

Patient Attribution: Why the Method Matters

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Healthcare providers are increasingly profiled on the value of their care through publicly reported performance metrics, including clinical care outcomes, utilization indices, and costs of care.^{1,2} Seeking the best perceived value of health services drives the demand for reporting reliable provider metrics. Physician groups use these measures to make practice decisions regarding resource allocation, population health management innovations, and quality improvement efforts.³ Providers whose performance demonstrates high value may attract more patients, benefit through pay-for-performance contracts, and serve as exemplars of high-value care. Large employers use narrow networks, high-deductible plans, and tiered employee cost sharing to steer individuals toward high-value providers.⁴ Accurate and reliable healthcare quality and cost measures are required to calculate the value of medical care for all stakeholders.

However, these performance measures can vary dramatically depending on the way that patients are attributed to providers.⁵⁻⁷ Accurate and reliable identification of the physician-patient relationship is therefore a key component of evaluating and delivering high-value care and is at the core of population health management. Although several white papers have been published on attributing patients to providers,^{8,9} no standard exists,⁹ resulting in a variety of attribution methodologies used by different organizations for a range of purposes. Because these attribution methods use varying dimensions to identify and attribute patients, the resulting outcome, utilization, and cost metrics vary.⁶ At the same time, healthcare organizations are increasingly linking patients prospectively with providers to enable population health management, responsibility, and continuity of care.¹⁰⁻¹² Criteria for patient empanelment vary across institutions and introduce yet another alternative for patient attribution. If metrics of care quality and efficiency are to be used to evaluate and compare clinicians and practices, the healthcare system would benefit from a better understanding of attribution methodologies and their ramifications on resulting comparisons.

Prior studies have examined the impact of varying attribution methodologies on primary care provider (PCP) patient mix,

ABSTRACT

OBJECTIVES: To assess the impact of 5 commonly used patient attribution methods on measured healthcare cost, quality, and utilization metrics within an integrated healthcare delivery system.

STUDY DESIGN: Cross-sectional analysis of administrative data of all patients attributed (by any of 5 methods) and/or paneled to a primary care provider (PCP) at Mayo Clinic Rochester (MCR) in 2011.

METHODS: We retrospectively applied 5 attribution methods to MCR administrative data from January 1, 2010, to December 31, 2011. MCR is an integrated healthcare delivery system serving primary care and referral populations. The referral practice is geographically colocated but otherwise distinct from 6 primary care practice sites that include pediatric, internal medicine, and family medicine groups. Patients attributed by each method were compared on their concordance with PCP empanelment, quality measures, healthcare utilization, and total costs of care.

RESULTS: The 5 methods attributed between 61,813 (42%) and 106,152 (72%) of paneled patients to a PCP at MCR, although not necessarily to the paneled PCP. There was marked variation in care utilization and total costs of care, but not quality measures, among patients attributed by the different methods and between those paneled versus not paneled. Patients with more primary care visits were more likely to be attributed by all methods.

CONCLUSIONS: Reliable identification of the physician-patient relationship is necessary for accurate evaluation of healthcare processes, efficiencies, and outcomes. Optimization and standardization of attribution methods are therefore essential as health systems, payers, and policy makers seek to evaluate and improve the value of delivered care.

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performance rankings,¹³ and cost profiles.¹⁴ Patient attribution is particularly challenging in integrated healthcare delivery systems with colocated primary and specialty care, as most attribution methods were designed for primary care or medical home settings.¹⁵ Although methods have been proposed for episode attribution (eg, Dowd et al,¹⁶ CMS Medicare Access and CHIP Reauthorization Act episode cost measurement¹⁷), primary care attribution methods are being applied to multispecialty and integrated care delivery systems.¹⁸ In these situations, specialty care may superficially meet the criteria of primary care attribution algorithms, although it falls outside the intended scope and dramatically alters the measured performance of institutions on publicly reported measures.^{5,19}

Patients, health systems, providers, policy makers, and payers who consume this information need to be cognizant of how differences in attribution methods affect the way that healthcare is measured, evaluated, and reported. Our study examines how specifications of 5 representative primary care attribution methods influence measured clinical quality, care utilization, and total costs of care among primary care patients in an integrated healthcare delivery system with robust primary and specialty care practices. We evaluate attribution through 5 methods applied retrospectively, with previously established Mayo Clinic Rochester (MCR) PCP patient assignments. Our objective was not to propose a gold-standard approach for patient attribution, but rather to assess how variation in methods affects measured indices of care quality, utilization, and cost. Because these metrics are used to assess individual provider, group, and system performances, we first assess the accuracy of patient attribution to their true paneled PCPs (as these are the providers tasked with optimizing their care) and then examine differences in quality, healthcare utilization, and costs among the attribution methods and compare paneled and unpaneled patients.

