

Health Information Network Participation Profiles and Patient-Reported Discharge Information in U.S. Acute Care and Critical Access Hospitals

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Abstract

Background: U.S. hospitals participate in overlapping state or regional health information organizations (HIOs), national networks, electronic health record (EHR) vendor networks, and, increasingly, the Trusted Exchange Framework and Common Agreement (TEFCA). Earlier studies have linked health information exchange (HIE) to patient experience. However, we did not identify studies examining current combinations of HIO, national network, EHR vendor network, and TEFCA participation in relation to patient-reported discharge information, including whether these associations differ for critical access hospitals (CAHs).

Objective: This study aims to examine whether hospital network participation profiles were associated with patient-reported discharge information and whether these associations differed between acute care hospitals and CAHs.

Methods: We linked the 2022-2025 U.S. hospital participation in health information networks dataset from the Office of the National Coordinator for Health Information Technology (ONC) to Centers for Medicare & Medicaid Services (CMS) hospital and Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) data, the 2023 Agency for Healthcare Research and Quality (AHRQ) hospital linkage file, and 2023 Rural-Urban Continuum Codes (RUCC). The source cohort included 2,651 nonfederal acute care hospitals and CAHs whose latest ONC survey response was from 2024 or 2025. The exposure was a prespecified six-category profile combining HIO, national network, vendor network, and current TEFCA participation. The primary outcome was the adjusted HCAHPS percentage reporting receipt of recovery-at-home discharge information. We used multiple imputation to address missing hospital characteristics and inverse probability weighting to account for differences in public HCAHPS reporting. Regression models adjusted for hospital characteristics, state, and survey year.

Results: The source cohort included 1,871 (70.6%) acute care hospitals and 780 (29.4%) CAHs. The primary outcome was publicly reported for 2,409 (90.9%) hospitals, including 1,852 (99.0%) of 1,871 acute care hospitals and 557 (71.4%) of 780 CAHs. Adjusted discharge-information scores differed across the six network profiles (Wald chi-square = 29.03, df = 5; $P < 0.001$), driven mainly by the single-conventional-network category, whose difference from the three-network reference was -1.43 percentage points, with a 95% confidence interval (CI) of -2.09 to -0.76 ($P < 0.001$). Hospitals participating in all three conventional networks plus TEFCA scored 0.28 percentage points higher than hospitals using the same three networks without TEFCA (95% CI, -0.15 to 0.70; $P = 0.206$), a nonsignificant difference. The profile-by-hospital-type interaction was also not significant (Wald chi-square = 7.18, df = 5; $P = 0.207$). Findings were consistent across prespecified sensitivity analyses.

Conclusions: Network participation patterns were related to patient-reported discharge information scores. Greater network participation did not consistently correspond to better performance, and TEFCA participation showed no clear additional association. We did not detect a significant difference in these relationships between acute care hospitals and CAHs.

Categories: Health Policy, Public Health, Healthcare Technology

Keywords: critical access hospitals, discharge information, hcahps, health information exchange, health information networks, interoperability, patient experience, rural health, tefca

Introduction

Timely access to clinical information from outside organizations is a longstanding goal of U.S. health information technology policy. Hospitals now exchange information through several overlapping pathways, including state, regional, or local health information organizations (HIOs); national networks such as

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Carequality, CommonWell Health Alliance, and eHealth Exchange; and electronic health record (EHR) vendor networks. These pathways are not necessarily substitutes: hospitals commonly use several methods, and qualitative workflow research has shown substantial differences in when, why, and by whom exchanged information is used. Thus, information availability does not guarantee that data are integrated into clinical workflows or used during care [1-3].

Federal policy and certification requirements have shaped hospital interoperability; adoption of the 2015 Health IT Certification Edition was associated with increased interoperable exchange [4]. Layered over these arrangements, the Trusted Exchange Framework and Common Agreement (TEFCA) adds a nationwide network-of-networks structure intended to establish common policy and technical requirements across existing exchange arrangements. TEFCA became operational in late 2023 [5]. Because implementation is recent, evidence about whether current participation is associated with patient-facing outcomes remains limited.

Patient experience is a plausible but distal outcome of information exchange. A national analysis published in 2011 found that implemented health information exchange (HIE) was associated with selected Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) outcomes, and a 2023 study reported an indirect relationship between HIE adoption and patient satisfaction through organizational efficiency [6,7]. Better access to outside information could support medication reconciliation, referral continuity, and discharge planning; care-transition performance has itself been associated with overall patient experience [8]. These studies predated current TEFCA participation and did not characterize the combinations of HIO, national-network, and vendor-network participation that hospitals now use.

Rural and safety-net hospitals may face distinct interoperability constraints. National analyses have identified lower interoperable exchange among hospitals serving marginalized populations and lower participation in some exchange pathways among critical access hospitals (CAHs) [9]. State-level longitudinal research has also documented technical, vendor, and organizational barriers to HIE participation [10]. Earlier CAH-specific research found that access to technical assistance and implementation resources was associated with greater health information technology capability and fewer reported challenges [11]. Yet CAHs tend to receive better HCAHPS ratings than larger hospitals, a gap that owes much to structural features such as size [12]. Hospital size also changes how HCAHPS response rates relate to several domain scores, including discharge information [13]. Any comparison of network profiles and patient experience therefore requires explicit adjustment for hospital size, ownership, teaching status, system affiliation, safety-net burden, and rurality.

Recent national work found that HIO participation was associated with broader clinical exchange, public-health reporting, and health-related social-needs exchange, but it did not evaluate patient-experience outcomes [14]. We did not identify a hospital-level study that jointly examined current TEFCA participation, HIO participation, national-network participation, and vendor-network participation in relation to HCAHPS discharge information with a prespecified CAH interaction. The objective of this study was to examine the association between hospital network-participation profiles and patient-reported discharge information in U.S. acute care hospitals and CAHs. Specifically, we assessed differences across six prespecified network profiles, compared hospitals participating in all three conventional networks with and without TEFCA, and evaluated whether these associations differed by hospital type.

Materials And Methods

Design and data sources

We conducted a national hospital-level cross-sectional study using public secondary data. Each hospital, identified by its six-digit Centers for Medicare & Medicaid Services (CMS) certification number (CCN), was one unit of analysis. We finalized the protocol and statistical analysis plan before running the profile-outcome association models.

Network participation came from the U.S. Hospital Participation in Health Information Networks dataset published by the Office of the National Coordinator for Health Information Technology (ONC), which compiles each hospital's latest available response from the 2022-2025 American Hospital Association Information Technology Supplement [15]. For each hospital, the file identifies current participation in a HIO, a national network, an EHR vendor network, and the TEFCA. ONC codes nonresponses to each participation item as zero; accordingly, we use the term coded participation rather than confirmed nonparticipation.

Hospital type, state, county, and CMS ownership came from CMS Hospital General Information. Primary and secondary patient-experience outcomes came from the May 13, 2026, hospital-level HCAHPS release, covering discharges from July 1, 2024, through June 30, 2025 [16]. Public HCAHPS scores are based on four consecutive quarters and are adjusted for patient mix and survey mode; hospitals require at least 25 completed surveys for public reporting [17]. Hospital beds, health-system affiliation, teaching intensity, ownership, disproportionate-share-hospital burden, and uncompensated-care burden came from the 2023 Agency for Healthcare Research and Quality (AHRQ) Compendium Hospital Linkage File [18]. Rurality came

from the 2023 U.S. Department of Agriculture (USDA) Rural-Urban Continuum Codes (RUCC), which classify counties and county equivalents into three metropolitan and six nonmetropolitan categories [19].

CCNs were normalized to six digits before linkage. Identifiers with alphabetic suffixes were treated as federal facility identifiers and excluded from the numeric CCN namespace rather than having the suffix removed. In the AHRQ file, 154 alphanumeric federal identifiers and 124 rows without a CCN were excluded before linkage, and no duplicate valid numeric CCNs remained. RUCC geography was linked by 2023 county-equivalent Federal Information Processing Standards (FIPS) codes, and Connecticut legacy county labels were reconciled to the 2023 planning regions using the official census town crosswalk.

