ORIGINAL ARTICLE

Physician Practice Revenues and Use of Information Technology in Patient Care

Michael F. Furukawa, PhD, Jonathan D. Ketcham, PhD, and Mary E. Rimsza, MD

Objectives: Although information technology (IT) may improve efficiency and quality of patient care, the adoption of clinical IT by physicians has been limited. This study investigates the relationships between physician practice revenue and use of clinical IT.

Research Design: We undertook a cross-sectional analysis of data on 6849 U.S. physicians in physician-owned practices who responded to the 2000–2001 Community Tracking Study Physician Survey. Physician practice revenues, measured as the percentage of total revenues, is defined along 2 dimensions: type (capitation, noncapitated managed care, or fee-for-service) and source (Medicare, Medicaid, or private/other). Analyses were adjusted for physician and practice characteristics and geographic location.

Measures: The proportion of physicians using IT for 5 functions of patient care: treatment guidelines, formularies, patient notes or lists, electronic prescriptions, and data exchange with other physicians.

Results: Practice revenues are associated with differences in physicians' use of IT in patient care. Above-average Medicaid revenue was associated with 20% higher use of IT overall (incidence density ratio = 1.20, 95% confidence interval [CI] = 1.12–1.30). Above-average capitation revenue corresponds to higher use of IT overall (incidence density ratio = 1.10, 95% CI = 1.02–1.19) and greater odds of using IT for guidelines (odds ratio = 1.26, 95% CI = 1.05–1.53). Above-average noncapitated managed care revenue, however, has no apparent relationship with IT use.

Conclusions: Differences in the type and source of physician revenues were associated with differences in the use of IT in patient care in 2000–2001. The relationships between practice revenues and IT use varied across clinical IT functions.

Key Words: clinical information systems, physician payment, capitation, Medicaid, managed care, medical groups

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Information technology (IT) holds the potential to improve the efficiency and quality of patient care.[1,2] Evidence suggests that greater physician use of IT for clinical support functions can reduce medication errors and improve the management of chronic illness.[3–6] Although political interest in clinical IT is high,[7,8] the adoption of IT by physicians has been slow.[9–15] Greater physician adoption is thought to be limited by high initial cost and uncertain financial benefits.[16] The financial impact of IT adoption likely depends on a range of organizational, demographic, and market factors. Existing research has found that levels of adoption vary with a number of physician characteristics such as age, specialty, and practice size.[9,11,13–15] The use of clinical IT might also vary with the source and type of practice revenues. Public and private payers alike have sought to promote the use of clinical IT as a component of quality improvement through initiatives such as pay-for-performance.[17] These recent efforts have been undertaken despite a dearth of research on the relationship between physician revenues and use of IT in patient care.

In this work, we quantify the relationships between the type and source of revenues and use of clinical IT in physician practices. We investigate 3 main hypotheses. First, we analyze how physician participation in capitation is associated with adoption of clinical IT. Previous research concluded that the degree of capitation was the largest determinant of the return on investment from electronic medical records,[18] yet the relationships between capitation and IT use remains unknown. By shifting the risk of future medical expenses onto physicians, capitation might provide incentives for physicians to invest in IT to manage illness and implement processes to reduce the cost of care.[19,20]

Hypothesis 1: Greater Participation in Capitation Is Positively Associated With Physician Use of Clinical IT

In addition to capitation, managed care organizations (MCOs) often use a number of tools to influence physician practice patterns. MCOs rely on utilization review, disease management, and physician profiling, and compensation is often tied to these initiatives. For example, HEDIS measures for immunization and screening rates are used by MCOs as measures of physician performance.[21] Such external incentives promote physicians' use of care management processes, which often rely on IT,[5,22] yet their relationships with IT use have not been documented. If physicians view IT as enhancing their ability to track and monitor their performance on measures that MCOs used to determine incentives, then managed care's use of these measures could promote adoption of IT.[22] MCO participation may also be associated with adoption of clinical IT if IT enhances physicians' ability to negotiate higher MCO reimbursement. If physicians with higher use of IT are more willing to contract with MCOs, or

From the Arizona State University, Tempe, Arizona.
Reprints: Michael Furukawa, School of Health Management and Policy, W. P. Carey School of Business, Arizona State University, P.O. Box 874506, Tempe, AZ 85287-4506. E-mail: Michael.Furukawa@asu.edu.