METHODS

Patients and Setting

This is a cross-sectional study of patients who received primary care at MCR or were paneled to an MCR PCP between January 1, 2011, and December 31, 2011 (N = 150,963). MCR is an integrated healthcare delivery system based in Rochester, Minnesota, that serves local (47.7%), regional (21.3%), national (29.6%), and international (1.4%) patients. All primary care patients (people residing in the local catchment area, as well as MCR employees and dependents) are assigned (paneled) to a PCP in order to provide continuity of care and optimize population health management. Patients are paneled to any available PCP and are typically paneled prior to being seen. Empanelment is not contingent on past or future encounters with the paneled PCP. Patients are administratively removed from a panel

TAKEAWAY POINTS

We retrospectively applied 5 commonly used patient attribution methods to 2 years of integrated healthcare system data. Patients attributed by each method were compared on concordance with provider empanelment, quality measures, utilization, and total cost.

- ▶ The proportion of patients correctly attributed to their paneled provider ranged from 22% to 45%.
- ▶ There was marked variation in care utilization and total costs by method.
- ▶ Quality compliance rates were comparable across attribution methods.

Our study extends previous research by evaluating the effects of existing primary care attribution methods on quality, utilization, and cost within an integrated healthcare delivery system. Standardized attribution methods are essential to improve value.

if they are inactive in the MCR system for 3.5 years. Approximately 10% of patients on primary care panels at MCR changed panel status from 2010 to 2011.

Patients are seen in 1 of 6 primary care clinics: 3 urban, 2 suburban, and 1 rural. MCR PCPs include physicians in family medicine (n = 29), internal medicine (n = 201), and pediatrics (n = 70); residents in these 3 specialties (n = 223); and family medicine–trained advanced practice providers (APPs), including nurse practitioners (n = 44) and physician assistants (n = 29). Graduate medical education residency programs last 3 years and begin and end on approximately July 1; therefore, one-third of patients on trainee panels are expected to change PCP midyear.

We also identified patients who were not paneled to an MCR PCP but were nonetheless assigned to an MCR PCP by 1 or more methods during the 2011 calendar year. Most of these patients received either acute or urgent care. Two general internal medicine groups and 1 pediatrics group serve patients living outside the local area in a consultative practice. They do not provide continuity of care and therefore are not considered PCPs.

The study was deemed exempt from institutional review board review because it involved analysis of pre-existing data.

Attribution Methods

We examined 5 patient attribution methods with methodological variability. They are summarized in [Table 1](#)^{18,20,21} and, in greater detail, the [eAppendix Table](#) (eAppendix available at [ajmc.com](#)). The methods were the (1) Dartmouth (“ACO”) method²⁰ used by CMS for Medicare accountable care organization (ACO) attribution and Medicare Shared Savings Program, (2) public health plan (“public payer”) method used for performance-based contracts by a health plan providing Medicaid coverage in the Midwestern United States (specifications obtained from MCR Contracting Department), (3) private health plan (“private payer”) method used for provider profiling by a large commercial health plan (specifications obtained from MCR Contracting Department), (4) HealthPartners (HP) method²¹ submitted to the National Quality Forum as an example attribution method for total cost of care calculations, and (5) Minnesota Community Measurement (MNCM) method¹⁸ used for mandatory public reporting in Minnesota.

TABLE 1. Summary of Key Dimensions Used by 5 Selected Patient Attribution Methods

	ACO ^a	Public ^b	Private ^c	HP ^d	MNCM
Portion of care	Plurality	Plurality	Majority	Majority	Majority
Time frame	2 years	1 year	1-2 years ^e	1 year	1-2 years ^e
Visit type	E&M	E&M	E&M	E&M	All noninpatient visits
Provider type	PCP; specialty	PCP only	PCP only	PCP; emergency department	PCP only
Assignment	Hierarchy ^f	1 pass	2 passes ^e	Hierarchy ^f	2 passes ^e

ACO indicates accountable care organization; E&M, evaluation and management provider visit; HP, HealthPartners; MNMCM, Minnesota Community Measurement; PCP, primary care provider.

Sources: For public and private health plan methods, specifications obtained from Mayo Clinic Rochester Contracting Department; for ACO method, Bynum et al²⁰; for HP method, HealthPartners²¹; for MNMCM method, MNMCM.¹⁸

^aDartmouth attribution method used by CMS ACO attribution and Medicare Shared Savings Program.

^bAttribution method used for performance-based reimbursement and incentive contracts by a health plan providing Medicaid coverage in a Midwestern state.

^cAttribution method used for provider profiling by a Midwestern health plan.

^dAttribution method provided by HP with National Quality Forum total cost of care submission.