Eligibility criteria

Hospitals were included if they met all of the following criteria: (1) a record in the ONC Hospital Participation in Health Information Networks dataset with a usable six-digit numeric CCN; (2) a matching current record in CMS Hospital General Information; (3) CMS classification as an acute care hospital or CAH; and (4) a latest ONC survey response from 2024 or 2025. We applied the survey-year criterion because TEFCA became operational in late 2023, so earlier responses could not reflect current TEFCA participation. Hospitals were excluded if they did not have a usable numeric CCN, did not match a current CMS record, had a CMS hospital type other than acute care hospital or CAH, or had a latest ONC response from 2022 or 2023. When a CCN appeared more than once, the record with the latest survey year was retained. Inclusion in the structural outcome model additionally required a publicly reported H_COMP_6_Y_P score, which CMS releases only for hospitals with at least 25 completed surveys [17]. Eligible hospitals without a publicly reported primary outcome remained in the source cohort for modeling outcome observation.

Cohort construction

The ONC source contained 3,393 hospital records. Twelve records (0.4%) did not yield a usable numeric CCN during identifier normalization, and one duplicate record was removed after retaining the latest survey-year record, leaving 3,380 unique usable CCNs (99.6% of the source records). Of these, 3,293 (97.4%) matched current CMS hospital records. Among the matched hospitals, 3,250 (98.7%) were classified as acute care hospitals or CAHs; 43 (1.3%) with other CMS hospital types were excluded. Restriction to hospitals whose latest ONC response was from 2024 or 2025 excluded 599 (18.4%) of these 3,250 hospitals, leaving a final source cohort of 2,651 (81.6%) hospitals. Of these, 242 (9.1%) did not have a publicly reported primary HCAHPS outcome; these hospitals remained in the source cohort for modeling outcome observation but were excluded from the structural outcome model. No sample-size calculation or sampling procedure was used, since the cohort was a census of all hospitals meeting the prespecified eligibility and linkage criteria. Figure 1 summarizes cohort selection and primary-outcome availability.

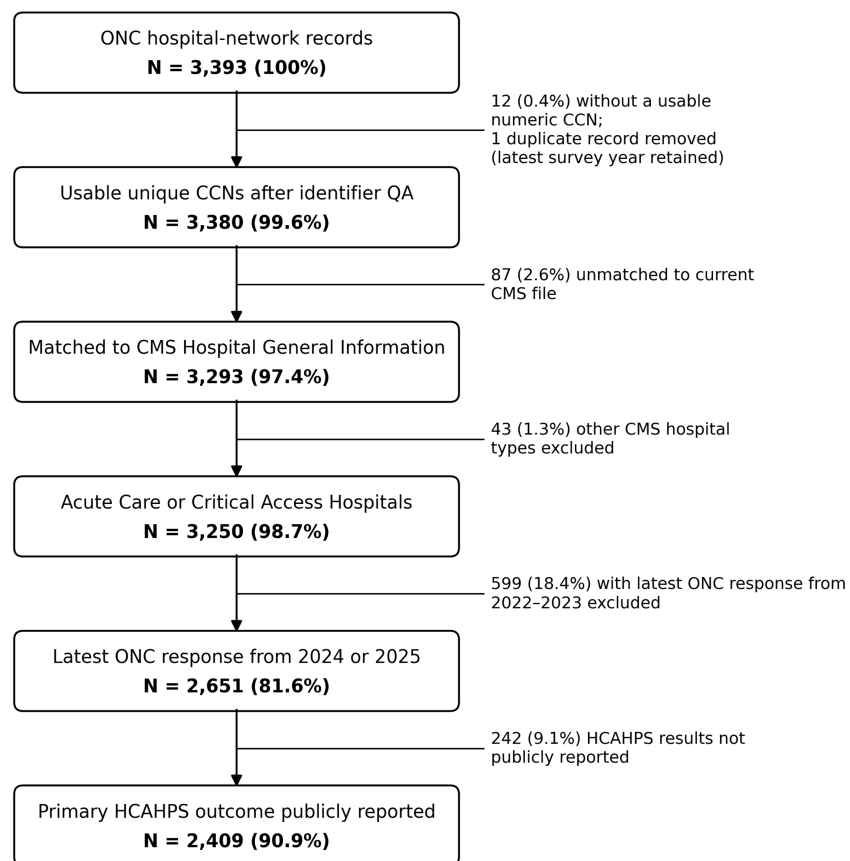


FIGURE 1: Cohort construction and outcome availability

Flow diagram showing construction of the final study cohort from the ONC hospital dataset. The source contained 3,393 (100%) hospital records. After identifier normalization, 12 (0.4%) records without a usable numeric CCN were excluded, and one duplicate record was removed after retaining the latest survey-year record, leaving 3,380 (99.6%) unique usable CCNs. Of these, 87 (2.6%) did not match a current CMS hospital record, leaving 3,293 (97.4%); 43 (1.3%) with other CMS hospital types were excluded, leaving 3,250 (98.7%) acute care hospitals or CAHs. Excluding 599 (18.4%) hospitals whose latest ONC survey response was from 2022 or 2023 produced the final cohort of 2,651 (81.6%) hospitals. The primary HCAHPS discharge information outcome was publicly available for 2,409 (90.9%) hospitals; 242 (9.1%) did not have a publicly reported result. Percentages use the preceding step as the denominator.

CAH, Critical Access Hospital; CCN, Centers for Medicare & Medicaid Services Certification Number; CMS, Centers for Medicare & Medicaid Services; HCAHPS, Hospital Consumer Assessment of Healthcare Providers and Systems; ONC, Office of the National Coordinator for Health Information Technology; QA, Quality assurance.

Image credit: This figure was created by the authors using Python (Python Software Foundation, Wilmington, DE).

Exposure

Four binary ONC indicators were ordered HIO-national-vendor-TEFCA and combined into a prespecified six-category profile: no coded participation (profile zero); one conventional network without TEFCA (profile one); two conventional networks without TEFCA (profile two); all three conventional networks without TEFCA (profile three); TEFCA plus zero to two conventional networks (profile four); and TEFCA plus all three conventional networks (profile five). Profile three was the model reference because the prespecified contrast between profiles five and three compares hospitals with identical conventional-network breadth and differs only in current TEFCA participation. The categories were finalized using exposure frequencies, policy timing, literature, and outcome-availability diagnostics before outcome means by profile were examined.

Outcomes

The primary outcome was H_COMP_6_Y_P, the percentage of patients reporting that hospital staff gave them information about what to do during recovery at home [20]. Secondary outcomes were “Communication

About Medicines-Always,” “Overall Hospital Rating of 9 or 10,” “Definitely Recommend the Hospital,” “Nurse Communication-Always,” and “Doctor Communication-Always.” The HCAHPS discharge information linear-mean score was rejected as the primary outcome because it was publicly available for only 277 (28.0%) of 989 CAHs in the broader feasibility cohort.

Covariates

The prespecified adjustment set comprised CAH status, $\log_2(\text{beds} + 1)$ -transformed hospital size, Healthcare Cost Report Information System (HCRIS) ownership, health system affiliation, teaching intensity, high disproportionate share hospital (DSH) patient-percentage status, uncompensated care burden, high uncompensated care burden status, metropolitan versus nonmetropolitan RUCC classification, state fixed effects, and ONC survey year. CMS ownership was included in a prespecified sensitivity analysis because its three-category classification agreed with HCRIS ownership for only 1,588 (61.1%) of the 2,600 hospitals with both variables. HCAHPS completed survey count was used in a precision-weighted sensitivity analysis but not in the primary structural model.

