Supplemental Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix. Additional Methods

A. Attributing beneficiaries to ACOs or non-ACO providers

We followed the MSSP attribution rules to assign each beneficiary in each study year to the ACO or non-ACO TIN that accounted for the most allowed charges for primary care services received by the beneficiary in that year, but made 3 modifications to the attribution algorithm to achieve greater balance between comparison groups and across years and to reflect recent changes. Our approach is described elsewhere[1] and is summarized below. Specifically, first, we attributed beneficiaries based on *outpatient* primary care services (current procedural terminology [CPT] codes 99201-99215, G0402, G0438, and G0439) but not physician services provided in nursing facilities or other settings (99304-99318, 99324-99340, and 99341-99350) that have been included in the definition of primary care services in the MSSP rules. We excluded these latter services from consideration because nursing facilities (or physicians working in nursing facilities) are underrepresented in ACO contracts, as demonstrated in prior work.[2] Consequently, inclusion of these services would cause the ACO group to be systematically different from the control group. For example, high-cost beneficiaries receiving both outpatient primary care and post-acute care in a given year could be attributed to the non-ACO TIN providing their post-acute care even if they receive the plurality of their outpatient primary care from an ACO.[3] Our exclusion of physician services in nursing facilities also reflects recent changes to the rules for patient attribution, which now exclude physician visits in SNFs from the attribution algorithm because their inclusion causes particularly sick patients with significant post-acute care needs to be attributed away from ACOs.[3,4] These high-cost patients are likely to be targets of care management efforts by

ACOs but, under the original rules, would not be attributed to an ACO if they received more care at SNFs than primary care at the ACO.

Second, we further limited attribution to step 1 of the MSSP algorithm, in which beneficiaries with at least one primary care services from a primary care physician (PCP) are attributed to the ACO or non-ACO TIN accounting for the plurality of allowed charges for primary care services provided by PCPs. PCPs are defined by claim specialty codes for internal medicine, family practice, general practice, or geriatric medicine. We did not include in our analysis beneficiaries without any primary care services from a PCP, who are attributed in step 2 of the algorithm on the basis of primary care services received from non-PCP providers. As described in the Methods, we did this because many ACOs in the MSSP only have PCPs in their contracting networks. Thus, beneficiaries attributed via step 2 would be preferentially assigned to the control group since they could not be attributed to ACOs with only PCPs. As demonstrated in prior work,[1] pre-contract differences in annual total Medicare spending between ACOs and the control group were greater when employing both steps of the algorithm than when employing step 1 only. Thus, limiting attribution to outpatient primary care services provided by PCPs achieved better balance between comparison groups.

Third, we included outpatient specialty consultations (CPT codes 99241-99245) in the set of outpatient primary care services used for attribution because these codes were eliminated from the Medicare Physician Fee Schedule starting in 2010. Thereafter, physicians instead used office visit codes in the 99201-99215 range to bill for consultations.[5] Thus, including outpatient specialty consultation codes ensured consistency over the study period in the services considered in beneficiary attribution.

These codes were used by PCPs for certain types of visits, such as pre-operative evaluations.

We followed MSSP rules for incorporating primary care services provided in safety-net settings such as federally qualified community health centers and rural health clinics and billed under CMS Certification Numbers in the Outpatient claims rather than under TINs in the Carrier (Physician/Supplier) claims.[6]

B. Modifying ACO definitions to adjust for changes in TINs used for billing and changes in physician composition of TINs

Because organizations may change the set of TINs under which they bill over time, we modified ACO definitions in a sensitivity analysis to incorporate major TINs used by ACO providers in the post-contract period but not the pre-contract period, or vice-versa. In a second sensitivity analysis, we redefined ACOs as collections of physicians to hold physician composition constant over time. The details of these modifications are described below.

We held constant over study years the definitions of ACOs as collections of TINs and CMS Certification Numbers (CCNs), but participating provider groups may have changed the TINs under which they billed over the study period. Some TINs may have been retired, while others may have been newly established, perhaps even for the purpose of defining a newly integrated group's ACO. In addition, the composition of physicians within ACO TINs also likely changed over time. We updated previously described methods for modifying ACO definitions in two ways to test the sensitivity of our results to changes in billing entities used by ACO providers and changes in physician composition of TINs. Details about these modifications are provided below. To

summarize, results were not substantially changed by modified ACO definitions to account for changes in TINs used by participating providers or the composition of physicians within TINs.