^eTwo passes: assignment based first on 1 year; if still unattributed, second-year data were included.

^fAssignment favors primary care provider first, then specialist in absence of primary care.

All methods attribute patients at the provider level, except MNMCM, which attributes them at the clinic level. In this study, MNMCM was applied at the provider level to facilitate direct comparison. Also, APPs are classified as PCPs by all methods except the public payer method, which considers the APP practice setting to determine PCP status. At MCR, APPs practice in a wide range of settings and were therefore classified based on their clinical practice site.

Independent Variables

Administrative data from between January 1, 2010, and December 31, 2011, were used to document diagnoses (*International Classification of Diseases, Ninth Revision [ICD-9]* codes), procedures (Current Procedural Technology and *ICD-9* codes), number and type of visits, financial information, service locations, provider identifiers, and patient characteristics as of December 31, 2011. The operational definition of chronic conditions was based on Naessens et al,²² which supplements the chronic conditions identified by Hwang et al²³ in Agency for Healthcare Research and Quality Clinical Classifications Software.²⁴ Comorbidity burden was quantified using the total count of chronic diseases recorded during 2010-2011 and the Reference Unscaled Adjusted Clinical Group (ACG) Weight²⁵ based on 2011 billing diagnoses. The Reference Unscaled ACG Weight is an estimate of concurrent resource use associated with a given ACG based on a reference database and expressed as a relative value.²⁵ Attribution was based on data from 2010 to 2011, with the specific time frame dependent on the method.

For each attribution method, patients were categorized as (1) attributed by that method to the paneled MCR PCP (attributed-matched), (2) attributed to an MCR PCP who is different from the paneled MCR PCP (attributed-unmatched), (3) attributed to an MCR PCP but not paneled to any PCP at MCR (attributed-unpaneled), or (4) paneled to a PCP at MCR but not attributed to any MCR PCP using that attribution method (paneled-unattributed).

Outcome Measures

We compared the (1) extent and concordance of attribution; (2) percentage of patients meeting criteria for receiving high-quality diabetes, vascular, asthma, and depression care; (3) annual standardized cost of care²⁶; and (4) number of inpatient (IP), emergency department (ED), and outpatient (OP) visits in 2011. Nonvisit and e-health services were excluded.

Statistical Analysis

Descriptive statistics were calculated for each attribution method. The proportion of patients attributed by each method was calculated for paneled and nonpaneled patients. Utilization, clinical outcome, and cost statistics were calculated based on all patients attributed by that method within each cohort. Analyses were performed using SAS version 9.4 (SAS

Institute; Cary, North Carolina).

RESULTS

Patient Characteristics Across Attribution Methods

In 2011, 146,469 patients were paneled to a PCP. Another 4494 patients who were not paneled to a PCP in 2011 were attributed by at least 1 method. Between 61,813 (42%) and 106,152 (72%) of paneled patients were attributed to any PCP by the 5 attribution methods, although not necessarily to the paneled PCP (Figure 1). Overall, the ACO method attributed the highest number of patients to MCR providers (n = 108,589) and had the highest proportion of attributed-matched patients (60.6%). In contrast, the HP method attributed the fewest (n = 63,837) patients and also had the lowest proportion of attributed-matched patients (51.5%). In general, the 3 methods that allowed 2 years of data to be used for attribution (ie, ACO, private payer, MNMCM) attributed more patients.

All methods had more attributed-matched than attributed-unmatched patients (Figure 1). The ratio of attributed-matched to attributed-unmatched patients ranged from 1.1 for the HP method to 2.0 for the private payer method; a higher ratio is indicative of more accurate PCP matching. The proportion of paneled patients who were not attributed despite having billed services during the measurement period varied from less than 28% using the ACO method to almost 58% using the HP method.

Patients attributed by the 5 methods differed on key demographic, payer, and clinical characteristics. Overall, attributed patients were older, had higher prevalence of chronic disease, and had higher ACG weights than paneled patients (attributed or not) (Table 2). The ACO method, which attributed the largest proportion of patients overall, had younger patients with the lowest mean ACG weight; it attributed nearly all paneled patients with the chronic conditions examined. In contrast, the HP method, which attributed the fewest

patients overall, yielded a cohort with older patients and attributed a higher proportion of patients with chronic diseases.

Healthcare Utilization and Total Cost of Care

Healthcare utilization and total standardized costs of care varied for attributed patients across all methods (Table 3). Methods attributing fewer patients had higher total costs of care during the year of attribution. Mean costs were highest for patients attributed by the HP method and lowest for patients attributed by the ACO method. Differences in mean cost between methods were driven by the type of patients attributed. As shown in Figure 2, the ACO method captured a higher proportion of primary care patients in each cost category, but it also attributed a much larger portion of patients who had no healthcare costs in 2011.

