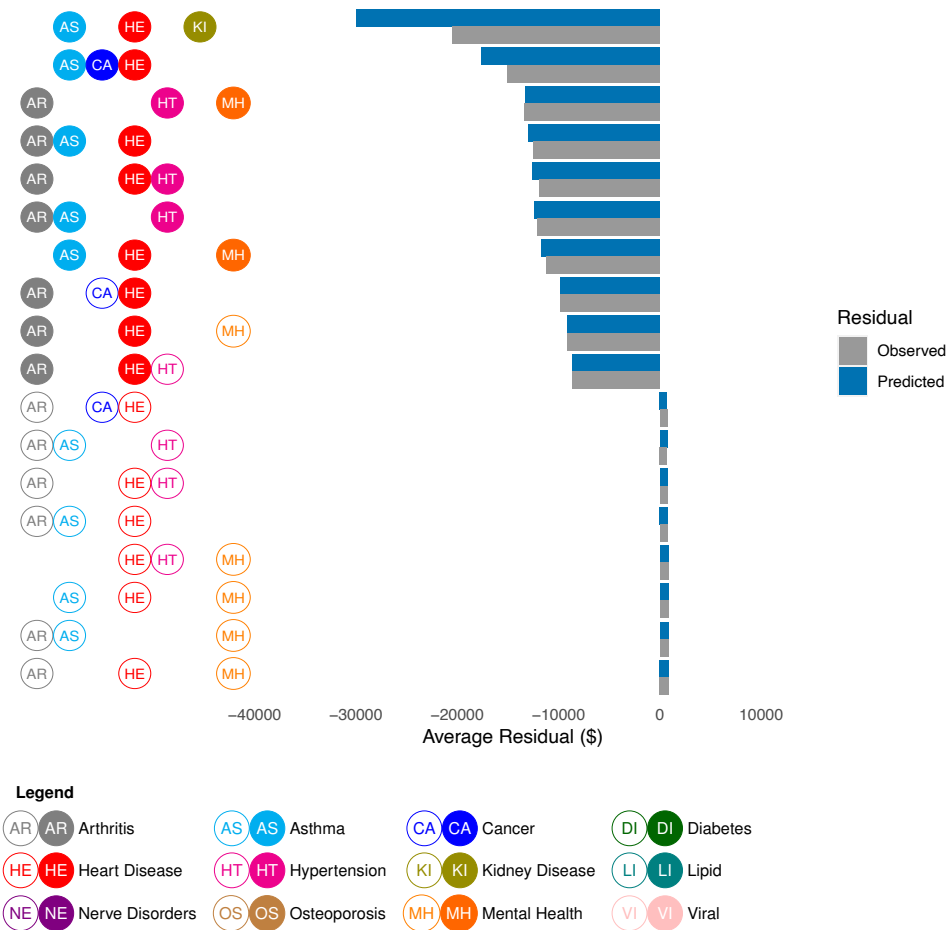
Note: Unfilled circles indicate the lack of a condition.

Figure S4. Top Under- and Overcompensated Groups in the Marketplaces Risk Adjustment, Observed vs Predicted Residuals (minimum node size: 10,000, maximum nodes: 64)



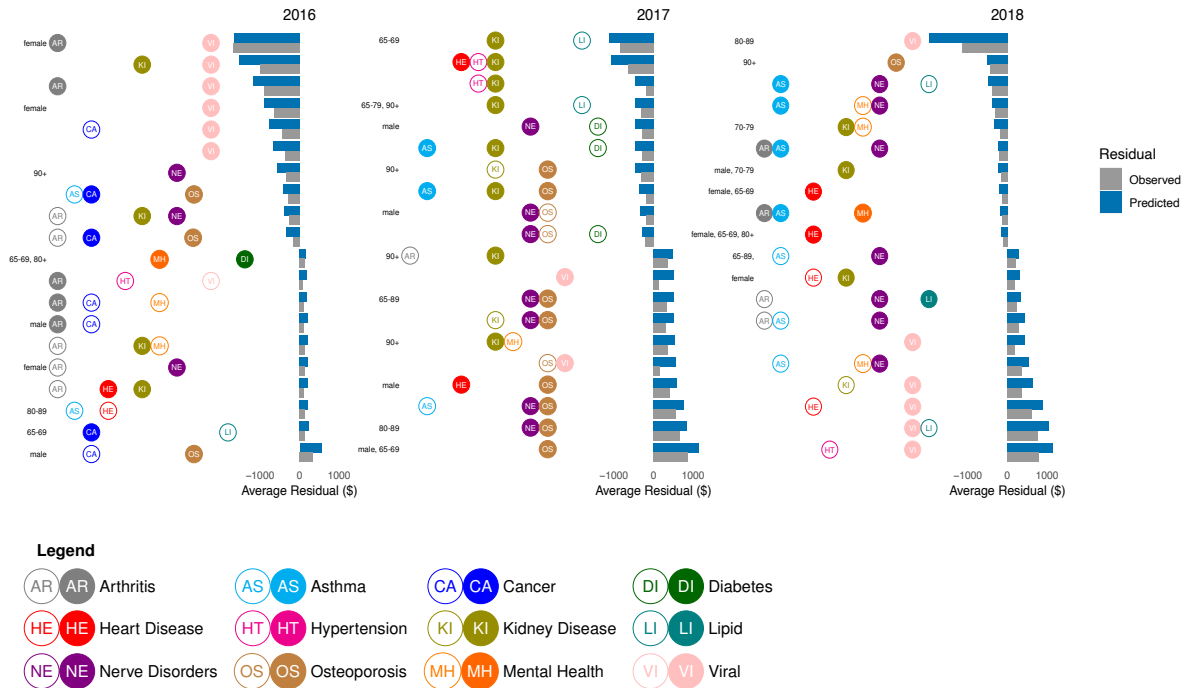
Note: Unfilled circles indicate the lack of a condition.

Figure S5. Top Under- and Overcompensated Groups in the Marketplaces Risk Adjustment, Observed vs Predicted Residuals (minimum node size: 100, maximum nodes: 8)



Note: Unfilled circles indicate the lack of a condition.

Figure S6. Top Under- and Overcompensated Groups in the Medicare Risk Adjustment by Year (minimum node size: 10,000, maximum nodes: 8)



Note: Unfilled circles indicate the lack of a condition.