Missing data and observation weighting

We addressed missing covariate data using multiple imputation by chained equations (MICE). This method estimates missing values sequentially using relationships among variables in the dataset, allowing hospitals with incomplete covariate information to remain in the analysis. Each required confounder was more than 97% complete, and 2,580 (97.3%) of 2,651 hospitals had complete data for all required confounders. We generated 20 imputed datasets using five chained-equation cycles and deterministic random seeds. Continuous variables were imputed using predictive mean matching with five candidate donors selected from Bayesian ridge predictions. Binary and nominal variables were imputed using stochastic L2-regularized logistic and multinomial regression, respectively [21,22]. The imputation models included network-participation profile, CAH status, the outcome-observation indicator, observed outcomes, all analysis covariates, and auxiliary variables. Observed covariate values were preserved in every imputed dataset.

Public HCAHPS reporting differed substantially by hospital type. The primary outcome was available for 1,852 of 1,871 acute care hospitals (99.0%), compared with 557 of 780 CAHs (71.4%). Reporting also varied by network participation. We therefore estimated each hospital’s probability of having a publicly reported outcome in the 2,651-hospital source cohort to calculate inverse probability of observation weights. The denominator model included network profile, CAH status, profile-by-hospital-type interactions, the full covariate set, state, survey year, a squared $\log_2(\text{beds} + 1)$ term, and bed-size interactions with hospital type and survey year. Standardized near-unpenalized L2 logistic regression was fit with $C = 100$, the lbfgs solver, tolerance 10^{-6} , and a 2,000-iteration ceiling; all final observation models converged without warnings. The numerator model for stabilization contained CAH status and survey year. Stabilized inverse probability of observation weights were trimmed at the first and 99th percentiles and normalized to a mean of one [23]. Because stabilized weights preserve the numerator-model margins, covariate balance was assessed within CAH-by-survey-year strata.

Statistical analysis

The primary structural model used weighted ordinary least squares to estimate adjusted percentage-point differences in HCAHPS discharge information scores. The model included network profile, CAH status, the prespecified covariates, state fixed effects, and survey year, with HC3 heteroskedasticity-robust standard errors [24]. The primary hypothesis test was a five-degree-of-freedom global Wald test of the profile factor. Adjusted marginal means were estimated for all six categories. The primary planned contrast was profile five minus profile three. A key secondary model added all profile-by-critical-access-hospital product terms and used a global five-degree-of-freedom interaction test. Prespecified stratified analyses also fitted the primary structural model separately within acute care hospitals and CAHs.

Estimates and robust variances were pooled across imputations using Rubin’s rules [22]. Multivariate profile tests evaluated the pooled coefficient vector using the total Rubin covariance matrix and an asymptotic chi-square reference distribution, and adjusted means and planned contrasts were calculated as linear combinations of pooled model coefficients.

Secondary outcomes used the primary model specification. We controlled the false discovery rate across their five global profile tests using the Benjamini-Hochberg procedure [25]. Prespecified sensitivity analyses used completed survey count precision weights, state-clustered standard errors, CMS ownership in place of HCRIS ownership, fractional logit with average marginal effects, unweighted complete-covariate complete-case analysis, restriction to 2025 ONC responses, and exclusion of the all-zero profile. An additional diagnostic sensitivity analysis, not prespecified, added a squared $\log_2(\text{beds} + 1)$ term to the outcome model. In an exploratory alternative parameterization, the six-category profile was replaced by a conventional-network count (0 to 3), a current-TEFCA indicator, and their interaction. Tests were two-sided, with $\alpha = 0.05$. Analyses used deterministic random seeds in a version-controlled CPython 3.13.14 pipeline executed in the validated Ubuntu 24.04 x 86-64 environment, with NumPy 2.3.5, SciPy 1.17.0, scikit-learn 1.8.0, pandas 2.2.3, and statsmodels 0.14.6.

Ethics and reporting

The study used publicly available hospital-level data and did not include individual-level HCAHPS responses, human subjects, or identifiable private information. Institutional review board review and informed consent were therefore not required. Reporting was guided by STROBE (Strengthening the Reporting of OBservational studies in Epidemiology) principles for cross-sectional studies [26].

Use of artificial intelligence tools

OpenAI’s ChatGPT was used to assist with code drafting and debugging, reproducibility auditing, document organization, and formatting. Numerical results, tables, and scientific figures were generated by executable Python code and checked against saved outputs. The authors verified the underlying data, analyses, citations, interpretation, and final submitted content. ChatGPT was not listed as an author, and no generative AI image tool was used to create or alter scientific data or scientific figures.

Results

Cohort and hospital characteristics

The final cohort included 2,651 hospitals from all 50 states and the District of Columbia: 1,871 (70.6%) acute care hospitals and 780 (29.4%) CAHs. Of these, 2,409 (90.9%) publicly reported the primary HCAHPS outcome, including 1,852 (99.0%) of 1,871 acute care hospitals and 557 (71.4%) of 780 CAHs. Compared with acute care hospitals, CAHs were more frequently located in nonmetropolitan counties, 621 (79.6%) vs. 406 (21.7%); less often affiliated with a health system, 432 (57.1%) vs. 1,725 (92.4%); substantially smaller, with a median of 25 vs. 166 beds; and less likely to report current TEFCA participation, 223 (28.6%) vs. 859 (45.9%). Before adjustment, the mean (SD) discharge information score was 89.05% (4.60) among observed CAHs and 85.62% (3.82) among observed acute care hospitals; this comparison is subject to differential outcome reporting and confounding. Table 1 presents detailed cohort characteristics.

Characteristic	All hospitals (N = 2,651)	Acute care (N = 1,871)	Critical access (N = 780)
ONC survey year 2025	2,289 (86.3%)	1,644 (87.9%)	645 (82.7%)
Nonmetropolitan county	1,027 (38.7%)	406 (21.7%)	621 (79.6%)
Health-system affiliated	2,157 (82.2%)	1,725 (92.4%)	432 (57.1%)
Current TEFCA participation	1,082 (40.8%)	859 (45.9%)	223 (28.6%)
Major or very major teaching hospital	306 (11.7%)	305 (16.4%)	1 (0.1%)
High DSH patient percentage	333 (12.8%)	333 (17.9%)	0 (0.0%)
High uncompensated-care burden	504 (19.3%)	326 (17.6%)	178 (23.6%)
Primary HCAHPS outcome publicly reported	2,409 (90.9%)	1,852 (99.0%)	557 (71.4%)
Ownership: Government	382 (14.6%)	299 (16.1%)	83 (11.0%)
Ownership: Nonprofit	1,889 (72.3%)	1,243 (67.0%)	646 (85.6%)
Ownership: For-profit	340 (13.0%)	314 (16.9%)	26 (3.4%)
Beds, median (IQR)	97 (25–237)	166 (81–301)	25 (19–25)
Observed discharge information score, mean (SD)	86.42 (4.26)	85.62 (3.82)	89.05 (4.60)

TABLE 1: Characteristics of the 2024–2025 source cohort

Values are N (%) unless otherwise indicated. Percentages for variables with missing AHRQ/HCRIS data use the nonmissing denominator.

AHRQ, Agency for Healthcare Research and Quality; DSH, Disproportionate share hospital; HCAHPS, Hospital Consumer Assessment of Healthcare Providers and Systems; HCRIS, Healthcare Cost Report Information System; IQR, Interquartile range; ONC, Office of the National Coordinator for Health Information Technology; SD, Standard deviation; TEFCA, Trusted Exchange Framework and Common Agreement.

Network profiles and primary analysis

The six exposure categories contained 123 (4.6%) hospitals with no coded participation, 312 (11.8%) with one conventional network, 689 (26.0%) with two conventional networks, 445 (16.8%) with all three conventional networks without TEFCA, 495 (18.7%) with TEFCA plus zero to two conventional networks,

and 587 (22.1%) with TEFCA plus all three conventional networks. Outcome availability ranged from 89 (72.4%) of 123 hospitals in the no-coded-participation category to 573 (97.6%) of 587 in the TEFCA-plus-all-three category. The profile counts and adjusted primary-outcome means are presented in Table 2.