Generally, attributed patients had higher healthcare utilization than unattributed patients (Table 3). Mean OP, IP, and ED utilization were lowest when measured with the ACO method. Patients attributed by the public payer and HP methods had the highest IP and ED use in both 2011 and 2012. Total costs of care in 2011 were also highest among patients attributed by the public payer method, whereas patients attributed by HP had highest mean costs in 2012. The ACO and public payer methods attributed almost all patients with 2011 costs exceeding \$100,000.

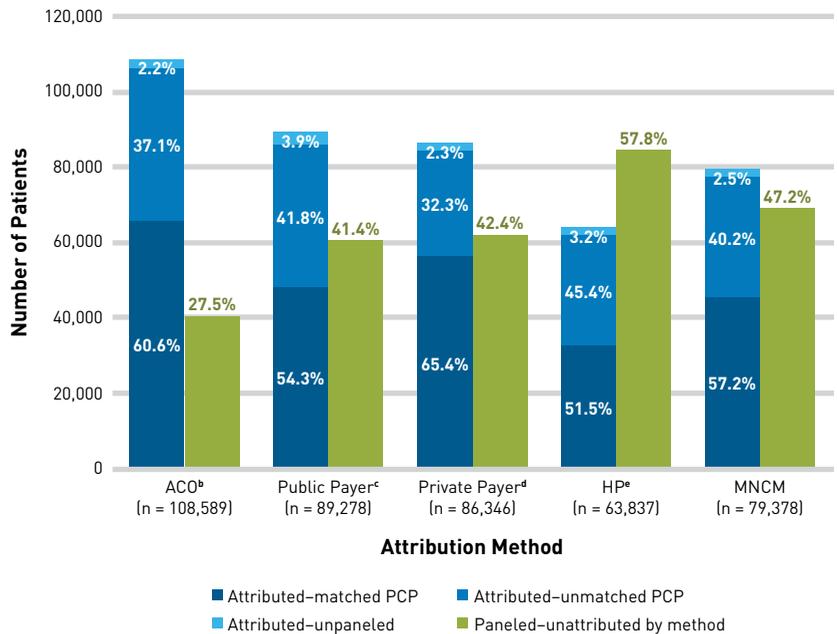
Quality Measures

Both the number of patients included in the assessment (measure denominator) and the percentage of compliance with the 4 chronic disease quality measures differed by attribution method (Table 3). Nonetheless, quality measure compliance rates were comparable across attribution methods.

DISCUSSION

Measuring and reporting indices of health outcomes, utilization, and costs of care are important for improving the value of delivered care, particularly in the context of primary care medical homes, ACOs, and bundled payment programs. Effective population health management, accurate assessment of performance-based contracts, and informed patient engagement are predicated on accurately and reliably attributing patients to providers. Although prior studies have examined the impact of patient attribution methods on select clinical outcomes^{2,5,19,20,27,28} or more broadly evaluated the impact of different dimensions of attribution algorithms,⁶ our study extended

FIGURE 1. Number of Patients Attributed and Proportion of Attribution Match With Panel Assignment, by Attribution Method^a



ACO indicates accountable care organization; HP, HealthPartners; MNMCM, Minnesota Community Measurement; PCP, primary care provider.

^aUnattributed percentages for each method are calculated from the number of paneled patients in 2011 (N = 146,469).

^bDartmouth attribution method used by CMS ACO attribution and Medicare Shared Savings Program.

^cAttribution method used for performance-based reimbursement and incentive contracts by a health plan providing Medicaid coverage in a Midwestern state.

^dAttribution method used for provider profiling by a Midwestern health plan.

^eAttribution method provided by HP with National Quality Forum total cost of care submission.

these findings by evaluating the impact of existing primary care attribution methods on measured care quality, utilization, and costs of care within an integrated healthcare delivery system. Integrated healthcare delivery practices provide an increasing fraction of medical care in the United States,²⁹ yet how attribution methods originally designed for primary care settings translate to multispecialty groups has not been assessed.

There was substantial variability among methods in the number of attributed patients and their characteristics, with several attribution dimensions emerging as particularly important. First, 3 methods attributed patients based on the majority rather than plurality of visits (ie, HP, private payer, and MNMCM). These attributed fewer patients than methods attributing based on the plurality of visits and matched a lower proportion of patients to their paneled PCPs; attributed patients were older with more comorbidities and higher utilization and costs. Another key dimension is the time frame of measurement. Methods permitting 2 years (ie, ACO, private payer, and MNMCM) had more attributed-matched patients without face-to-face encounters during the assignment year that could be attributed using encounters during the extended look-back period. These patients were younger and healthier, with fewer

TABLE 2. Characteristics of Attributed Primary Care Patients, by Attribution Method, and Patients Paneled in 2011