First we identified ACO TINs that appeared in the 2008 claims for the 20% sample of beneficiaries but not in either the 2013 or 2014 claims, or vice-versa. Of the 9,604 TINs constituting the ACOs in the 2012 and 2013 MSSP cohorts and billing for services used for attribution, 71% appeared in both periods of claims. Among the 2,764 TINs not present in both periods, over half were used by a single NPI (solo practitioners), and over 90% were used by 5 or fewer NPIs and thus accounted for a small share of attributed patients. Because these small TINs served few Medicare beneficiaries, they may have fallen out of the claims used for the study as a result of their Medicare patients not being included in the 20% sample or as a result of their few patients in the sample not receiving care in a given year. Consistent with previously described patterns,[1] we identified relatively few ACO TINs (only 82) with at least 20 billing NPIs that did not appear in both periods. For these TINs, we determined the NPIs billing primarily under them in the period in which the TIN was present in the claims. We then determined the TINs under which those NPIs billed in the other period. We found that, in the alternate period, 33% of the NPIs billed under a different TIN but one that was also part of the definition of the NPI's ACO. For TINs whose NPIs billed in the alternate year predominantly under TINs not included in their ACO's definition, we determined the name of the practice or group denoted by the TIN and used web searches to determine if that practice or group was part of the organization sponsoring the ACO contract. This process resulted in the addition of only 15 TINs to ACO definitions,[1] indicating that

meaningful changes over the study period in the billing entities used by providers participating in the MSSP were not common (i.e., few sizable TINs in ACO definitions were retired or came into existence during the study period).

After adding these 15 TINs to ACO definitions, we then compared the number of beneficiaries attributed to each ACO in 2008 and 2014. We identified 26 ACOs whose attributed population grew by 70% or more from 2008 to 2014, indicating either rapid growth in the organization's physician membership or a shift in billing away from TINs not included in an ACO's contract to TINs that are included. We then conducted a sensitivity analysis using modified ACO definitions that included the additional TINs and treated these 26 ACOs as collections of NPIs instead of collections of TINs (which eliminated the marked changes in the number of beneficiaries attributed to these ACOs). Results were similar to our main analysis.

In a second sensitivity analysis, we redefined each ACO as a fixed collection of NPIs rather than a fixed set of TINs, based on the NPIs listed for each ACO in the CMS ACO Provider-level Research Identifiable File. Holding the physician composition of ACOs constant over time in this manner addressed both any flux in the TINs used by ACO providers over time and also any turnover in the composition of physicians within practices. Since some physician turnover is expected within organizations, defining ACOs as fixed sets of NPIs should also introduce some attenuation bias, for example by causing some misattribution of patients to ACOs in years before their physician joined a practice in an ACO or after their physician left a practice in an ACO. Estimates from analyses using these NPI-based definitions of ACOs were substantively similar and did not alter our conclusions.

C. ACOs subgroup analyses

As described in the Methods, our primary interest was to compare ACOs that are independent physician groups or collections of physician groups with ACOs financially integrated with hospitals. Because prior research has demonstrated that overall ACO savings differ by measures of baseline efficiency, when comparing independent physician groups with hospital-integrated groups, we also allowed differential changes in use and spending to differ by baseline SNF use in ACO service areas and baseline SNF use for ACOs' attributed populations relative to regional averages. Specifically, we categorized ACOs according to whether risk-adjusted SNF use (annual number of SNF days per beneficiary among hospitalized beneficiaries) in their service area at baseline was above or below the median among ACO service areas, and we categorized ACOs according to whether risk-adjusted SNF use in their attributed population was above or below average SNF in their service area for the control group.