Code	Network profile	Source, N (%)	Outcome reported, N (%)	Adjusted mean, % (95% CI)	Difference from code 3, pp
0	No coded participation	123 (4.6%)	89 (72.4%)	86.92 (85.94 to 87.90)	+0.10
1	Single conventional network, no TEFCA	312 (11.8%)	258 (82.7%)	85.39 (84.81 to 85.97)	-1.43
2	Two conventional networks, no TEFCA	689 (26.0%)	620 (90.0%)	86.82 (86.49 to 87.14)	0.00
3	Three conventional networks, no TEFCA	445 (16.8%)	406 (91.2%)	86.82 (86.48 to 87.15)	Reference
4	TEFCA plus zero to two conventional networks	495 (18.7%)	463 (93.5%)	86.34 (85.94 to 86.74)	-0.48
5	TEFCA plus all three conventional networks	587 (22.1%)	573 (97.6%)	87.09 (86.78 to 87.41)	+0.28

TABLE 2: Network-profile counts and adjusted primary-outcome means

Source percentages use the 2,651-hospital cohort as the denominator; outcome percentages use each profile's source N. Adjusted means are standardized to the 2,651-hospital source cohort using multiply imputed covariates and stabilized inverse probability of observation weights. The global profile test was Wald $\chi^2 = 29.03$ (df = 5); source percentages use the full cohort (N = 2,651), while outcome-reporting percentages use the corresponding profile totals. Adjusted means are standardized to the source cohort.

CI, Confidence interval; pp, Percentage points; TEFCA, Trusted Exchange Framework and Common Agreement.

Adjusted discharge information means differed across profiles (global Wald chi-square = 29.03, df = 5; P < 0.001). By profile, the adjusted means were 86.92% for no coded participation, 85.39% for one conventional network, 86.82% for two conventional networks, 86.82% for three conventional networks without TEFCA, 86.34% for TEFCA plus zero to two conventional networks, and 87.09% for TEFCA plus all three conventional networks. Relative to the three-conventional-network reference, the single-conventional-network category was 1.43 percentage points lower (95% CI, -2.09 to -0.76; P < 0.001). Other category coefficients were not statistically significant at the 0.05 level. Full model coefficients are provided in the Appendix. Figure 2 plots these means with their confidence intervals (CIs).

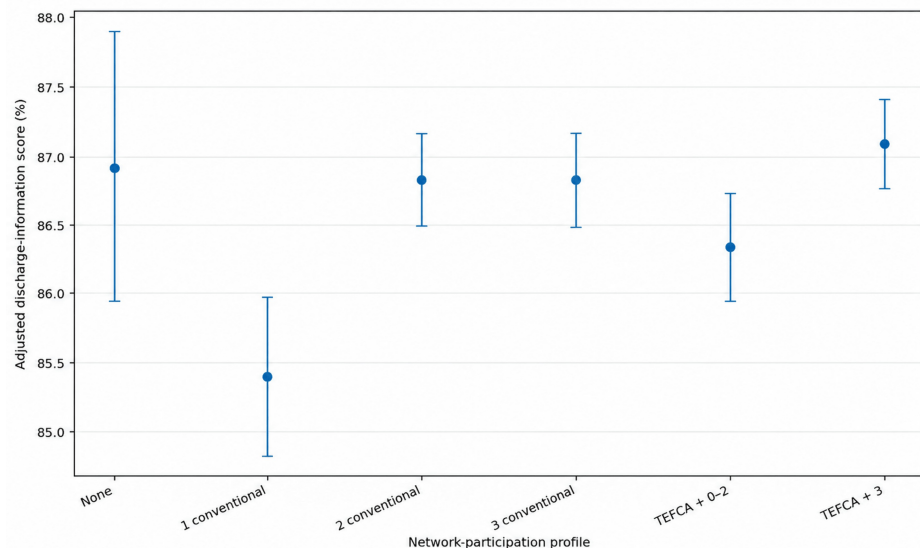


FIGURE 2: Adjusted HCAHPS discharge information scores by network profile

Points show adjusted means, and whiskers show 95% confidence intervals. The vertical axis is truncated to display adjusted differences.

HCAHPS, Hospital Consumer Assessment of Healthcare Providers and Systems; TEFCA, Trusted Exchange Framework and Common Agreement.

Image credit: This figure was created by the authors using Python (Python Software Foundation, Wilmington, DE).

In the primary planned contrast, hospitals with TEFCA plus all three conventional networks scored 0.28 percentage points higher than those with all three conventional networks alone (95% CI, -0.15 to 0.70; $P = 0.206$). Thus, the data did not support an incremental TEFCA association among hospitals already coded as participating in all three conventional network pathways.

CAH interaction

Hospital type did not significantly modify the profile association (global profile-by-CAH interaction Wald chi-square = 7.18, $df = 5$; $P = 0.207$). Within hospital groups, the profile five-versus-three contrast was 0.12 percentage points among acute care hospitals (95% CI, -0.30 to 0.54; $P = 0.575$) and 1.01 percentage points among CAHs (95% CI, -0.47 to 2.49; $P = 0.182$). CAHs had the larger point estimate. Its CI was wide, though, and the formal interaction test did not detect differential associations by hospital type. Figure 3 shows the adjusted profile means by hospital group, which are also tabulated in Appendix Table 9.

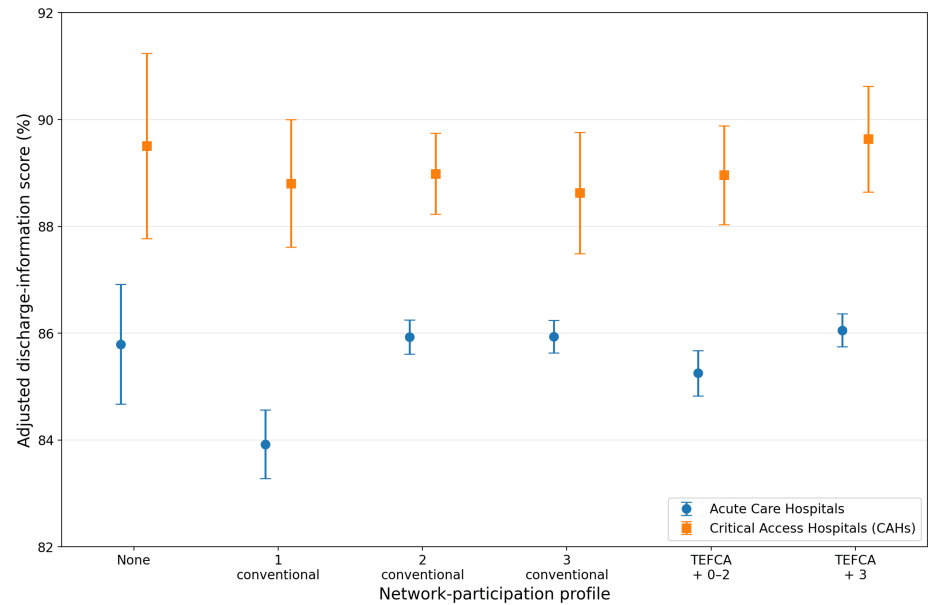


FIGURE 3: Adjusted network-profile means by hospital group

Points show adjusted means, and whiskers show 95% confidence intervals. Adjusted means within each hospital group are standardized to that group's own covariate distribution. Vertical separation between the two series therefore reflects both hospital type and differences in the covariate distributions of acute care hospitals and CAHs and should not be interpreted as an adjusted between-group contrast. Comparisons across network profiles within each hospital group remain interpretable as within-group profile contrasts. Profiles are categorical and are not connected; the vertical axis is truncated to display adjusted differences.

CAH, Critical Access Hospital; HCAHPS, Hospital Consumer Assessment of Healthcare Providers and Systems; TEFCA, Trusted Exchange Framework and Common Agreement.

Image credit: This figure was created by the authors using Python (Python Software Foundation, Wilmington, DE).

In separately fitted stratified models, the global profile test was statistically significant among acute care hospitals (chi-square = 39.74, df = 5; P < 0.001) but not among CAHs (chi-square = 1.74, df = 5; P = 0.884). The profile five-versus-three contrast was 0.20 percentage points (95% CI, -0.21 to 0.62; P = 0.343) among acute care hospitals and 0.80 percentage points (95% CI, -1.09 to 2.69; P = 0.409) among CAHs (Table 3). Because these are within-group tests from separate models, they do not by themselves demonstrate effect modification.