	ACO ^a	Public Payer ^b	Private Payer ^c	HP ^d	MNCM	Paneled Patients
Number of attributed patients	108,589	89,278	86,346	63,837	79,378	146,469
% paneled	97.76	96.12	97.66	96.83	97.45	100
% female	54.67	55.44	55.89	54.03	54.66	53.12
Patient age, years, mean (SD)	38 (25)	39 (26)	40 (25)	42 (25)	39 (25)	36 (23)
Age at assignment, n (%)						
≤18 years	30,906 (28.46)	26,090 (29.22)	24,028 (27.83)	15,594 (24.43)	22,411 (28.23)	40,805 (27.86)
19-44 years	31,287 (28.81)	23,168 (25.95)	22,431 (25.98)	16,689 (26.14)	21,162 (26.66)	50,518 (34.49)
45-64 years	28,514 (26.26)	23,039 (25.81)	23,946 (27.73)	17,594 (27.56)	21,644 (27.27)	35,638 (24.33)
≥65 years	17,882 (16.47)	16,981 (19.02)	15,941 (18.46)	13,960 (21.87)	14,161 (17.84)	19,508 (13.32)
Insurance type, n (%)						
No encounter data						15,358 (10.49)
Medicare	12,914 (11.89)	12,302 (13.78)	11,430 (13.24)	10,020 (15.70)	10,100 (12.72)	13,596 (9.28)
Medicaid	9004 (8.29)	7376 (8.26)	6222 (7.21)	5155 (8.08)	6199 (7.81)	10,569 (7.22)
Commercial/other	79,252 (72.98)	64,624 (72.39)	62,777 (72.70)	44,994 (70.48)	58,076 (73.16)	95,353 (65.10)
Other government	341 (0.31)	273 (0.31)	246 (0.28)	205 (0.32)	246 (0.31)	435 (0.30)
Self-pay	7078 (6.52)	4703 (5.27)	5671 (6.57)	3463 (5.42)	4757 (5.99)	11,158 (7.62)
Residence, n (%)						
No 2010 or 2011 encounter data						15,357 (10.48)
Local (Olmsted or surrounding counties)	104,625 (96.35)	85,413 (95.67)	83,375 (96.56)	61,285 (96.00)	76,601 (96.50)	126,818 (86.58)
Regional (remainder within 120 miles)	2292 (2.11)	2067 (2.32)	1723 (2.00)	1331 (2.08)	1604 (2.02)	2627 (1.79)
National or international	1672 (1.54)	1798 (2.01)	1248 (1.45)	1221 (1.91)	1173 (1.48)	1667 (1.14)
ACG weight, mean (SD)	0.82 (1.72)	0.95 (1.89)	0.88 (1.74)	0.91 (1.80)	0.82 (1.65)	0.69 (1.57)
Chronic conditions, n (%)						
Diabetes	8392 (7.73)	7984 (8.94)	7411 (8.58)	6261 (9.81)	6641 (8.37)	8753 (5.98)
Congestive heart failure	2009 (1.85)	2164 (2.42)	1766 (2.05)	1532 (2.40)	1470 (1.85)	2017 (1.38)
Asthma	9405 (8.66)	8505 (9.53)	8023 (9.29)	6121 (9.59)	6917 (8.71)	10,219 (6.98)
Depression	12,515 (11.53)	10,933 (12.25)	10,595 (12.27)	8039 (12.59)	9119 (11.49)	14,155 (9.66)
Cancer	8103 (7.46)	7515 (8.42)	7335 (8.49)	5908 (9.25)	6450 (8.13)	8936 (6.10)
≥3 chronic conditions	34,665 (31.92)	31,765 (35.58)	30,667 (35.52)	24,565 (38.48)	26,617 (33.53)	37,271 (25.45)

ACG indicates Adjusted Clinical Group; ACO, accountable care organization; HP, HealthPartners; MNM, Minnesota Community Measurement.

^aDartmouth attribution method used by CMS ACO attribution and Medicare Shared Savings Program.

^bAttribution method used for performance-based reimbursement and incentive contracts by a health plan providing Medicaid coverage in a Midwestern state.

^cAttribution method used for provider profiling by a Midwestern health plan.

^dAttribution method provided by HP with National Quality Forum total cost of care submission.

medical services in the assignment year. Restricting attribution of patients to those with a majority of services from a single PCP and just 1 attribution-eligible year selects for costly high utilizers and misses younger, healthier patients who are less likely to have office visits and more likely to have lower costs. This has important implications for PCPs (who would not receive feedback on care provided to all their patients), patients (who may not be identified as needing services through population management approaches), and health systems (which may misallocate resources away from undercounted patients). Methods that attribute patients without healthcare expenditures during the measurement year may support and reward proactive population health management. Specifically, patient portals, e-consults, telemedicine, and other approaches to manage patients without reliance on face-to-face clinical encounters

may deliver high-quality, patient-centered care yet not be captured by attribution methods, quality-of-care metrics, and utilization indices that focus exclusively on having face-to-face visits. Such methods may facilitate chronic disease management among those who already have chronic disease and utilize health services, but they are not optimal for disease prevention and risk management among patients without current health needs or utilization of health services.

