# Supplementary Online Content

Kosar CM, Loomer L, Thomas KS, White EM, Panagiotou OA, Rahman M. Association of diagnosis coding with differences in risk-adjusted short-term mortality between critical access and non–critical access hospitals. *JAMA*. doi:10.1001/jama.2020.9935

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

eMethods

**Study Population**. Our sample consists of rural Traditional Medicare beneficiaries admitted to CAHs and non-CAHs between January 1, 2007 and November 30, 2017 with a primary diagnosis of pneumonia, congestive heart failure, chronic obstructive pulmonary disease, stroke, septicemia, urinary tract infection, and arrhythmia (identified with international classification of diseases [ICD] codes, **eTable 1**). These conditions were selected due to being common causes for admission to both CAHs and non-CAHs, which we ascertained by examining the distribution of diagnosis related groups (DRGs) assigned to discharges. We list the top 10 most prevalent medical DRGs among CAH and non-CAH discharges in **eTable 2**. Diagnoses from the DRGs common to both CAHs and non-CAHs were selected, with the exception of 'esophagitis, gastroenteritis, and miscellaneous digestive disorders' because of the high diagnostic heterogeneity within this group.

Analyses were limited to rural beneficiaries because CAHs are generally not an alternative site of care for urban beneficiaries (**eFigure 1**). Additionally, non-CAHs where urban beneficiaries receive care are likely to be inherently different from non-CAHs where rural beneficiaries receive care. Medicare Advantage enrollees were excluded given evidence that their diagnoses are over-coded due to different payment mechanisms that are not the focus of this study.

We retained all hospitalizations in our analysis that met the CMS definition of index hospitalization. As such, hospitalizations fulfilling one or more of the following criteria were excluded: date of admission within 30 days of a prior discharge (readmissions are not considered index hospitalizations); date of admission before February 1, 2007, for which readmission status cannot be ascertained; date of discharge after November 30, 2016, for which follow-up is

censored; or discharge status was left against medical advice. If a patient had multiple index hospitalizations during a calendar year then only one was selected at random to be included. Contiguous hospitalizations (involving transfers) were combined into a single episode of care and the patient outcome was attributed to the first hospital.

eFigure 1. Proportion of Hspitalizations Among Traditional Medicare Beneficiaries Occurring at Critical Access Hospitals
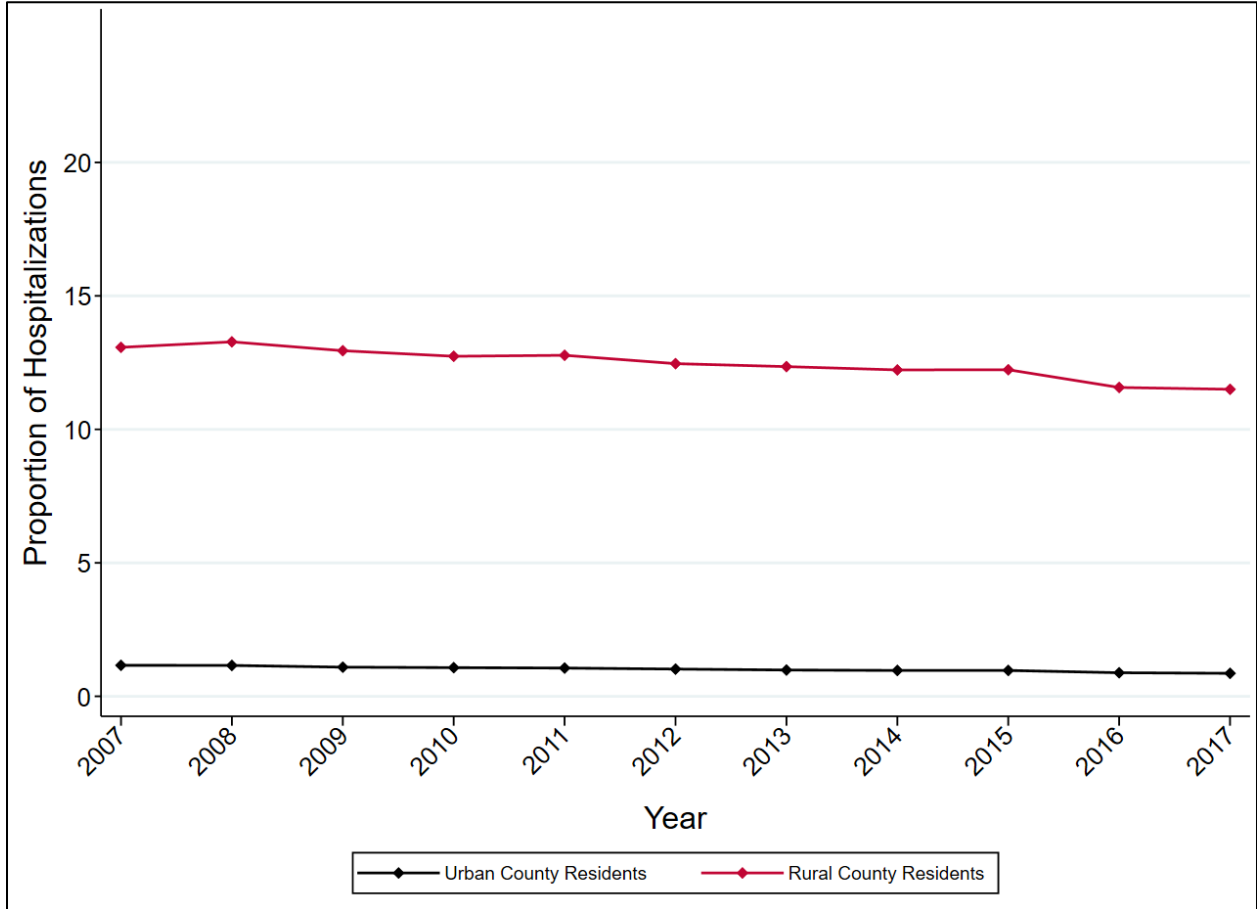