We applied previously described methods to estimate these baseline levels,[1] and we used claims from 2008 (before the study period) to assess baseline SNF use for these measures to minimize bias from regression to the mean—a concern particularly for comparisons of ACOs with baseline levels of spending or use above vs. below their regional average. As in prior work,[1,2] this approach (using 2008 data) was effective in identifying subgroups of ACOs with significantly different average levels in the pre-contract period while ensuring that regression to the mean did not contribute to estimated subgroup differences. Specifically, after observing convergence in levels between subgroups from 2008 (the year used for categorization) to 2009, we found no evidence of regression to the mean over the pre-contract period (2009-2011 for the 2012 cohort or

2009-2012 for the 2013 cohort). For example, for the 2012 cohort, pre-contract trends in annual per-beneficiary SNF spending were similar between ACOs and the control group within each of the subgroups defined by baseline SNF use relative to local averages, and the pre-contract trend difference was actually slightly higher ($4/beneficiary faster; P=0.79) for ACOs with baseline SNF use above the local average than for ACOs with baseline SNF use below the local average. This difference was not statistically significant and in the opposite direction from what would be expected if ACOs with above average SNF use regressed to a local mean.

The eFigure displays the estimates of the subgroup comparisons generated by models allowing differential changes to vary by each of the 3 ACO characteristics (organizational type, baseline SNF use in the ACO service area, and baseline SNF use in the ACO relative to the regional average). Panel A displays estimates from patient-level models of inpatient spending, Panel B displays estimates from patient-level models of annual SNF spending, and Panel C displays estimates from admission-level models of SNF spending in the post-acute period. Estimates are provided separately for the 2012 and 2013 ACO cohorts and pooled for the 2013-2014 post-contract period to improve precision. Estimated reductions in inpatient and SNF spending were consistently greater for independent physician groups than for hospital-integrated groups across ACO cohorts and analyses, contributing to previously described greater savings among independent physician groups,[1,7] but these subgroups differences in inpatient and SNF spending were not statistically significant (eFigure, Panels A-C). Of note, comparisons of independent physician groups with hospital-integrated groups that were not adjusted for subgroup differences associated with baseline SNF use yielded a similar pattern of results

supporting similar conclusions. Estimated reductions in SNF spending also were consistently greater in the 2012 and 2013 cohorts for ACOs in areas with high levels of SNF use at baseline than for ACOs in areas with low levels of baseline SNF use, but these differences also were not statistically significant (P=0.06 for post hoc test of subgroup differences in SNF spending reductions conditional on admission, pooled across cohorts and post-contract years, Panel C).

eReferences

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eTable 1. Pre-Contract Differences in Patient Characteristics Between ACOs and Control Group[a]

Patient Characteristic	Unadjusted pre-contract mean[b]			Pre-contract difference between ACOs and control group					
				2012 MSSP cohort (N=114 ACOs)			**2013 MSSP cohort** (N=106 ACOs)		
	Overall sample of patients (N = 12,650,860 patient-years	**Admissions** (N = 4,418,002)	**SNF stays** (N = 814,996)	**Overall sample of patients** (ACO N = 11,279,358)	**Admissions** (ACO N = 3,947,563)	**SNF stays** (ACO N = 727,839)	**Overall sample of patients** (ACO N = 14,875,576)	**Admissions** (ACO N = 5,094,459)	**SNF stays** (ACO N = 947,575)
Age, y	72.2	73.7	79.3	0.3[h]	0.3	0.1	0.3[h]	0.4[h]	0.2[h]
Female sex, %	58.9	58.5	66.1	0.7	1.0[j]	0.9[i]	0.3[h]	0.5[h]	0.8[h]
Race or ethnic group[c], %									
Non-Hispanic white	83.5	81.9	86.7	-1.1	-0.9	-0.7	0.0	0.6	0.7
Non-Hispanic black	8.5	10.6	8.1	-0.2	0.0	0.0	-0.3	-0.8	-0.6
Hispanic	4.7	4.9	3.3	0.3	0.4	0.3	-0.2	0.0	-0.3
Other	3.2	2.5	1.9	1.0	0.5	0.3	0.5	0.2	0.2
Medicaid recipient, %	16.0	24.2	28.1	-0.7	-0.7	0.0	-1.8[h]	-2.8[j]	-3.6[j]
Disabled[d], %	21.8	24.9	16.5	-1.8[i]	-1.4[i]	-0.9	-1.9[j]	-1.6[i]	-1.4[j]
End-stage renal disease, %	1.0	5.0	3.8	0.0	0.3	0.1	-0.1	-0.2	-0.3[i]
Long-term nursing home resident, %	1.4	3.1	7.0	0.2	0.4	1.0	-0.3[j]	-0.7[j]	-1.4[j]
No. of CCW conditions[e]	5.7	7.8	8.6	0.0	0.0	0.0	0.0	-0.1	-0.1[h]