Other aspects of attribution methodologies may not alter the accuracy of attribution in primary care practices but have important implications for multispecialty practices and integrated care delivery systems. Methods that include specialists or ED providers as attribution-eligible providers (ie, ACO and public payer) had minimal impact on the proportion of attributed-matched patients

TABLE 3. Utilization and Cost Measures for Attributed Primary Care Patients, by Attribution Method, and Patients Paneled in 2011

	ACO ^a (n = 108,589)	Public Payer ^b (n = 89,278)	Private Payer ^c (n = 86,346)	HP ^d (n = 63,837)	MNCM (n = 79,378)	Paneled Patients (n = 146,469)
% with any cost	92.61	99.95	99.90	100	99.93	80.67
n (%) with costs >\$100,000	1499 (1.38)	1729 (1.94)	1305 (1.51)	1185 (1.86)	1101 (1.39)	1580 (1.08)
Overall cost, mean (SD)	\$9646 (\$32,648)	\$11,867 (\$36,040)	\$10,499 (\$32,567)	\$11,642 (\$35,380)	\$9799 (\$31,589)	\$7879 (\$29,732)
ED cost, mean (SD)	\$437 (\$1791)	\$476 (\$1884)	\$463 (\$1821)	\$458 (\$1819)	\$429 (\$1738)	\$373 (\$1626)
Inpatient cost, mean (SD)	\$3613 (\$26,371)	\$5049 (\$29,381)	\$3814 (\$25,992)	\$4749 (\$28,779)	\$3477 (\$24,787)	\$2917 (\$23,824)
% with primary care E&M	80.89	97.61	88.61	98.66	92.01	63.82
Outpatient E&M visits, primary care, mean (SD)	2.34 (2.63)	2.80 (2.62)	2.63 (2.77)	2.69 (2.46)	2.43 (2.48)	1.85 (2.56)
Outpatient E&M visits, primary care, median (IQR)	2.00 (1.00-3.00)	2.00 (1.00-3.00)	2.00 (1.00-3.00)	2.00 (1.00-3.00)	2.00 (1.00-3.00)	1.00 (0.00-3.00)
% with specialty care E&M	51.73	55.71	55.33	53.55	52.20	45.67
Outpatient E&M visits, specialty care, mean (SD)	1.78 (3.35)	1.97 (3.52)	1.95 (3.51)	1.86 (3.35)	1.80 (3.34)	1.53 (3.15)
Outpatient E&M visits, specialty care, median (IQR)	1.00 (0.00-2.00)	1.00 (0.00-3.00)	1.00 (0.00-2.00)	1.00 (0.00-2.00)	1.00 (0.00-2.00)	0.00 (0.00-2.00)
% with ED visits	16.19	17.48	17.19	16.77	16.16	14.10
ED visits, mean (SD)	0.24 (0.74)	0.26 (0.77)	0.25 (0.75)	0.24 (0.74)	0.23 (0.71)	0.20 (0.68)
ED visits, median (IQR)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
% with hospitalizations	9.17	11.72	9.80	10.40	8.77	7.78
Hospitalizations, mean (SD)	0.13 (0.51)	0.17 (0.57)	0.14 (0.52)	0.15 (0.54)	0.12 (0.50)	0.11 (0.46)
Hospitalizations, median (IQR)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
Hospital days, mean (SD)	5.52 (10.00)	5.99 (10.10)	5.44 (9.51)	6.20 (10.60)	5.43 (9.18)	5.27 (10.10)
Asthma						
Number qualified	1235	731	882	1123	1058	1343
% compliance (95% CI)	48.10 (45.26-50.94)	49.11 (45.82-51.78)	47.51 (46.74-52.88)	48.80 (45.41-52.81)	49.81 (44.15-50.87)	47.65 (44.92-50.38)
Depression						
Number qualified	1623	1009	1210	1356	1396	1753
% compliance (95% CI)	39.37 (36.94-41.80)	36.57 (35.05-40.31)	38.26 (37.28-42.52)	37.68 (33.54-39.60)	39.90 (35.47-41.05)	39.13 (36.80-41.46)
Diabetes						
Number qualified	2824	2165	2346	2690	2513	2935
% compliance (95% CI)	41.71 (39.85-43.57)	42.96 (40.43-44.25)	42.46 (40.45-44.39)	42.34 (40.83-45.09)	42.42 (40.42-44.50)	41.64 (39.82-43.46)
Vascular						
Number qualified	655	478	522	619	574	682
% compliance (95% CI)	60.46 (56.64-64.28)	60.88 (56.65-64.51)	63.03 (57.44-65.56)	60.58 (56.42-65.34)	61.50 (58.80-67.26)	61.14 (57.41-64.87)

ACO indicates accountable care organization; E&M, evaluation and management; ED, emergency department; HP, HealthPartners; IQR, interquartile range; MNMCM, Minnesota Community Measurement.