Counties were classified as rural or urban based on Rural-Urban Continuum Codes, which were developed by the US Department of Agriculture and last updated in 2013.

eFigure 2. HCC Scores Among Patients Discharged From Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017.
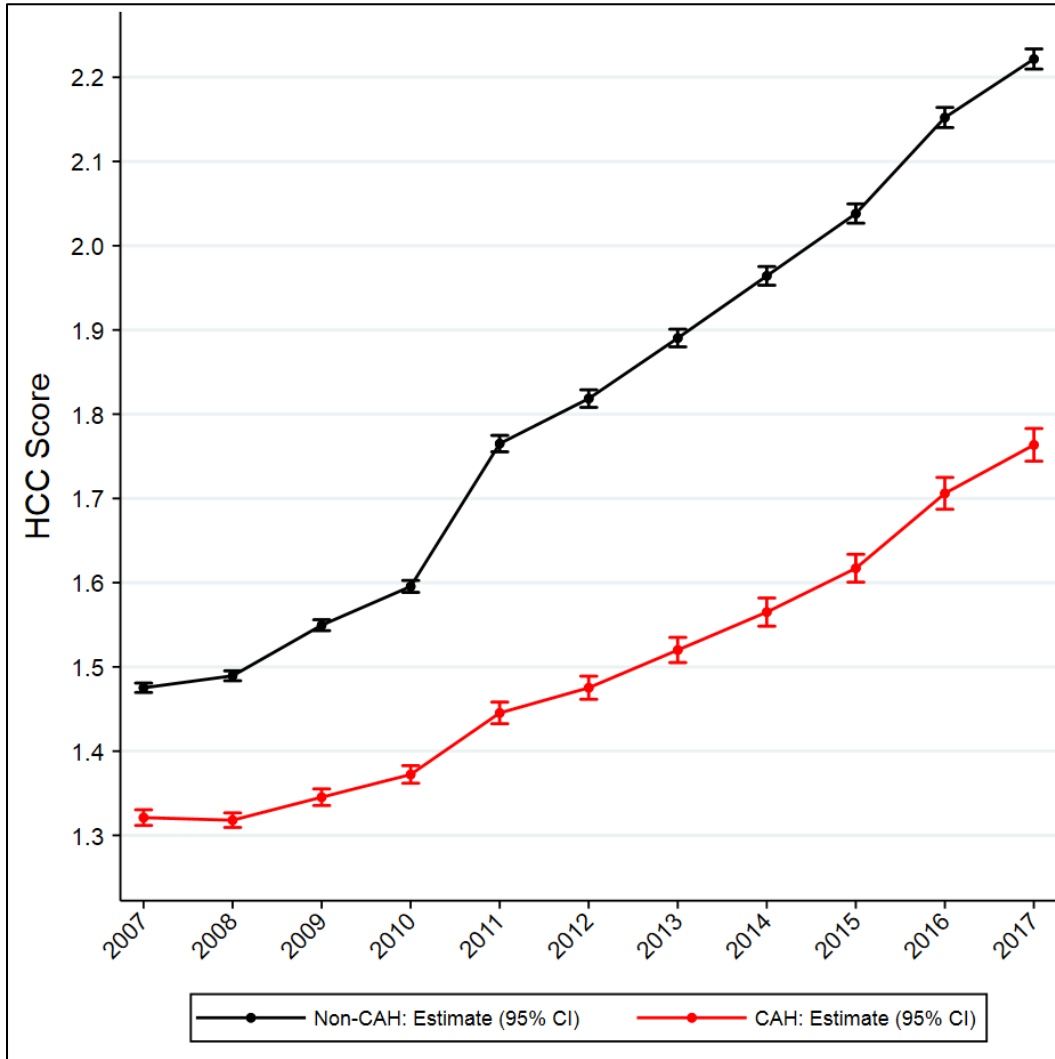


Covariates in the adjusted model were: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. CAH=Critical Access Hospital; CI=Confidence Interval.