HCC risk score[f]	1.23	2.13	2.21	0.00	0.00	-0.01	-0.01[h]	-0.03[h]	-0.04[h]
ZCTA-level characteristic									
% below FPL	9.1	9.6	9.1	-0.5[i]	-0.5[j]	-0.5[j]	-0.4[i]	-0.5[j]	-0.5[j]
% with high school degree	75.4	74.2	75.6	0.9[h]	0.9[h]	1.0[i]	1.1[i]	1.3[i]	1.4[i]
% with college degree	19.4	18.3	19.0	0.6	0.6	0.8[h]	1.0[h]	1.2[i]	1.4[i]
DRG payment weight[g]	-	1.57	1.74	-	0.01[i]	0.00	-	0.01	0.01
Acute admission length of stay,[g] days	-	6.17	8.05	-	-0.01	-0.07	-	-0.08[i]	-0.14[i]
Acute admission spending,[g] $	-	8,406	9,934	-	18	-85	-	-6	-33

[a]Means and percentages were adjusted for geography to reflect comparisons within hospital referral regions. ZCTA denotes ZIP Code tabulation area. FPL denotes federal poverty level. DRG denotes diagnosis related group.
[b]Pre-contract means are presented for years 2009-2011 for consistency, but in estimation of pre-contract differences, the pre-contract period extended through 2012 for the 2013 cohort. Pre-contract means provide a basis for calculating differential changes as relative percentages.
[c]Race or ethnic group was determined from Medicare master beneficiary summary files.
[d]Indicates that disability was the original reason for Medicare eligibility.
[e]Chronic conditions from the Chronic Conditions Data Warehouse (CCW) included 27 conditions: acute myocardial infarction, Alzheimer's disease, Alzheimer's disease and related disorders or senile dementia, anemia, asthma, atrial fibrillation, benign prostatic hyperplasia, chronic kidney disease, chronic obstructive pulmonary disease, depression, diabetes, heart failure, hip/pelvic fracture, hyperlipidemia, hypertension, hypothyroidism, ischemic heart disease, osteoporosis, rheumatoid arthritis/osteoarthritis, stroke/transient ischemic attack, breast cancer, colorectal cancer, endometrial cancer, lung cancer, prostate cancer, cataracts, and

glaucoma. Indicators for all 27 conditions were included in analytic models, as well as indicators of having multiple (≥2 through ≥9) conditions. Counts of conditions presented in the table include all conditions except cataracts and glaucoma.

[f]Hierarchical Condition Categories (HCC) risk scores are derived from demographic and diagnostic data in Medicare enrollment and claims files, with higher scores indicating higher predicted spending in the subsequent year. For each beneficiary in each study year, we assessed the HCC score based on enrollment and claims data in the prior year.

[g]DRG payment weights, length of stay, and inpatient spending were used as additional measures to assess whether case mix for the admission-level and SNF stay-level analyses differentially changed as a result of differential changes in admission and SNF stay rates. For the analysis of SNF stays, these measures were assessed for the admission preceding each SNF stay.

[h]Statistically different from zero at a $P<.05$ level.

[i]Statistically different from zero at a $P<.01$ level.

[j]Statistically different from zero at a $P<.05$ level.

eTable 2. Patient-Level Analysis: Acute and Post-Acute Care Spending and Mortality For 2013 Cohort Of MSSP ACOs vs Control Group[a]

	Unadjusted pre-contract mean	Adjusted pre-contract difference, ACOs−control group (N = 11,135,252 patient-years)	*P* Value	Adjusted pre-contract difference in annual trend, ACOs−control group (N = 11,135,252 patient-years)	*P* Value	Differential change in post-contract period for ACOs vs. control group			
						Post-year 2013 (ACO N = 284,454)		Post-year 2014 (ACO N = 284,698)	
						Estimate (95% CI)	*P* Value	Estimate (95% CI)	*P* Value
Spending, $									
Acute inpatient care[b]	3,400	13	.65	-11	.27	22 (-34,77)	.44	-33 (-92,27)	.28
Facility	2,923	7	.79	-10	.24	17 (-33,66)	.51	-30 (-83,23)	.26
Professional	477	6	.24	-1	.67	5 (-2,12)	.19	-3 (-12,6)	.54
Post-acute facility care	1,172	4	.79	7	.16	4 (-24,31)	.80	-25 (-54,4)	.10
Facility	1,136	4	.81	7	.15	3 (-24,30)	.84	-25 (-53,4)	.09
SNF	813	10	.47	2	.65	-13 (-33,6)	.19	-27 (-49,-6)	.01
IRF	202	-3	.65	4	.07	8 (-3,19)	.16	7 (-4,18)	.24
LTCH	121	-4	.54	2	.49	8 (-4,20)	.18	-4 (-16,8)	.52
Professional	37	1	.51	0	.89	1 (0,2)	.19	0 (-2,1)	.53
Home health	630	16	.26	-1	.87	-3	.61	1	.86