Hospital group	Source, N (%)	Outcome reported, N (%)	Global χ² (df)	Global P	Profile 5–3, pp (95% CI)	Contrast P
Acute care	1,871 (70.6%)	1,852 (99.0%)	39.74 (5)	<0.001	0.20 (-0.21 to 0.62)	0.343
Critical access	780 (29.4%)	557 (71.4%)	1.74 (5)	0.884	0.80 (-1.09 to 2.69)	0.409

TABLE 3: Prespecified analyses stratified by hospital group

These are within-group tests from separately fitted models. A significant test in one hospital group and a nonsignificant test in another does not, by itself, demonstrate effect modification. The formal profile-by-CAH interaction in the primary interaction model was χ² = 7.18 (df = 5; P = 0.207).

CAH, Critical Access Hospital; CI, Confidence interval; pp, Percentage points.

Sensitivity and secondary analyses

No prespecified sensitivity analysis changed the global profile result; the test remained statistically significant with completed-survey precision weighting, state-clustered inference, CMS ownership substitution, fractional-logit modeling, complete-covariate analysis, restriction to 2025 responses, and exclusion of the all-zero profile. Table 4 summarizes the primary test alongside each sensitivity analysis.

Analysis	Global χ^2 (df)	Global P	Profile 5–3 difference, pp (95% CI)	Contrast P
Primary MICE + IPOW + HC3	29.03 (5)	<0.001	0.28 (-0.15 to 0.70)	0.206
Completed-survey-count precision weighting	30.57 (5)	<0.001	0.14 (-0.31 to 0.59)	0.533
State-clustered standard errors	14.42 (5)	0.013	0.28 (-0.28 to 0.83)	0.333
CMS ownership substituted	48.92 (5)	<0.001	0.32 (-0.11 to 0.75)	0.144
Fractional logit average marginal effect	30.20 (5)	<0.001	0.29 (-0.13 to 0.71)	0.176
Unweighted complete-covariate complete case	30.31 (5)	<0.001	0.23 (-0.19 to 0.65)	0.276
2025 ONC responses only	31.04 (5)	<0.001	0.34 (-0.11 to 0.80)	0.139
Exclude all-zero coded profile	26.34 (4)	<0.001	0.25 (-0.18 to 0.67)	0.251

TABLE 4: Primary test and prespecified sensitivity analyses

Analyses included 2,651 source hospitals and 2,409 with reported outcomes, except for the complete-covariate analysis (2,580/2,353), the 2025-only analysis (2,289/2,092), and the analysis excluding profile 0 (2,528/2,320). Values in parentheses indicate source hospitals/hospitals with reported outcomes.

CI, Confidence interval; CMS, Centers for Medicare & Medicaid Services; HC3, Heteroskedasticity-consistent covariance estimator type 3; IPOW, Inverse probability of observation weighting; MICE, Multiple imputation by chained equations; ONC, Office of the National Coordinator for Health Information Technology; pp, Percentage points.

Across these analyses, the profile five-versus-three contrast ranged from 0.14 to 0.34 percentage points and was never statistically significant. Figure 4 displays it for each analysis.

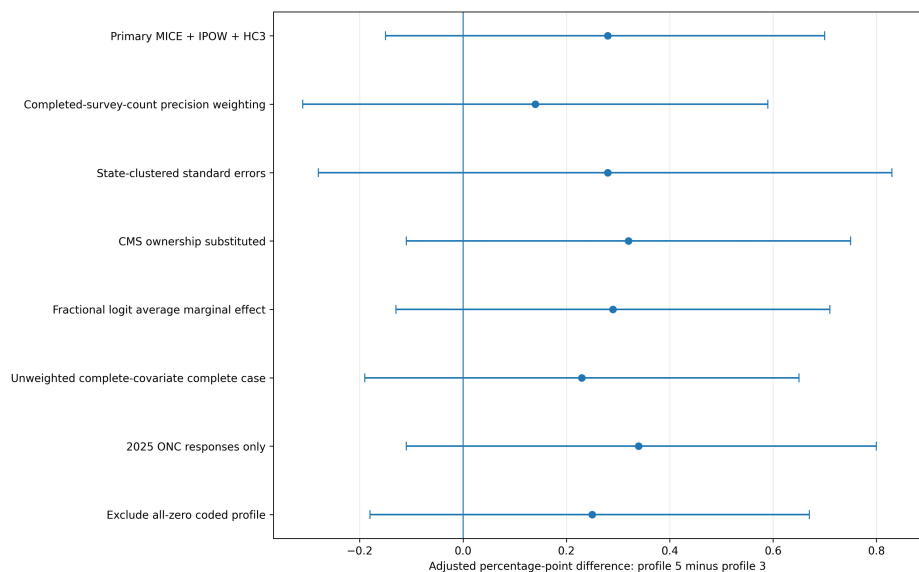


FIGURE 4: Prespecified profile five-versus-three contrast across sensitivity analyses

Points show the adjusted difference between profile five (TEFCA plus all three conventional networks) and profile three (all three conventional networks without TEFCA); whiskers show 95% confidence intervals.

CMS, Centers for Medicare & Medicaid Services; HC3, Heteroskedasticity-consistent covariance estimator type 3; IPOW, Inverse probability of observation weighting; MICE, Multiple imputation by chained equations; ONC, Office of the National Coordinator for Health Information Technology; TEFCA, Trusted Exchange Framework and Common Agreement.

Image credit: This figure was created by the authors using Python (Python Software Foundation, Wilmington, DE).

An additional diagnostic sensitivity analysis, not prespecified, added a squared log2(beds + 1) term to the outcome model. The global profile test remained significant (chi-square = 23.66, df = 5; P < 0.001), the profile five-versus-three contrast was 0.23 percentage points (95% CI, -0.20 to 0.66; P = 0.293), and the profile-by-CAH interaction remained nonsignificant (chi-square = 7.42, df = 5; P = 0.191). All three inferential decisions and estimate directions were unchanged (Table 5).

Result	Canonical model	Flexible bed-size squared model
Global six-profile test	$\chi^2 = 29.03$; df = 5; P < 0.001	$\chi^2 = 23.66$; df = 5; P < 0.001
Profile 5 minus profile 3	0.28 pp (95% CI -0.15 to 0.70); P = 0.206	0.23 pp (95% CI -0.20 to 0.66); P = 0.293
Global profile-by-CAH interaction	$\chi^2 = 7.18$; df = 5; P = 0.207	$\chi^2 = 7.42$; df = 5; P = 0.191
Linear log2(beds + 1) coefficient	-0.65 (95% CI, -0.79 to -0.51); P < 0.001	-2.70 (95% CI, -3.94 to -1.46); P < 0.001
Squared log2(beds + 1) coefficient	Not included	0.146 (95% CI, 0.063 to 0.228); P < 0.001

TABLE 5: Flexible bed-size diagnostic sensitivity analysis

The flexible model was a diagnostic sensitivity analysis that was not prespecified. All three inferential decisions were unchanged, and the profile 5-minus-3 estimate remained positive and nonsignificant.

CAH, Critical Access Hospital; CI, Confidence interval; pp, Percentage points.

All five secondary HCAHPS outcomes showed global differences across the six profiles after false-discovery-rate correction (all q ≤ 0.0245). None showed a statistically significant profile five-versus-three contrast; contrast estimates ranged from -0.34 to 0.29 percentage points (Table 6).