eFigure 3. Sensitivity of Mortality Differences Between Critical Access Hospitals and Non-Critical Access Hospitals to Diagnosis Coding, 2007-2017.
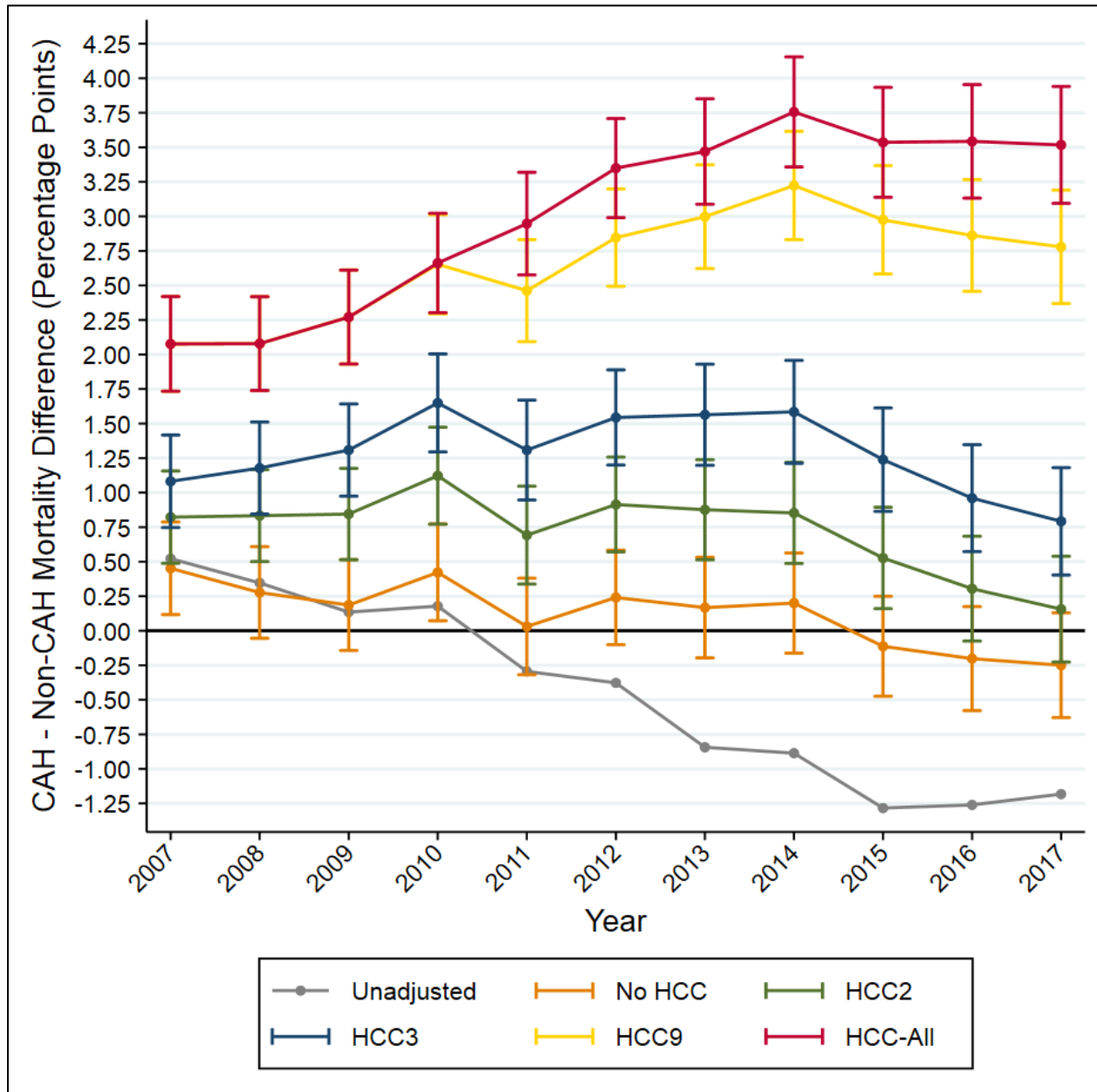


Mortality includes in-hospital and 30-day post-discharge mortality. All adjusted models include the following covariates: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. Models in the legend are distinguished by whether or not they use the HCC score as an additional covariate, and the number of discharge diagnoses used to calculate the HCC score for that specification. Bars represent 95% confidence intervals for each adjusted point estimate. CAH=Critical Access Hospital.

eTable 1. List of Inclusionary Diagnoses and *International Classification of Diseases* Codes

| Diagnosis | ICD-9 | ICD-10 |
| --- | --- | --- |
| Pneumonia | 480.xx-486.xx, 487.0, 488.01, 488.11 | J10.0x, J11.0x, J12.xx-J18.xx, J09.X1 |
| COPD | 490.xx-492.xx, 493.2x, 496.xx | J40.xx-J44.xx |
| Heart Failure | 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.xx | I09.81, I11.0, I13.0, I13.2, I50.xx |
| Arrhythmia | 427.xx | I48.xx, I49.xx, R00.0, R00.1 |
| UTI | 599.00 | N390.0 |
| Septicemia | 38.xx, 995.91, 995.92 | A40.xx, A41.xx, R65.2x |
| Stroke | 430.xx, 431.xx, 432.xx, 433.x1, 434.x1, 436.xx | I60.xx-I63.xx |

COPD=Chronic Obstructive Pulmonary Disease; UTI=Urinary Tract Infection

eTable 2. Top 10 Most Prevalent Diagnosis Related Groups for Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017

| Base Diagnosis Related Group | Admissions/Year | Prevalence |
|---|---|---|
| Critical Access Hospitals | | |
| Pneumonia | 26,778 | 12.0 |
| COPD | 16,846 | 7.6 |
| Heart failure | 14,319 | 6.4 |
| UTI | 11,940 | 5.4 |
| Esophagitis/Gastroenteritis/Misc. digestive disorders | 10,162 | 4.6 |
| Misc. disorders of nutrition, metabolism, and fluids | 9,064 | 4.1 |
| Arrhythmia | 6,634 | 3.0 |
| Septicemia | 6,262 | 2.8 |
| Cellulitis | 6,209 | 2.8 |
| Stroke | 5,303 | 2.4 |
| Non-Critical Access Hospitals | | |
| Septicemia | 68,734 | 4.5 |
| Pneumonia | 68,375 | 4.4 |
| Heart failure | 66,723 | 4.3 |
| COPD | 64,780 | 4.2 |
| Arrhythmia | 42,196 | 2.7 |
| Stroke | 41,250 | 2.7 |
| Esophagitis/Gastroenteritis/Misc. Digestive Disorders | 38,951 | 2.5 |
| UTI | 36,054 | 2.3 |
| Renal failure | 34,133 | 2.2 |
| GI Bleed | 31,966 | 2.1 |

eTable 3. Distribution of Transfers at CAHs and Non-CAHS

| Transfer Type | Frequency | Proportion |
|---|---|---|
| Non-CAH to Non-CAH | 87,275 | 70.2% |
| Non-CAH to CAH | 600 | 0.5% |
| CAH to Non-CAH | 33,695 | 27.1% |
| CAH to CAH | 2,804 | 2.3% |