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if MCOs seek out such practices when forming their networks, then a positive relationship between MCO participation and IT use would exist as well.

Hypothesis 2: Greater Participation in Noncapitated Managed Care Is Positively Associated With Physician Use of Clinical IT

We also consider the share of revenues from private or public sources. A number of Medicaid programs have pursued quality improvement initiatives and disease management.[23] These activities, in combination with Medicaid's large presence in some markets, might allow Medicaid to be particularly influential in some physicians' adoption of IT. Recent research from California demonstrated that practices with greater involvement in Medi-Cal were more likely to adopt care management processes,[24] but the relationship with IT use was not examined. Apart from these initiatives, a greater prevalence of chronic illness among Medicaid patients might also provide greater benefits from IT use by physicians treating more Medicaid patients.

Hypothesis 3: Greater Participation in Medicaid Is Positively Related to Higher Use of IT

States have adopted different strategies for these initiatives. Some states rely predominantly on Medicaid MCOs, while others have contracted directly with providers through Primary Care Case Management (PCCM).[25] We investigate whether the relationships between Medicaid revenues and IT use differed with the prevalence of Medicaid MCOs in the market. Relative to Medicaid, Medicare has few incentives that might promote physician use of IT, and no relationship between Medicare revenues and IT use is expected.

METHODS

Community Tracking Study Physician Survey

The study uses data from the restricted-use version of the Community Tracking Study (CTS) Physician Survey from Round Three (2000–2001).[26,27] The CTS is a nationally representative telephone survey of nonfederal U.S. physicians practicing at least 20 hours per week of direct patient care. The survey is conducted in 60 randomly selected communities on a stratified random sample of 12,406 physicians. Respondents report physician and practice characteristics, the type and source of practice revenues, as well as use of clinical IT within the practice. Sampling weights permit nationally representative estimates that account for the complex survey design.

In this work, we limited the sample for our analysis to the 6849 physicians in physician-owned practices located in 1 of the 60 CTS sites. We excluded physicians working in HMO settings, hospitals, medical schools, or government facilities to avoid potentially confounding influences that might affect clinical IT adoption. Physicians in these settings might have less influence on the decision to adopt clinical IT, and revenues may come from sources other than patient care (eg, HMO premiums or medical education payments). Thus, we note that our analysis does not include physicians working in federal or other government facilities (eg, VA), and our results are generalizable only to physician-owned practices. Examining only practices in the 60 CTS sites allows us to consider within-site differences.

Physician Use of IT in Patient Care

The CTS Physician Survey asks, "In your (main) practice, are computers or other forms of information technology used" for each of 5 applications:

- "to obtain information about treatment alternatives or recommended guidelines" (*guidelines*)
- "to obtain information on formularies" (*formularies*)
- "to access patient notes, medication lists, or problem lists" (*notes*)
- "to write prescriptions" (*prescribing*)
- "for clinical data and image exchanges with other physicians" (*exchange*).

These functions range in complexity and cost, roughly increasing in the aforementioned order listed. Obtaining information on guidelines and formularies could require only a personal computer and an internet connection. Accessing patient notes, medication lists, and problem lists requires elements of an electronic medical record, whereas electronic prescribing and clinical data exchange usually requires adoption of more advanced IT systems that are connected to other entities. Each IT function can be adopted separately,[14] and they are likely to relate to reimbursement differently. For example, capitation might promote greater use of clinical IT to access guidelines to improve management of chronic illness while having little effect on electronic prescribing. General trends between revenues and the cost or complexity of IT are unclear a priori, as simpler functions might be more responsive to revenues, or they may require less incentive to be adopted. For each physician, we also measure the overall level of clinical IT, defined as the number of these 5 IT functions used (*count*).