Outcome	Global χ^2	Global P	BH-FDR q	Profile 5–3, pp (95% CI)	Contrast P
Communication about medicines: always	12.88	0.0245	0.0245	0.29 (-0.40 to 0.97)	0.412
Overall hospital rating: 9–10	22.70	<0.001	<0.001	0.09 (-0.90 to 1.07)	0.863
Definitely recommend hospital	28.18	<0.001	<0.001	-0.34 (-1.50 to 0.81)	0.560
Nurse communication: always	30.53	<0.001	<0.001	0.09 (-0.43 to 0.62)	0.725
Doctor communication: always	24.61	<0.001	<0.001	0.07 (-0.46 to 0.60)	0.796

TABLE 6: Secondary HCAHPS outcomes

BH-FDR, Benjamini-Hochberg false-discovery rate; CI, Confidence interval; HCAHPS, Hospital Consumer Assessment of Healthcare Providers and Systems; pp, Percentage points.

In the exploratory alternative parameterization, each additional conventional network was associated with a 0.32-percentage-point higher discharge information score when TEFCA was absent (95% CI, 0.05 to 0.59; P = 0.021). Neither the TEFCA indicator (P = 0.587) nor the conventional network count-by-TEFCA interaction (P = 0.471) was significant (Appendix Table 11).

Weight diagnostics

Outcome-observation weighting cost little precision; the mean effective sample size was 2,365.8, equivalent to 98.2% of the 2,409 observed hospitals, with a minimum of 2,364.4 (98.1% of the observed sample) across imputations. No estimated denominator probability fell below 0.0165, the maximum raw weight was 15.35, and the mean upper weight-trimming threshold was 1.79 (Table 7). Balance diagnostics flagged hospital size among 2024 CAHs. Nonlinear bed-size terms and interactions were therefore added to the final observation model. In the final canonical analysis, the maximum within-stratum absolute standardized mean difference (SMD) declined from 0.217 before weighting to 0.177 after weighting (Appendix Figure 5). Residual imbalance was concentrated in hospital size among CAHs, where it stayed above 0.10 after weighting in both survey years (0.177 in 2024 and 0.110 in 2025) and remained an important limitation. Exact four-bit profile descriptives, adjusted means from the profile-by-CAH interaction model, full primary-model coefficients, and the alternative exposure parameterization are reported in Appendix Tables 8–11, respectively.

Diagnostic	Result
Observed primary-outcome hospitals, N (%)	2,409 (90.9%)
Mean effective sample size (% of observed)	2,365.8 (98.2%)
Minimum effective sample size across imputations (% of observed)	2,364.4 (98.1%)
Minimum denominator probability	0.0165
Maximum raw weight	15.35
Mean 99th-percentile trimming threshold	1.79
Maximum within-stratum absolute SMD before weighting	0.217
Maximum within-stratum absolute SMD after weighting	0.177

TABLE 7: Outcome-observation weight diagnostics

SMD, Standardized mean difference.

Discussion

In this national cohort, patient-reported discharge information scores differed across network-participation profiles, but higher network participation did not consistently correspond to better scores. Neither the prespecified TEFCA comparison nor the interaction between network profile and hospital type was statistically significant.

The significant global test shows that scores differed across profiles, not that more network connections lead to better patient experience. Hospitals with one conventional network had the lowest adjusted score, while hospitals with two and three conventional networks had nearly identical adjusted means. Hospitals in the mixed category, TEFCA with fewer than all three conventional pathways, did not outperform the three-conventional-network reference. Configuration, integration, organizational capacity, and actual use may matter more than membership counts. Prior studies similarly found that hospitals use multiple complementary exchange methods and that workflow integration and information use vary substantially across settings [1-3].

A null TEFCA contrast is not surprising given the policy timeline. TEFCA went live in late 2023, while the HCAHPS outcome window began in July 2024 [5]. Hospitals may have been classified as participants before exchange was fully incorporated into referral, medication reconciliation, or discharge workflows. Participation also does not measure transaction volume, data completeness, clinician awareness, or whether exchanged information was available when discharge decisions were made. Contemporary national evidence likewise suggests that HIOs and networks are pathways for interoperability, but participation in particular services does not automatically produce higher rates of every exchange activity [14].

Our results add to earlier studies of HIE and patient experience while showing that associations may vary across current network configurations. Vest and Miller found associations between implemented HIE and selected HCAHPS measures, and Lee et al. reported an indirect relationship mediated by hospital efficiency [6,7]. Earlier outcome evidence has also been mixed: a national analysis found no association between hospital HIE participation and lower risk-adjusted readmission rates [27], while a systematic review found some evidence of reduced duplicative testing, costs, and admissions but concluded that rigorous evidence for broad clinical outcomes remained limited [28]. Our analysis adds post-TEFCA data and separates several current network configurations.

We are also cautious about the CAH results. In the primary model, CAH status was associated with a 0.83-percentage-point higher adjusted discharge information score (95% CI, 0.20 to 1.45; Appendix Table 10), which is directionally consistent with recent national work showing better reported experiences in CAHs, especially in smaller hospitals [12]. However, fewer CAHs had publicly reported HCAHPS results, and outcome availability was related to network participation. Response-rate relationships also differ by hospital size for discharge information and other HCAHPS domains [13]. Weighting kept nearly all of the observed sample, and the main conclusions held in complete-case and stratified analyses (Tables 3, 4), yet some bed-size imbalance remained among CAHs. A nonsignificant interaction test also does not show that the profile associations are equivalent across hospital types.

Connectivity is only a first step; policymakers also need to know whether it becomes operational use. Near-term TEFCA evaluation should include whether hospitals can locate records, receive clinically relevant data,

integrate them into the EHR, reconcile medications, and use information in discharge planning, not only whether the hospital reports participation. Workflow research indicates that use depends on clinical roles, local processes, and prompts [3]. Rural hospitals may also require technical assistance and implementation support to convert membership into routine use [11]. For researchers, longitudinal designs should exploit future waves of ONC data, hospital adoption timing, and more proximal outcomes. Repeated hospital observations could support fixed-effects or difference-in-differences analyses as TECCA participation matures.

The study's strengths include a large national cohort, post-launch TECCA data, and advanced specification of the network profiles and primary comparison. Linking several public sources allowed adjustment for hospital size, system affiliation, teaching status, ownership, safety-net burden, and rurality, with multiple imputation for missing covariates and inverse probability of observation weighting for differential HCAHPS reporting. We tested the main conclusions in multiple sensitivity analyses, and the full source-to-results workflow was version-controlled and rerun from checksum-verified source snapshots in a separate validated release environment (see Appendix section "Reproducibility and persistent archives").

Limitations

Network participation in the ONC file is self-reported, and an unanswered item is recorded as zero, so some hospitals coded as having little or no participation may simply have skipped the question. Membership is also a weak proxy for use. A hospital could belong to all three conventional networks without those connections translating into information that was available or used during discharge. Survey year is not a participation date and overlaps the July 2024 to June 2025 HCAHPS window, so we cannot say whether participation preceded the scores; the design does not support causal claims. Ownership was measured inconsistently across sources, with AHRQ/HCRIS and CMS classifications agreeing for only 1,588 (61.1%) of 2,600 hospitals; substituting CMS ownership changed the size of the global test statistic but not its conclusion. We also could not adjust for staffing, leadership, finances, EHR-vendor capabilities, or local market conditions, and a hospital-level analysis cannot show what happens at the bedside.

Missing HCAHPS results were concentrated in CAHs and in hospitals with fewer network connections. Weighting corrects for this only to the extent that measured characteristics explain which hospitals reported, and it did not fully balance hospital size among CAHs (maximum within-stratum absolute SMD after weighting, 0.177 for 2024 and 0.110 for 2025 ONC responses). Relative to its 242 nonreporting events, the observation model was large (77 columns), and the outcome models treated its weights as known. Profiles based on conventional-network counts combine different network types, while profile four also groups hospitals reporting TECCA participation with zero, one, or two conventional networks. This grouping was intended to avoid unstable estimates for uncommon combinations, but it limits interpretation. Hospitals within the same profile may have substantially different exchange arrangements, and the results cannot identify which specific network combinations account for the observed associations. Imputation drew from fixed fitted parameters rather than full posterior draws, which falls short of proper Bayesian multiple imputation. The practical impact is likely limited here. Only 71 (2.7%) hospitals were missing a required confounder, and the complete-covariate analysis, with no imputation at all, gave the same decisions on the global profile test and the TECCA contrast (Table 4).