CAH=Critical Access Hospital

eTable 4. Count of Discharge Diagnoses Among Patients Admitted to Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017

| Year | Unadjusted | | | | Adjusted | | | |
|------|------|------|------|------|------|------|------|------|
| | CAH | Non-CAH | Difference (95% CI) | *P* | CAH | Non-CAH | Difference (95% CI) | *P* |
| 2007 | 6.86 | 7.80 | -0.95 (-1.04, -0.85) | <0.001 | 6.82 | 7.81 | -0.99 (-1.08, -0.90) | <0.001 |
| 2008 | 7.01 | 7.96 | -0.95 (-1.05, -0.86) | <0.001 | 6.98 | 7.96 | -0.99 (-1.08, -0.90) | <0.001 |
| 2009 | 7.23 | 8.19 | -0.96 (-1.05, -0.86) | <0.001 | 7.20 | 8.19 | -0.99 (-1.08, -0.90) | <0.001 |
| 2010 | 7.55 | 8.52 | -0.98 (-1.07, -0.88) | <0.001 | 7.52 | 8.53 | -1.01 (-1.11, -0.92) | <0.001 |
| 2011 | 9.28 | 12.23 | -2.95 (-3.20, -2.71) | <0.001 | 9.27 | 12.23 | -2.96 (-3.19, -2.73) | <0.001 |
| 2012 | 9.66 | 12.85 | -3.19 (-3.44, -2.93) | <0.001 | 9.73 | 12.83 | -3.10 (-3.35, -2.86) | <0.001 |
| 2013 | 10.07 | 13.48 | -3.41 (-3.69, -3.13) | <0.001 | 10.21 | 13.45 | -3.24 (-3.51, -2.98) | <0.001 |
| 2014 | 10.53 | 14.07 | -3.54 (-3.84, -3.25) | <0.001 | 10.73 | 14.04 | -3.31 (-3.58, -3.03) | <0.001 |
| 2015 | 10.88 | 14.48 | -3.61 (-3.91, -3.30) | <0.001 | 11.05 | 14.45 | -3.40 (-3.68, -3.11) | <0.001 |
| 2016 | 11.36 | 14.85 | -3.49 (-3.80, -3.17) | <0.001 | 11.56 | 14.81 | -3.25 (-3.54, -2.97) | <0.001 |
| 2017 | 11.96 | 15.65 | -3.70 (-4.02, -3.38) | <0.001 | 12.25 | 15.60 | -3.35 (-3.65, -3.06) | <0.001 |

Covariates in the adjusted model were: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. CAH=Critical Access Hospital; CI=Confidence Interval.

eTable 5. Assessment of Change in Diagnosis Coding Differences Between Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017

| Variable | (1) Diagnosis Count | | (2) HCC Score | |
|---|---|---|---|---|
| | β (95% CI) | P | β (95% CI) | P |
| CAH | -1.00 (-1.12, -0.89) | <0.001 | -0.22 (-0.23, -0.20 ) | <0.001 |
| Year | | | | |
| 2007 | -0.66 (-0.69, -0.63) | <0.001 | -0.10 (-0.11, -0.10 ) | <0.001 |
| 2008 | -0.49 (-0.52, -0.46) | <0.001 | -0.09 (-0.09, -0.08 ) | <0.001 |
| 2009 | -0.29 (-0.31, -0.27) | <0.001 | -0.03 (-0.04, -0.03 ) | <0.001 |
| 2010 | Referent | | Referent | |
| 2011 | 3.66 ( 3.55, 3.78) | <0.001 | 0.16 ( 0.16, 0.17 ) | <0.001 |
| 2012 | 4.23 ( 4.11, 4.35) | <0.001 | 0.20 ( 0.19, 0.21 ) | <0.001 |
| 2013 | 4.77 ( 4.65, 4.90) | <0.001 | 0.25 ( 0.24, 0.25 ) | <0.001 |
| 2014 | 5.27 ( 5.13, 5.40) | <0.001 | 0.29 ( 0.28, 0.30 ) | <0.001 |
| 2015 | 5.59 ( 5.46, 5.73) | <0.001 | 0.34 ( 0.33, 0.35 ) | <0.001 |
| 2016 | 5.86 ( 5.72, 5.99) | <0.001 | 0.43 ( 0.42, 0.44 ) | <0.001 |
| 2017 | 6.62 ( 6.48, 6.76) | <0.001 | 0.48 ( 0.47, 0.49 ) | <0.001 |
| CAH x 2007 | -0.01 (-0.08, 0.06) | 0.76 | 0.07 ( 0.06, 0.08 ) | <0.001 |
| CAH x 2008 | -0.00 (-0.06, 0.06) | 0.96 | 0.05 ( 0.04, 0.06 ) | <0.001 |
| CAH x 2009 | 0.00 (-0.04, 0.05) | 0.76 | 0.01 ( 0.01, 0.02 ) | <0.001 |
| CAH x 2010 | Referent | | Referent | |
| CAH x 2011 | -1.93 (-2.10, -1.76) | <0.001 | -0.11 (-0.12, -0.10 ) | <0.001 |
| CAH x 2012 | -2.11 (-2.31, -1.92) | <0.001 | -0.13 (-0.14, -0.12 ) | <0.001 |
| CAH x 2013 | -2.28 (-2.50, -2.06) | <0.001 | -0.16 (-0.17, -0.14 ) | <0.001 |
| CAH x 2014 | -2.36 (-2.60, -2.12) | <0.001 | -0.18 (-0.20, -0.17 ) | <0.001 |
| CAH x 2015 | -2.39 (-2.64, -2.13) | <0.001 | -0.20 (-0.22, -0.19 ) | <0.001 |
| CAH x 2016 | -2.28 (-2.54, -2.01) | <0.001 | -0.23 (-0.25, -0.22 ) | <0.001 |
| CAH x 2017 | -2.46 (-2.74, -2.18) | <0.001 | -0.25 (-0.27, -0.23 ) | <0.001 |