Physician and Practice Characteristics

The CTS reports a number of physician and practice characteristics that we employ in this study. Physician characteristics include age (<35, 35–44, 45–54, 55–64, 65 years or older), gender, race, specialty (family practice, internal medicine, medical specialties, surgical specialties, pediatrics, psychiatry, obstetrics and gynecology), board certification status, and medical training (allopathic vs. osteopathic, U.S. vs. foreign medical school). We divide physician-owned practices by size and specialty (single vs. multispecialty). Practice size was divided into 5 categories: solo, small (2–5 physicians), medium (6–19), large (20–49), or very large groups (50+). Finally, we included the perceived competitive situation of the practice (not at all competitive, somewhat-competitive, or very-competitive). Physicians perceiving greater competition may have greater incentive to adopt clinical IT to the extent that IT allows them to attract and retain patients or improve their negotiating leverage with insurers.

Practice Revenues

The main variables of interest are the percent of the practice's patient care revenues from each type or source.

Revenue type is divided into 3 categories that sum to 100%: capitation, noncapitated managed care, and fee-for-service. Capitation is defined as revenue derived from risk-bearing contracts, whereas managed care is defined as revenue derived from noncapitated managed care contracts. This approach permits us to consider whether managed care relates to clinical IT use through mechanisms other than capitation. Similarly, revenue source is divided into 3 categories summing to 100%: Medicare, Medicaid, and private or other. For each of these revenue measures, we assign physicians into 1 of 3 categories: none or very-low, average or below-average, and above-average. These revenue measures were generated from self-reported responses rather than from financial records. The CTS performed logical editing for consistency and imputed missing values, although responses were not validated with other sources.

We further investigated whether relationships between Medicaid revenues and IT use vary with the prevalence of Medicaid managed care. Information in the CTS does not allow us to directly examine the interaction between revenue source and type. As a result, for Medicaid we created a dummy variable for counties that had an above-average percentage of Medicaid enrollees in HMOs based on the County Medicaid Managed Care Penetration Dataset.[28] We then examined the interaction of the practice's Medicaid revenue share to test whether Medicaid HMO penetration is related to clinical IT adoption.

Analysis

We reported bivariate results examining clinical IT adoption by categories of revenue type and source. We then used logistic regressions to analyze the association between the type and source of practice revenues and each of the IT functions and log-linear regressions to analyze the IT count measure. SUDAAN software was used to compute variance estimates that account for the complex survey design of the CTS, even when only a subpopulation of the survey sample is analyzed. Log-linear regressions were used for the IT count because SUDAAN cannot perform negative binomial estimation. We relied on Stata to compare negative binomial and log-linear results, and they had similar size and significance. Stata, however, cannot produce reliable variance estimates for the CTS.[29]

In the multivariate regressions, we controlled for the physician and practice-level characteristics described previously. In addition, the specification includes dummy variables for the 60 sites in the CTS survey. Although market-level factors are likely to be important in physicians' decisions about whether to use clinical IT, our main focus is on the practice's revenues. As a result, we study only within-site differences in clinical IT use.

RESULTS

T1 T2 Table 1 reports the characteristics of physicians in our analysis, whereas the first row in Table 2 reports the percentage of physicians using each of the 5 clinical IT functions. On average, physicians were using IT for 1.48 of these 5 functions of patient care. The extent of use tends to decline with cost and complexity, where the most widespread function is obtaining information about guidelines (49% of physicians), but only 10% used clinical IT to write prescriptions. The remainder of Table 2 demonstrates how IT varies by revenue type and source before adjusting for physician and practice characteristics and location. Practices with above-average participation in capitation had significantly higher rates of clinical IT usage overall and for guidelines, formularies, prescribing, and exchange. However, fewer differences appeared across categories of noncapitated managed care revenue, with some evidence that above-average managed care revenue corresponds to lower use of IT overall. Both greater Medicare and greater Medicaid participation was associated with higher IT use overall and for each of the 5 IT functions.

Regression Results

T3 Table 3 reports the results from multivariate regressions. As in the unadjusted bivariate results, capitation revenue was associated with greater use of clinical IT. Physicians with above-average capitation had a 10% higher overall use of clinical IT and 26% higher odds of using IT for guidelines relative to those in practices with no capitation. These results are consistent with capitation's incentives for managing care, particularly chronic illness. Greater noncapitated managed care revenue, however, was not significantly associated with different levels of IT use, suggesting that capitation alone accounts for relationships between managed care and IT use.