^aDartmouth attribution method used by CMS ACO attribution and Medicare Shared Savings Program.

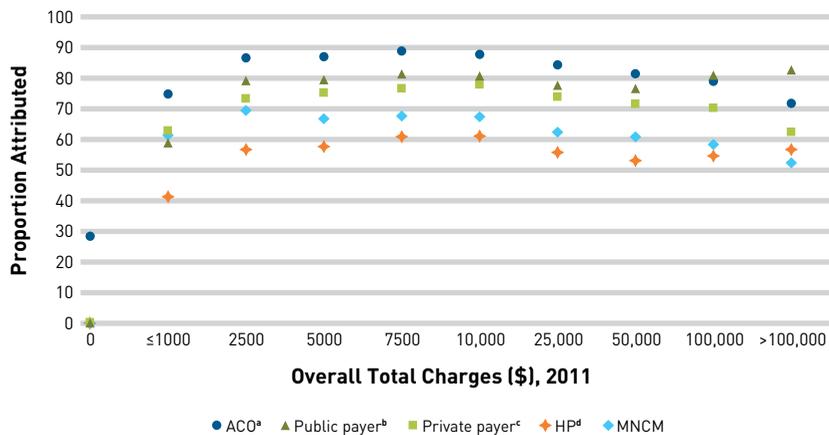
^bAttribution method used for performance-based reimbursement and incentive contracts by a health plan providing Medicaid coverage in a Midwestern state.

^cAttribution method used for provider profiling by a Midwestern health plan.

^dAttribution method provided by HP with National Quality Forum total cost of care submission.

but did attribute more paneled patients to specialists. These methods also attributed unpaneled patients; these patients are not part of our primary care population and likely receive their primary care elsewhere, potentially biasing profiling. Another feature that has greater bearing for multispecialty and academic practices is the

classification of APPs and trainees as PCPs irrespective of their practice setting. As a result, referral patients were misattributed as primary care patients. We attempted to minimize this in our analyses by considering service location; public payer is the only attribution method to formally do so. Although APPs and medical

FIGURE 2. Proportion of Attribution Capture by Method for Categories of Overall Total Charges in 2011

ACO indicates accountable care organization; HP, HealthPartners; MNM, Minnesota Community Measurement.

*Dartmouth attribution method used by CMS ACO attribution and Medicare Shared Savings Program.

^bAttribution method used for performance-based reimbursement and incentive contracts by a health plan providing Medicaid coverage in a Midwestern state.

^cAttribution method used for provider profiling by a Midwestern health plan.

^dAttribution method provided by HP with National Quality Forum total cost of care submission.

trainees are not currently available in the National Provider Index, we propose that for the purposes of attribution, they should be accounted by the type and location of care that they provide.

We did not find much variation in quality measures across methods, despite marked differences in the number of individuals assessed. This is reassuring for patients, providers, and payers. However, these measures reflect chronic disease management, and all methods effectively attribute patients with existing diseases who already utilize health services. The goal of population health is to prevent disease, deliver primary and preventive care, and thus reduce the personal and economic impacts of illness. The process of empanelment facilitates this for all patients, whereas most attribution methods—even the ACO method, which captures the most patients overall and the most patients without utilization or chronic disease—fall short.

Limitations

Our findings must be considered in the context of their limitations. All 5 attribution methods were applied to institutional administrative data, which do not capture services and encounters received outside of our institution. However, paneled primary care patients have been shown to have higher provider continuity,³⁰ particularly as a large portion of the included primary care patients have employer-sponsored health benefit plans with higher out-of-pocket costs for services outside our system. These conditions limit the extent of missing services. Some attribution criteria were not incorporated in comparisons across methods to allow for consistent and more meaningful analyses. For example, the public payer method attributes certified medical home patients as the first step; we did not

have access to these data and were unable to incorporate this step. In addition, the private payer method excludes high-cost patients (>\$200,000); however, because we were interested in understanding how high-cost patients were attributed across methods, we included them in our analyses. Although these specific criteria might improve attribution in certain situations, they are unique to each method and thus limit comparisons. How these methods apply to specialty care providers is outside the scope of this study. Finally, this study is based on a single integrated health system, which potentially limits its generalizability. However, this does not change the main implications of the study—specifically, the marked variation in measured utilization and cost profiles depending on the attribution methodology of measurement-eligible patients.