The table includes point estimates derived from linear regression models for two outcomes: (1) diagnosis count and (2) HCC score. The terms of interest, CAH, calendar year, and CAH x year (interaction), are presented. Covariates in the adjusted model were: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. CAH=Critical Access Hospital; CI=Confidence Interval

eTable 6. Mean HCC Scores Among Patients Admitted to Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017

| Year | Unadjusted | | | | Adjusted | | | |
|------|------|-------------|---------------------|--------|------|-------------|---------------------|--------|
|      | CAH  | Non-CAH     | Difference (95% CI  | *P*    | CAH  | Non-CAH     | Difference (95% CI  | *P*    |
| 2007 | 1.31 | 1.48 | -0.16 (-0.17, -0.15) | <0.001 | 1.32 | 1.48 | -0.15 (-0.16, -0.14) | <0.001 |
| 2008 | 1.31 | 1.49 | -0.19 (-0.2, -0.17) | <0.001 | 1.32 | 1.49 | -0.17 (-0.18, -0.16) | <0.001 |
| 2009 | 1.33 | 1.55 | -0.22 (-0.24, -0.21) | <0.001 | 1.35 | 1.55 | -0.2 (-0.22, -0.19) | <0.001 |
| 2010 | 1.35 | 1.60 | -0.25 (-0.26, -0.23) | <0.001 | 1.37 | 1.60 | -0.22 (-0.24, -0.21) | <0.001 |
| 2011 | 1.40 | 1.77 | -0.37 (-0.39, -0.35) | <0.001 | 1.45 | 1.77 | -0.32 (-0.34, -0.3) | <0.001 |
| 2012 | 1.42 | 1.83 | -0.41 (-0.43, -0.39) | <0.001 | 1.48 | 1.82 | -0.34 (-0.36, -0.33) | <0.001 |
| 2013 | 1.45 | 1.90 | -0.46 (-0.48, -0.43) | <0.001 | 1.52 | 1.89 | -0.37 (-0.39, -0.35) | <0.001 |
| 2014 | 1.48 | 1.98 | -0.5 (-0.53, -0.48) | <0.001 | 1.57 | 1.96 | -0.4 (-0.42, -0.38) | <0.001 |
| 2015 | 1.52 | 2.06 | -0.53 (-0.56, -0.51) | <0.001 | 1.62 | 2.04 | -0.42 (-0.44, -0.4) | <0.001 |
| 2016 | 1.60 | 2.17 | -0.57 (-0.6, -0.54) | <0.001 | 1.71 | 2.15 | -0.45 (-0.47, -0.42) | <0.001 |
| 2017 | 1.66 | 2.24 | -0.59 (-0.61, -0.56) | <0.001 | 1.76 | 2.22 | -0.46 (-0.48, -0.44) | <0.001 |

Covariates in the adjusted model were: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. CAH=Critical Access Hospital; CI=Confidence Interval.

eTable 7. Adjusted Mean Discharge Diagnosis Count Before and After Transfer by CAH Status

| | Pre-Transfer (95% CI) | Post-Transfer (95% CI) | Pre-Post Change (95% CI); *P* |
|---|---|---|---|
| All Years | | | |
| CAH | 9.72 (9.57, 9.88) | 13.41 (13.32, 13.52) | 3.69 (3.54, 3.84); <0.001 |
| Non-CAH | 11.63 (11.53, 11.73) | 13.35 (13.29, 13.41) | 1.72 (1.63, 1.80); <0.001 |
| CAH vs. non-CAH difference | -1.90 (-2.10, -1.72) | -0.07 (-0.06, 0.19) | 1.97 (1.79, 2.16); <0.001 |
| Pre-2011 | | | |
| CAH | 7.34 (7.26, 7.42) | 8.68 (8.65, 8.71) | 1.34 (1.25, 1.42); <0.001 |
| Non-CAH | 8.16 (8.13, 8.20) | 8.61 (8.60, 8.63) | 0.45 (0.41, 0.49); <0.001 |
| CAH vs. non-CAH difference | -0.82 (-0.92, -0.73) | 0.06 (0.02, 0.10) | 0.89 (0.79, 0.98); <0.001 |
| Post-2011 | | | |
| CAH | 11.24 (10.94, 11.38) | 16.45 (16.34, 16.56) | 5.20 (4.98, 5.42); <0.001 |
| Non-CAH | 13.95 (13.85, 14.13) | 16.52 (16.45, 16.59) | 2.56 (2.44, 2.70); <0.001 |
| CAH vs. non-CAH difference | -2.70 (-2.97, -2.43) | -0.07 (-0.21, 0.07) | 2.63 (2.37, 2.90); <0.001 |

The table contains results from three linear regression models estimating the number of discharge diagnoses before transfer, after transfer, and the pre- post- change as outcomes. CAH admission was the exposure of interest. Covariates in the adjusted model were: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. CAH=Critical Access Hospital; CI=Confidence Interval.