Conclusions

Hospital network participation profiles were associated with patient-reported discharge information scores, but greater participation was not consistently associated with higher scores. Among hospitals participating in all three conventional networks, the adjusted difference in scores between those with and without TECCA participation was not statistically significant. We also found no statistically significant evidence that profile associations differed between critical access and acute care hospitals. Network membership alone may not reliably reflect patients' experiences with discharge information. Future studies should examine how hospitals actually use and integrate exchanged information into patient care.

Appendices

Identifier linkage and geography

Identifier normalization, federal-facility exclusion, AHRQ linkage, and RUCC geography are described in the main text. One duplicated numeric CCN in the ONC dataset was resolved by retaining the latest survey-year record. The AHRQ identifier correction changed two historical audit-status labels but did not change the selected AHRQ records or any analytical covariate value. Two hospitals recorded under the former Valdez-Cordova Census Area were assigned to the Chugach Census Area based on city.

Multiple imputation

Twenty completed datasets were generated using five chained-equation cycles and deterministic seeds beginning with 20260805. Continuous variables used predictive mean matching with five candidate donors based on Bayesian ridge predictions; binary and nominal variables used stochastic L2-regularized logistic or multinomial regression. The imputation model included profile category, CAH status, primary-outcome

observation, outcomes when observed, state, survey year, and all analysis and auxiliary variables. Observed covariate values were never overwritten. The imputation procedure used fixed fitted parameters for stochastic draws; because the observed fractions of missing information were very small, this approach was retained for the release analysis, but it should not be interpreted as fully proper Bayesian multiple imputation.

Observation model and weighting

The denominator model for primary-outcome observation used predicted probability bounds of 10^{-6} to $1-10^{-6}$ in addition to the specification described in the main text. During release validation, the archived 500-iteration ceiling was shown to have produced convergence warnings in 17 of 20 primary denominator fits, even though the historical outputs were exactly reproducible. The canonical pipeline changed only the iteration ceiling to 2,000; the predictors, solver, regularization, tolerance, probability bounds, stabilization, trimming, and estimand were unchanged, and all final observation models converged without warnings. The final denominator design matrix contained 77 columns for 242 nonreporting events. The outcome models treated the estimated observation weights as fixed. Fractional-logit sensitivity estimates were reported as average marginal effects.

The exact four-bit profile frequencies and unadjusted outcome distributions are reported in Table [8](#).

Bits	Hospital group	Source, N (%)	Outcome reported, N (%)	Unadjusted mean, %	SD
0-0-0-0	Acute care	58 (3.1%)	54 (93.1%)	85.87	4.73
0-0-0-0	Critical access	65 (8.3%)	35 (53.8%)	89.09	4.39
0-0-0-1	Acute care	2 (0.1%)	2 (100.0%)	83.00	0.00
0-0-0-1	Critical access	0 (0.0%)	0 (—)	—	—
0-0-1-0	Acute care	17 (0.9%)	16 (94.1%)	84.31	4.59
0-0-1-0	Critical access	23 (2.9%)	14 (60.9%)	88.50	3.30
0-0-1-1	Acute care	11 (0.6%)	11 (100.0%)	83.73	4.52
0-0-1-1	Critical access	4 (0.5%)	2 (50.0%)	89.00	2.83
0-1-0-0	Acute care	29 (1.5%)	28 (96.6%)	84.68	3.65
0-1-0-0	Critical access	25 (3.2%)	13 (52.0%)	88.31	5.65
0-1-0-1	Acute care	80 (4.3%)	79 (98.8%)	83.05	3.24
0-1-0-1	Critical access	5 (0.6%)	4 (80.0%)	91.75	1.71
0-1-1-0	Acute care	58 (3.1%)	58 (100.0%)	86.66	2.54
0-1-1-0	Critical access	21 (2.7%)	19 (90.5%)	90.89	3.97
0-1-1-1	Acute care	30 (1.6%)	30 (100.0%)	85.83	2.49
0-1-1-1	Critical access	10 (1.3%)	9 (90.0%)	89.44	4.90
1-0-0-0	Acute care	138 (7.4%)	138 (100.0%)	83.38	5.56
1-0-0-0	Critical access	80 (10.3%)	49 (61.2%)	89.22	4.92
1-0-0-1	Acute care	15 (0.8%)	15 (100.0%)	85.47	4.37
1-0-0-1	Critical access	14 (1.8%)	10 (71.4%)	89.10	3.21
1-0-1-0	Acute care	100 (5.3%)	97 (97.0%)	86.18	3.29
1-0-1-0	Critical access	50 (6.4%)	33 (66.0%)	88.58	4.46
1-0-1-1	Acute care	52 (2.8%)	52 (100.0%)	85.54	3.21
1-0-1-1	Critical access	35 (4.5%)	32 (91.4%)	87.97	3.95
1-1-0-0	Acute care	271 (14.5%)	269 (99.3%)	85.99	3.38
1-1-0-0	Critical access	189 (24.2%)	144 (76.2%)	88.81	5.21
1-1-0-1	Acute care	182 (9.7%)	182 (100.0%)	84.36	4.80
1-1-0-1	Critical access	55 (7.1%)	35 (63.6%)	89.23	4.52
1-1-1-0	Acute care	341 (18.2%)	338 (99.1%)	86.32	2.66
1-1-1-0	Critical access	104 (13.3%)	68 (65.4%)	88.72	4.06
1-1-1-1	Acute care	487 (26.0%)	483 (99.2%)	86.36	3.44
1-1-1-1	Critical access	100 (12.8%)	90 (90.0%)	89.70	4.52

TABLE 8: Exact four-bit profile descriptives

Bits are ordered HIO–national network–vendor network–TEFCA and are displayed with hyphens to preserve all four binary positions. Source percentages use the hospital-group total as the denominator (acute care, 1,871; critical access, 780); outcome percentages use each row's source N. Values are unadjusted and are provided for transparency; sparse exact profiles were not modeled separately.

HIO, Health Information Organization; SD, Standard deviation; TEFCA, Trusted Exchange Framework and Common Agreement.

Adjusted profile means from the profile-by-CAH interaction model are reported in Table 9.

Hospital group	Code	Profile	Adjusted mean, %	95% CI
Acute care	0	No coded participation	85.79	84.67 to 86.91
Acute care	1	Single conventional network, no TEFCA	83.92	83.28 to 84.56
Acute care	2	Two conventional networks, no TEFCA	85.93	85.61 to 86.25
Acute care	3	Three conventional networks, no TEFCA	85.93	85.63 to 86.24
Acute care	4	TEFCA plus zero to two conventional networks	85.25	84.83 to 85.68
Acute care	5	TEFCA plus all three conventional networks	86.05	85.75 to 86.36
Critical access	0	No coded participation	89.51	87.77 to 91.24
Critical access	1	Single conventional network, no TEFCA	88.81	87.61 to 90.00
Critical access	2	Two conventional networks, no TEFCA	88.99	88.23 to 89.74
Critical access	3	Three conventional networks, no TEFCA	88.63	87.49 to 89.76
Critical access	4	TEFCA plus zero to two conventional networks	88.96	88.04 to 89.88
Critical access	5	TEFCA plus all three conventional networks	89.63	88.64 to 90.63

TABLE 9: Adjusted profile means from the profile-by-CAH interaction model

Adjusted means are standardized separately within each hospital group's source-cohort covariate distribution; differences between acute care and critical access means should therefore not be interpreted as adjusted hospital-type effects.

CAH, Critical Access Hospital; CI, Confidence interval; TEFCA, Trusted Exchange Framework and Common Agreement.

The largest within-stratum balance differences before and after weighting are displayed in Figure 5.