CONCLUSIONS

Accurate and reliable outcome, utilization, and cost data are needed by providers, admin-

istrators, and payers to appropriately allocate resources, focus interventions on areas of highest need, and improve the value of care. Population health management is predicated on data-driven stewardship of patient outcomes and healthcare utilization, replacing the traditional fee-for-service models of care. To achieve these aims, patients must be accurately and equitably attributed to the providers and systems managing their care. The marked variability in attribution methodologies hampers progress in population health management, and broader agreement on the key dimensions underlying these methods is necessary.

Although we compared 5 commonly used attribution methods with each other and with institutional PCP empanelment, proposing a gold-standard definition for patient attribution was beyond the scope of this analysis. Patient empanelment, just like each of the attribution approaches, has limitations. In particular, empanelment is not predicated on having encounters with that PCP and does not change on the basis of future encounters. Patients are paneled prior to their first primary care appointment on the basis of provider panel size. The discrepancy between seen and paneled PCPs was demonstrated in our study. Thus, as the healthcare community works toward a standardized and objective attribution method, our findings demonstrate how nuances of attribution approaches, such as specialty care, encounter types, and provider types, must be considered, because these factors significantly affect measured care utilization, quality, and cost. ■

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eAppendix Table. Attribution Method Specifications

Methods	Timeline	Majority/ Plurality	Qualified Visits	Qualified Providers	Tie breakers	Exclusions
Dartmouth (ACO)^a	24 month historical	Plurality	Charges > \$0 Ambulatory (E&M) visits	Family Practice Internal Medicine OB/GYN Pediatrics Physician Assistant Nurse Practitioner	Primary care is priority; assign medical specialist in absence of primary care; assign surgical specialist in absence of primary care and specialty care	Claims for ancillary care services Patients with no valid outpatient E&M visits in the 24-month period
Public^b	12 month	Plurality	Hierarchy: 1)E&M well- visit with well visit diagnosis code 2)Primary Care Provider E&M 3)Specialty Provider E&M	Adolescent Medicine Adult Medicine Family Practice General Medicine Geriatric Medicine Internal Medicine Pediatric and Adolescent Medicine Pediatric Internal Medicine Pediatric Primary Care Pediatrics OB/GYN Adult Nurse Practitioner Family Nurse Practitioner	Assign provider with most recent visit	Patients with no E&M visits

				Pediatric Nurse Practitioner		
Private^c	12 month with 3 month runout; unassigned are reprocessed using data from previous 12 month period	Majority; $\geq 51\%$ of visits	E&M: 99201-99215, 99341-99350, 99383-99387, 99393-99429, 99363-99380, 99441-99444, 99241-99255, 99381-99382, 99391-99392, 99460-99464, 99354-99360, 99450-99456, 99465	Family Practice Internal Medicine OB/GYN Pediatrics Physician Assistant Nurse Practitioner		
HealthPartners (HP)	12 month	Majority; $>50\%$ of visits	E&M visits: American College of Physicians Medicare Shared Savings/ Accountable Care Organization Final Rule Summary HCPCS codes: 99201-99215, 99304-99350, G0402, G0438, G0439	Adolescent medicine Adult medicine Developmental-behavioral pediatrics Emergency medicine Family medicine General practice Geriatric medicine Preventive medicine Women's health Gynecology Internal medicine OB/GYN Pediatrics Certified nurse first assistant	Assign provider with most recent visit	Patients with no claims or no primary care office visits in the 12 month period

				Certified nurse midwife Nurse practitioner Physician assistant		
Minnesota Community Measurement (MNCM)	12 month; unassigned with at least one office based claim in the final 3 months of the previous 12 month period are reprocessed using data from previous 12 month period	Majority; >50% of visits	Claim with place of service as 'office' or 'hospital outpatient'	Family medicine Internal medicine OB/GYN Geriatrics Pediatrics Physician assistant Nurse practitioner	Assign provider with most recent visit	Patients with no claims or no primary care office visits in the 12 months or in the last 3 months of the previous year

ACO indicates accountable care organization; E&M, evaluation and management; HP, HealthPartners; MNCM, Minnesota Community Measurement.

Sources: For public and private health plans, specifications obtained from Mayo Clinic Rochester Contracting Department.

^aDartmouth attribution method used by CMS ACO attribution and Medicare Shared Savings Program.

^bAttribution method used for performance-based reimbursement and incentive contracts by a health plan providing Medicaid coverage in a Midwestern state.

^cAttribution method used for provider profiling by a Midwestern health plan.