eTable 8. Mortality Event Counts at Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017

| Year | Pooled | | CAH | | Non-CAH | |
|------|-------------|-------|-------------|-------|---------------|-------|
| | n/N | % | n/N | % | n/N | % |
| 2007 | 42997/363640 | 11.8% | 8104/66148 | 12.3% | 34893/297492 | 11.7% |
| 2008 | 49640/400914 | 12.4% | 9388/74131 | 12.7% | 40252/326783 | 12.3% |
| 2009 | 47501/388329 | 12.2% | 8605/69715 | 12.3% | 38896/318614 | 12.2% |
| 2010 | 47466/384060 | 12.4% | 8494/67920 | 12.5% | 38972/316140 | 12.3% |
| 2011 | 48474/385464 | 12.6% | 8468/68656 | 12.3% | 40006/316808 | 12.6% |
| 2012 | 48247/379140 | 12.7% | 8141/65583 | 12.4% | 40106/313557 | 12.8% |
| 2013 | 48503/370394 | 13.1% | 7814/63040 | 12.4% | 40689/307354 | 13.2% |
| 2014 | 48939/366059 | 13.4% | 7734/61229 | 12.6% | 41205/304830 | 13.5% |
| 2015 | 49988/370471 | 13.5% | 7690/61896 | 12.4% | 42298/308575 | 13.7% |
| 2016 | 44462/339649 | 13.1% | 6514/54144 | 12.0% | 37948/285505 | 13.3% |
| 2017 | 45100/346600 | 13.0% | 6578/54741 | 12.0% | 38522/291859 | 13.2% |

CAH=Critical Access Hospital

eTable 9. Estimated Mortality Rates for Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017.

| Year | CAH | Non-CAH | Difference (95% CI) | $P$ |
|---|---|---|---|---|
| Unadjusted | | | | |
| 2007 | 12.25 | 11.73 | 0.52 (0.18, 0.86) | 0.003 |
| 2008 | 12.66 | 12.32 | 0.35 (0.01, 0.69) | 0.05 |
| 2009 | 12.34 | 12.21 | 0.14 (-0.21, 0.48) | 0.45 |
| 2010 | 12.51 | 12.33 | 0.18 (-0.18, 0.53) | 0.32 |
| 2011 | 12.33 | 12.63 | -0.29 (-0.65, 0.07) | 0.11 |
| 2012 | 12.41 | 12.79 | -0.38 (-0.74, -0.02) | 0.04 |
| 2013 | 12.40 | 13.24 | -0.84 (-1.22, -0.46) | <0.001 |
| 2014 | 12.63 | 13.52 | -0.89 (-1.25, -0.52) | <0.001 |
| 2015 | 12.42 | 13.71 | -1.28 (-1.66, -0.91) | <0.001 |
| 2016 | 12.03 | 13.29 | -1.26 (-1.64, -0.88) | <0.001 |
| 2017 | 12.02 | 13.20 | -1.18 (-1.57, -0.79) | <0.001 |
| Adjusted Model 1, with HCC Score | | | | |
| 2007 | 13.52 | 11.44 | 2.08 (1.73, 2.42) | <0.001 |
| 2008 | 14.07 | 11.99 | 2.08 (1.74, 2.42) | <0.001 |
| 2009 | 14.09 | 11.82 | 2.27 (1.93, 2.61) | <0.001 |
| 2010 | 14.55 | 11.89 | 2.66 (2.30, 3.02) | <0.001 |
| 2011 | 15.00 | 12.05 | 2.95 (2.58, 3.32) | <0.001 |
| 2012 | 15.49 | 12.15 | 3.35 (2.99, 3.71) | <0.001 |
| 2013 | 15.97 | 12.50 | 3.47 (3.09, 3.85) | <0.001 |
| 2014 | 16.50 | 12.74 | 3.76 (3.36, 4.15) | <0.001 |
| 2015 | 16.44 | 12.90 | 3.54 (3.14, 3.93) | <0.001 |
| 2016 | 16.07 | 12.52 | 3.54 (3.13, 3.95) | <0.001 |
| 2017 | 15.97 | 12.46 | 3.52 (3.09, 3.94) | <0.001 |
| Adjusted Model 2, without HCC Score | | | | |
| 2007 | 12.19 | 11.74 | 0.45 (0.12, 0.79) | 0.008 |
| 2008 | 12.60 | 12.33 | 0.28 (-0.05, 0.61) | 0.10 |
| 2009 | 12.38 | 12.20 | 0.19 (-0.14, 0.52) | 0.27 |
| 2010 | 12.71 | 12.28 | 0.42 (0.07, 0.77) | 0.02 |
| 2011 | 12.60 | 12.57 | 0.03 (-0.32, 0.38) | 0.86 |
| 2012 | 12.92 | 12.68 | 0.24 (-0.10, 0.58) | 0.17 |
| 2013 | 13.23 | 13.07 | 0.17 (-0.20, 0.53) | 0.37 |
| 2014 | 13.54 | 13.33 | 0.20 (-0.16, 0.56) | 0.28 |
| 2015 | 13.40 | 13.51 | -0.11 (-0.47, 0.25) | 0.54 |
| 2016 | 12.92 | 13.12 | -0.20 (-0.58, 0.17) | 0.29 |
| 2017 | 12.80 | 13.05 | -0.25 (-0.63, 0.13) | 0.20 |

Mortality includes in-hospital and 30-day post-discharge mortality. All adjusted models include the following covariates: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. Estimates derived from Model 1 are further adjusted for Hierarchical Condition Category (HCC score). CAH=Critical Access Hospital; CI=Confidence Interval.