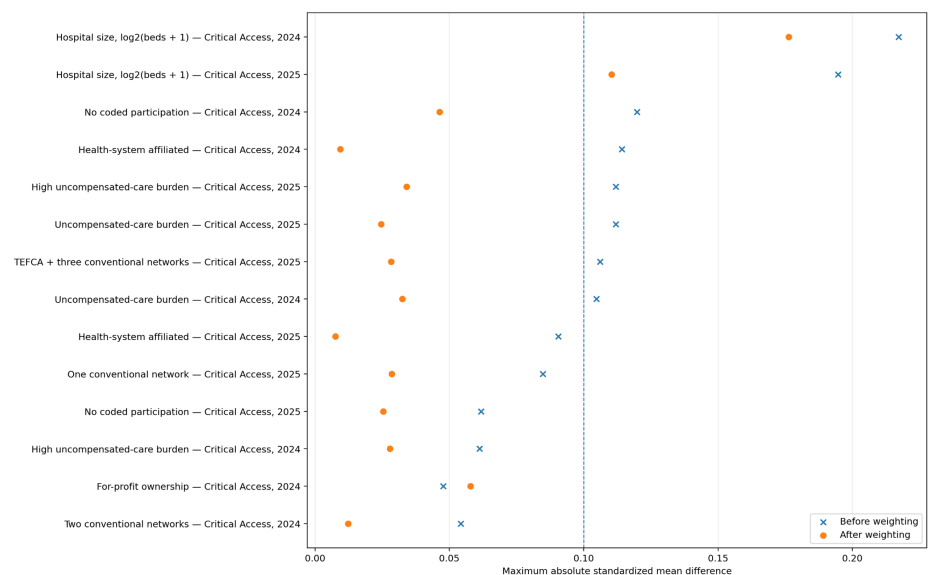


FIGURE 5: Outcome-observation weight balance diagnostics

Points show the maximum absolute standardized mean difference before and after weighting within hospital-group and ONC survey-year strata; the dashed vertical line marks 0.10. The 14 variable-stratum combinations with the largest imbalance are shown, all in CAHs; every acute care hospital stratum had an absolute standardized mean difference of 0.025 or less before and after weighting.

CAH, Critical Access Hospital; ONC, Office of the National Coordinator for Health Information Technology; SMD, Standardized mean difference; TEFCA, Trusted Exchange Framework and Common Agreement.

Image credit: This figure was created by the authors using Python (Python Software Foundation, Wilmington, DE).

The primary model coefficients are reported in Table 10.

Term	Estimate	SE	95% CI	P
Intercept	93.408	1.159	91.137 to 95.679	<0.001
profile_0	0.102	0.537	-0.950 to 1.155	0.849
profile_1	-1.427	0.338	-2.090 to -0.764	<0.001
profile_2	0.000	0.228	-0.448 to 0.447	0.999
profile_4	-0.477	0.275	-1.017 to 0.063	0.083
profile_5	0.276	0.218	-0.151 to 0.703	0.206
CAH	0.826	0.318	0.202 to 1.450	0.009
log2_beds_plus1	-0.652	0.073	-0.794 to -0.510	<0.001
ownership_1	0.193	0.215	-0.229 to 0.614	0.371
ownership_2	-2.678	0.343	-3.349 to -2.006	<0.001
health_system_affiliated	0.095	0.351	-0.593 to 0.784	0.787
teaching_intensity	0.341	0.373	-0.391 to 1.073	0.361
high_dsh_flag	-1.848	0.260	-2.358 to -1.338	<0.001
uncompensated_care_burden	-8.259	2.099	-12.372 to -4.145	<0.001
high_uncompensated_care_flag	-0.436	0.335	-1.093 to 0.221	0.194
nonmetro	0.171	0.219	-0.259 to 0.601	0.436
year2025	0.405	0.246	-0.077 to 0.886	0.099

TABLE 10: Primary model coefficients

Profile 3 (three conventional networks without TEFCA) is the reference category; profile_0 to profile_5 are the network participation profiles defined in Table 2. log2_beds_plus1, log2(beds + 1); ownership_1 and ownership_2, nonprofit and for-profit AHRQ/HCRIS ownership (reference: government); health_system_affiliated, health system affiliation; teaching_intensity, continuous AHRQ teaching intensity measure; high_dsh_flag, high DSH patient-percentage status; uncompensated_care_burden, uncompensated care burden as a proportion (0 to 1); high_uncompensated_care_flag, high uncompensated care burden status; nonmetro, nonmetropolitan county; year2025, 2025 ONC survey response. State fixed-effect coefficients are omitted from this table but are retained in the executable results file.

AHRQ, Agency for Healthcare Research and Quality; CAH, Critical Access Hospital; CI, Confidence interval; DSH, Disproportionate share hospital; HCRIS, Healthcare Cost Report Information System; ONC, Office of the National Coordinator for Health Information Technology; SE, Standard error; TEFCA, Trusted Exchange Framework and Common Agreement.

The exploratory count-plus-TEFCA parameterization is reported in Table 11.

Term	Estimate	SE	95% CI	P
Intercept	92.706	1.135	90.481 to 94.930	<0.001
conventional_count	0.321	0.139	0.049 to 0.594	0.021
current_tefca	-0.291	0.535	-1.339 to 0.758	0.587
count_x_tefca	0.148	0.206	-0.255 to 0.551	0.471
CAH	0.835	0.317	0.213 to 1.457	0.009
log2_beds_plus1	-0.664	0.073	-0.808 to -0.520	<0.001
ownership_1	0.165	0.216	-0.259 to 0.588	0.446
ownership_2	-2.788	0.350	-3.473 to -2.103	<0.001
health_system_affiliated	0.145	0.355	-0.551 to 0.841	0.683
teaching_intensity	0.306	0.415	-0.508 to 1.121	0.461
high_dsh_flag	-1.850	0.265	-2.369 to -1.330	<0.001
uncompensated_care_burden	-7.636	2.083	-11.719 to -3.554	<0.001
high_uncompensated_care_flag	-0.527	0.332	-1.177 to 0.124	0.113
nonmetro	0.134	0.220	-0.297 to 0.564	0.543
year2025	0.329	0.245	-0.152 to 0.809	0.180

TABLE 11: Alternative exposure parameterization

The conventional_count term ranges from 0 to 3 and counts HIO, national-network, and vendor-network participation; count_x_tefca is its interaction with current TEFCA participation; and current_tefca is the current TEFCA participation indicator. Other terms are defined as in Table 10. State fixed-effect coefficients are omitted from this table but are retained in the executable results file.

CAH, Critical Access Hospital; CI, Confidence interval; HIO, Health Information Organization; SE, Standard error; TEFCA, Trusted Exchange Framework and Common Agreement.

Reproducibility and persistent archives

The source-to-results workflow is publicly available at https://github.com/fox-aigod/hospital-network-hcahps-study and archived as software release v1.0.0 in Zenodo (DOI: 10.5281/zenodo.22698060). A separate source-snapshot provenance archive is available at DOI: 10.5281/zenodo.22699595 and contains permitted source snapshots, checksums, the source manifest, and rights and attribution documentation. The exact AHRQ Hospital Linkage File and row-level derivatives containing AHRQ-, IQVIA OneKey-, or AHA-linked fields are not redistributed pending clarification of redistribution rights; users may obtain the source file directly from AHRQ. The repository records release checksums; reconstructs the ONC-CMS cohort, HCAHPS linkage, AHRQ and USDA covariates, multiple imputations, observation weights, pooled models, tables, and figures; and includes automated scientific-consistency tests. GitHub Actions validates repository structure, dependency installation, source compilation, and unit tests without the archived raw-source snapshots. Historical outputs are retained for provenance; the official v1.0.0 results are based on the rerun in the validated release environment described in the "Materials & Methods" section. For the revised submission, Figures 1, 3 were re-rendered using a display-only plotting script (scripts/make_figures.py) added to the repository after the v1.0.0 release. Figure 3 reads the archived full-precision v1.0.0 interaction-adjusted means, and Figure 1 uses the locked cohort counts from the validated v1.0.0 analysis. No statistical models, imputations, weights, or estimates were recomputed. The numerical differences identified during release validation did not change any of the primary or substantive scientific conclusions.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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