						(-16,9)		(-15,17)	
Post-acute	108	1	.39	-1	.13	-2 (-5,2)	.39	1 (-3,4)	.72
Outpatient	522	14	.29	1	.84	-2 (-14,10)	.79	1 (-14,15)	.91
Mortality, %	3.24	-0.11	.001	0.01	.53	0.03 (-0.04,0.11)	.34	0.04 (-0.02,0.11)	.20

[a]SNF denotes skilled nursing facility. IRF denotes inpatient rehabilitation facility. LTCH denotes long-term care hospital.
[b]Inpatient facility spending did not include capital, disproportionate hospital, or indirect medical education payments. To adjust for between-hospital differences in Medicare payments for admissions in the same diagnosis-related group, we standardized inpatient facility spending by calculating a national mean payment for each DRG and summing mean payments across admissions for each beneficiary rather than actual Medicare payments. Estimates were not appreciably changed by this standardization.

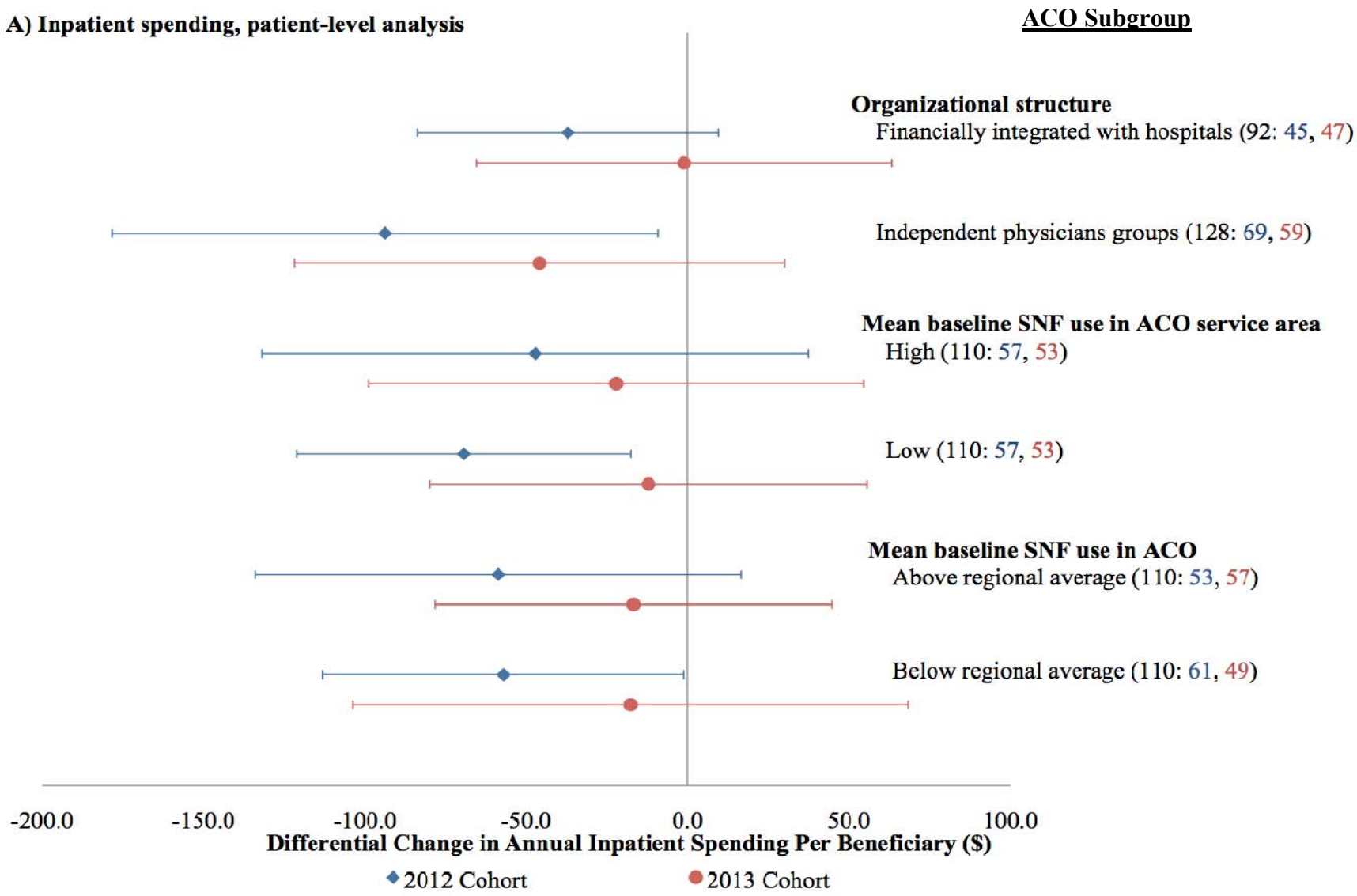
eTable 3. Admission-Level Analysis Among Hospitalized Patients: Post-Acute Care Spending and Use for 2013 Cohort of MSSP ACOs vs Control Group[a]