eTable 10. Assessment of Change in Mortality Differentials for Critical Access Hospitals and Non-Critical Access Hospitals, 2007-2017

| Variable | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | β (95% CI) | P | β (95% CI) | P |
| CAH | 1.61 (1.28, 1.94) | <0.001 | 0.26 (-0.06, 0.58) | 0.11 |
| Year | | | | |
| 2007 | Referent | | Referent | |
| 2008 | 0.56 (0.41, 0.72) | <0.001 | 0.71 (0.55, 0.86) | <0.001 |
| 2009 | -0.02 (-0.19, 0.14) | 0.80 | 0.54 (0.37, 0.71) | <0.001 |
| 2010 | -0.39 (-0.57, -0.21) | <0.001 | 0.42 (0.24, 0.60) | <0.001 |
| 2011 | -1.79 (-1.98, -1.60) | <0.001 | 0.50 (0.32, 0.68) | <0.001 |
| 2012 | -2.25 (-2.45, -2.06) | <0.001 | 0.33 (0.15, 0.51) | <0.001 |
| 2013 | -2.63 (-2.83, -2.43) | <0.001 | 0.36 (0.17, 0.54) | <0.001 |
| 2014 | -3.19 (-3.4, -2.98) | <0.001 | 0.17 (-0.03, 0.37) | 0.09 |
| 2015 | -3.85 (-4.06, -3.63) | <0.001 | -0.07 (-0.27, 0.13) | 0.51 |
| 2016 | -5.28 (-5.51, -5.05) | <0.001 | -0.72 (-0.93, -0.52) | <0.001 |
| 2017 | -6.16 (-6.39, -5.94) | <0.001 | -1.12 (-1.33, -0.92) | <0.001 |
| CAH x 2007 | Referent | | Referent | . |
| CAH x 2008 | 0.02 (-0.34, 0.37) | 0.93 | -0.15 (-0.51, 0.21) | 0.41 |
| CAH x 2009 | 0.21 (-0.17, 0.58) | 0.28 | -0.26 (-0.64, 0.12) | 0.18 |
| CAH x 2010 | 0.51 (0.12, 0.90) | 0.01 | -0.09 (-0.48, 0.30) | 0.66 |
| CAH x 2011 | 1.32 (0.91, 1.73) | <0.001 | -0.29 (-0.69, 0.11) | 0.15 |
| CAH x 2012 | 1.75 (1.33, 2.16) | <0.001 | -0.05 (-0.45, 0.35) | 0.81 |
| CAH x 2013 | 1.85 (1.43, 2.27) | <0.001 | -0.19 (-0.59, 0.21) | 0.36 |
| CAH x 2014 | 2.38 (1.94, 2.82) | <0.001 | 0.12 (-0.29, 0.53) | 0.57 |
| CAH x 2015 | 2.27 (1.81, 2.72) | <0.001 | -0.15 (-0.57, 0.27) | 0.48 |
| CAH x 2016 | 2.71 (2.23, 3.18) | <0.001 | -0.04 (-0.47, 0.39) | 0.85 |
| CAH x 2017 | 2.92 (2.43, 3.40) | <0.001 | 0.06 (-0.37, 0.49) | 0.79 |

The table includes point estimates derived from two linear regression models estimating mortality. The terms of interest, CAH, calendar year, and CAH x year (interaction), are presented. Covariates in both adjusted models were: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. Model 1 further adjusts for HCC score. CAH=Critical Access Hospital; CI=Confidence Interval

eTable 11. Estimated Mortality Rates for Critical Access Hospitals and Non-Critical Access Hospitals Excluding Transferred Patients, 2007-2017

| Year | CAH | Non-CAH | Difference (95% CI) | *P* |
|------|------|---------|--------------------|------|
| Unadjusted | | | | |
| 2007 | 11.75 | 11.51 | 0.24 (-0.10, 0.59) | 0.17 |
| 2008 | 12.26 | 12.11 | 0.15 (-0.20, 0.49) | 0.40 |
| 2009 | 11.84 | 11.99 | -0.15 (-0.51, 0.20) | 0.40 |
| 2010 | 12.02 | 12.12 | -0.10 (-0.46, 0.27) | 0.60 |
| 2011 | 11.89 | 12.43 | -0.54 (-0.91, -0.17) | 0.004 |
| 2012 | 12.01 | 12.60 | -0.59 (-0.96, -0.23) | 0.002 |
| 2013 | 11.95 | 13.02 | -1.07 (-1.46, -0.68) | <0.001 |
| 2014 | 12.17 | 13.29 | -1.12 (-1.50, -0.75) | <0.001 |
| 2015 | 11.87 | 13.45 | -1.58 (-1.96, -1.20) | <0.001 |
| 2016 | 11.41 | 13.03 | -1.62 (-2.00, -1.24) | <0.001 |
| 2017 | 11.54 | 12.92 | -1.39 (-1.78, -0.99) | <0.001 |
| Adjusted Model 1, with HCC Score | | | | |
| 2007 | 13.01 | 11.23 | 1.77 (1.43, 2.12) | <0.001 |
| 2008 | 13.63 | 11.80 | 1.83 (1.49, 2.17) | <0.001 |
| 2009 | 13.57 | 11.62 | 1.95 (1.62, 2.29) | <0.001 |
| 2010 | 14.05 | 11.70 | 2.35 (1.98, 2.71) | <0.001 |
| 2011 | 14.57 | 11.87 | 2.70 (2.33, 3.08) | <0.001 |
| 2012 | 15.09 | 11.97 | 3.12 (2.76, 3.48) | <0.001 |
| 2013 | 15.53 | 12.31 | 3.22 (2.83, 3.6) | <0.001 |
| 2014 | 16.05 | 12.53 | 3.52 (3.12, 3.91) | <0.001 |
| 2015 | 15.87 | 12.67 | 3.20 (2.81, 3.60) | <0.001 |
| 2016 | 15.43 | 12.29 | 3.14 (2.73, 3.55) | <0.001 |
| 2017 | 15.46 | 12.21 | 3.26 (2.83, 3.68) | <0.001 |
| Adjusted Model 2, without HCC Score | | | | |
| 2007 | 11.65 | 11.53 | 0.12 (-0.22, 0.46) | 0.49 |
| 2008 | 12.13 | 12.13 | 0.00 (-0.33, 0.34) | 0.99 |
| 2009 | 11.82 | 11.99 | -0.17 (-0.50, 0.16) | 0.32 |
| 2010 | 12.17 | 12.09 | 0.08 (-0.27, 0.43) | 0.66 |
| 2011 | 12.14 | 12.38 | -0.24 (-0.59, 0.11) | 0.18 |
| 2012 | 12.49 | 12.50 | -0.01 (-0.35, 0.34) | 0.96 |
| 2013 | 12.74 | 12.87 | -0.12 (-0.49, 0.24) | 0.51 |
| 2014 | 13.05 | 13.12 | -0.07 (-0.43, 0.29) | 0.70 |
| 2015 | 12.79 | 13.27 | -0.48 (-0.85, -0.11) | 0.01 |
| 2016 | 12.23 | 12.88 | -0.64 (-1.02, -0.27) | 0.001 |
| 2017 | 12.25 | 12.79 | -0.55 (-0.93, -0.16) | 0.005 |