Measure of post-acute care spending or use	Unadjusted pre-contract mean	Adjusted pre-contract difference, ACOs−control group (N = 3,885,671 admissions)	*P* Value	Adjusted pre-contract difference in annual trend, ACOs−control group (N = 3,885,671 admissions)	*P* Value	Differential change in post-contract period for ACOs vs. control group			
						Post-year 2013 (ACO N = 86,020)		Post-year 2014 (ACO N = 82,395)	
						Estimate (95% CI)	*P* Value	Estimate (95% CI)	*P* Value
Discharge setting, %									
Facility	22.6	0.2	.35	0.0	.55	0.1 (-0.3,0.5)	.60	-0.1 (-0.5,0.2)	.54
SNF	18.5	0.2	.40	0.0	.67	0.0 (-0.4,0.3)	.84	-0.2 (-0.6,0.1)	.19
IRF	3.3	0.0	.81	0.0	.37	0.1 (0.0,0.3)	.15	0.2 (0.0,0.3)	.04
LTCH	0.9	0.0	.56	0.0	.24	0.0 (-0.1,0.1)	.71	-0.1 (-0.1,0.0)	.14
Home	77.4	-0.2	.35	0.0	.55	-0.1 (-0.5,0.3)	.60	0.1 (-0.2,0.5)	.54
Spending during post-acute period, $									
SNF	2,207	24	.47	1	.95	-31 (-84,23)	.26	-50 (-102,3)	.07
IRF	525	-6	.74	8	.10	27 (-2,57)	.07	29 (-1,60)	.06
LTCH	338	4	.79	-1	.89	3	.87	-6	.74

						(-27,32)		(-40,28)	
Home health care	549	19	.02	-6	.08	-7 (-25,10)	.41	-5 (-19,9)	.49
Days during post-acute period, no.									
SNF	5.31	0.08	.26	0.03	.19	-0.04 (-0.16,0.09)	.57	-0.08 (-0.21,0.04)	.20
IRF	0.47	-0.01	.69	0.01	.25	0.02 (0.00,0.05)	.04	0.02 (0.00,0.04)	.10
LTCH	0.27	0.01	.62	0.00	.48	0.00 (-0.02,0.02)	.91	-0.01 (-0.03,0.02)	.47
Home health care	7.97	0.13	.30	-0.10	.10	-0.05 (-0.33,0.23)	.73	0.08 (-0.16,0.31)	.53
30-day readmission, %	17.6	-0.2	.07	0.0	.65	0.1 (-0.2,0.4)	.42	0.0 (-0.3,0.3)	.93

[a]SNF denotes skilled nursing facility. IRF denotes inpatient rehabilitation facility. LTCH denotes long-term care hospital.

eFigure. Differential Changes in Inpatient and SNF Spending by ACO Subgroup



B) SNF spending, patient-level analysis