Mortality includes in-hospital and 30-day post-discharge mortality. All adjusted models include the following covariates: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. Estimates derived from Model 1 are further adjusted for Hierarchical Condition Category (HCC score). CAH=Critical Access Hospital; CI=Confidence Interval.

eTable 12. Estimated Mortality Rates for Critical Access Hospitals and Non-Critical Access Hospitals Derived From a County Fixed Effects Model

| Year | CAH | Non-CAH | Difference (95% CI) | *P* |
|------|-----|---------|---------------------|-----|
| Unadjusted | | | | |
| 2007 | 12.25 | 11.73 | 0.52 (0.18, 0.86) | 0.003 |
| 2008 | 12.66 | 12.32 | 0.35 (0.01, 0.69) | 0.05 |
| 2009 | 12.34 | 12.21 | 0.14 (-0.21, 0.48) | 0.45 |
| 2010 | 12.51 | 12.33 | 0.18 (-0.18, 0.53) | 0.32 |
| 2011 | 12.33 | 12.63 | -0.29 (-0.65, 0.07) | 0.11 |
| 2012 | 12.41 | 12.79 | -0.38 (-0.74, -0.02) | 0.04 |
| 2013 | 12.40 | 13.24 | -0.84 (-1.22, -0.46) | <0.001 |
| 2014 | 12.63 | 13.52 | -0.89 (-1.25, -0.52) | <0.001 |
| 2015 | 12.42 | 13.71 | -1.28 (-1.66, -0.91) | <0.001 |
| 2016 | 12.03 | 13.29 | -1.26 (-1.64, -0.88) | <0.001 |
| 2017 | 12.02 | 13.20 | -1.18 (-1.57, -0.79) | <0.001 |
| Adjusted Model 1, with HCC Score | | | | |
| 2007 | 13.64 | 11.42 | 2.22 (1.86, 2.58) | <0.001 |
| 2008 | 14.21 | 11.97 | 2.25 (1.91, 2.59) | <0.001 |
| 2009 | 14.18 | 11.81 | 2.37 (2.02, 2.72) | <0.001 |
| 2010 | 14.69 | 11.86 | 2.83 (2.48, 3.19) | <0.001 |
| 2011 | 15.24 | 12.00 | 3.24 (2.88, 3.61) | <0.001 |
| 2012 | 15.65 | 12.11 | 3.53 (3.17, 3.90) | <0.001 |
| 2013 | 16.01 | 12.50 | 3.51 (3.13, 3.88) | <0.001 |
| 2014 | 16.50 | 12.74 | 3.76 (3.38, 4.13) | <0.001 |
| 2015 | 16.56 | 12.88 | 3.68 (3.29, 4.07) | <0.001 |
| 2016 | 16.03 | 12.53 | 3.50 (3.09, 3.90) | <0.001 |
| 2017 | 15.89 | 12.47 | 3.42 (3.01, 3.83) | <0.001 |
| Adjusted Model 2, without HCC Score | | | | |
| 2007 | 12.12 | 11.76 | 0.37 (0.00, 0.73) | 0.05 |
| 2008 | 12.57 | 12.34 | 0.23 (-0.12, 0.58) | 0.20 |
| 2009 | 12.21 | 12.24 | -0.03 (-0.38, 0.32) | 0.86 |
| 2010 | 12.57 | 12.31 | 0.26 (-0.10, 0.62) | 0.16 |
| 2011 | 12.45 | 12.60 | -0.15 (-0.51, 0.21) | 0.41 |
| 2012 | 12.66 | 12.74 | -0.08 (-0.44, 0.28) | 0.67 |
| 2013 | 12.87 | 13.14 | -0.27 (-0.64, 0.10) | 0.15 |
| 2014 | 13.07 | 13.43 | -0.36 (-0.73, 0.00) | 0.05 |
| 2015 | 13.11 | 13.57 | -0.46 (-0.84, -0.09) | 0.02 |
| 2016 | 12.42 | 13.22 | -0.80 (-1.19, -0.40) | <0.001 |
| 2017 | 12.28 | 13.15 | -0.87 (-1.25, -0.49) | <0.001 |

Mortality includes in-hospital and 30-day post-discharge mortality. All adjusted models include the following covariates: age, age-squared, sex, race (white, black, or other), Medicaid enrollment, Medicare entitlement reason (old age and survivors insurance versus all else), 27 chronic conditions present prior to the index admission (see Table 1), primary diagnosis, and Hospital Referral Region fixed effects. Estimates derived from Model 1 are further adjusted for Hierarchical Condition Category (HCC score). CAH=Critical Access Hospital; CI=Confidence Interval.