F1 Figure 1 shows the relationships between the count of clinical IT functions and capitation for physicians that are specialists (nonprimary care physicians), in group practices (nonsolo), or in multispecialty practices. The relationships between IT use and capitation for physicians that are specialists, in group practice, and in multispecialty groups is larger than the overall relationship, with adjusted differences in the IT count between no capitation and above-average capitation of 0.24, 0.21, and 0.30 respectively, versus 0.13 overall.

Greater participation in Medicaid is associated with higher use of IT overall and for 4 separate functions of patient care. Relative to practices with very-low Medicaid revenue shares, those with above-average Medicaid revenue shares had 20% greater clinical IT use overall, and those with average or below-average Medicaid revenue were 14% higher. Those with above-average Medicaid have 42–48% higher odds of using IT for formularies, notes, prescribing and exchange, while those with average or below-average Medicaid had 20–39% higher odds of using IT for formularies, notes, prescribing and exchange.

F2 Figure 2 reports for each IT function the adjusted difference in adoption between above-average and very-low Medicaid participation, separately for counties with low- and high-Medicaid HMO penetration. In both types of counties, we find positive associations between Medicaid participation and the likelihood of using clinical IT for formularies, notes, and exchange. For prescribing, the difference is only significant where Medicaid HMOs are prevalent.

The results in Table 3 reveal no association between clinical IT use and Medicare revenue share. The only exception was that those with below-average Medicare revenue had 48% higher odds of using clinical IT for prescribing than

TABLE 1. Characteristics of Physicians*

	Physician-Owned Practices in CTS Sites (n = 6849), %
Physician age, years	
Younger than 35	5.0
35–44	30.9
45–54	37.8
55–64	19.0
Older than 65	7.4
Gender	
Male	80.6
Female	19.4
Race	
White or other	97.2
Black	2.8
Specialty	
Family practice	16.2
Pediatrics	7.5
Internal medicine	13.0
Medical specialties	28.3
Surgical specialties	22.7
Ob-gyn	7.0
Psychiatry	5.4
Degree	
MD	93.4
DO	6.6
Medical school	
United States	78.4
International	21.6
Board certified	88.0
Multispecialty practice	14.3
Practice size	
Solo	42.8
2–5	29.1
6–19	19.0
20–49	4.1
50 or more	4.9
Perceived competition	
Not at all	28.1
Somewhat	46.6
Very competitive	25.3
Share of practice revenue: type, mean (SD)	
Fee-for-service	59.1 (0.9)
Capitation (%)	10.2 (0.5)
None (0)	61.0
Below-average (1–10)	15.6
Above-average (11–100)	23.4
Managed care, noncapitated (%)	30.7 (0.7)
Very-low (0–5)	22.4
Below-average (6–31)	36.0
Above-average (32–100)	41.6
Source, mean (SD)	
Private and other	54.5 (0.5)
Medicaid (%)	11.6 (0.3)
Very-low (0–5)	47.1
Below-average (6–12)	22.1
Above-average (13–100)	30.8
Medicare (%)	33.9 (0.6)
Very-low (0–5)	15.9
Below-average (6–34)	36.2
Above-average (35–100)	47.9

those with very-low Medicare, but this single finding is possibly spurious as the result of multiple comparisons.

The results in Table 3 also indicate significant relationships between clinical IT use and other physician and practice characteristics. For example, greater perceived competition was associated with higher clinical IT use overall and for use of IT for guidelines, formularies, and exchange. Although practices in both somewhat-competitive and very-competitive markets were more likely to use clinical IT, there were not systematic differences between the 2. We also found that physicians who were older, women, and in primary care were significantly less likely to use clinical IT. The use of clinical IT increases with practice size, although multispecialty practices did not have higher use of clinical IT than single-specialty practices. In addition, we find that osteopathic physicians are less likely to use IT, particularly for guidelines, formularies and notes, whereas international medical graduates are more likely to use IT overall and for formularies and notes. Medical specialties (eg, cardiology, gastroenterology) were most likely to use IT, particularly for guidelines, exchange, and notes. Psychiatrists had the highest odds of using clinical IT for notes, although they lagged behind others for prescribing. Family practitioners were most likely to use IT for prescribing.

DISCUSSION

These findings provide empirical support for the view that the type and source of physician revenues is associated with the use of clinical IT among physicians in physician-owned practices. To our knowledge, this is the first study to perform multivariate analysis with nationally-representative data to examine how practice revenues relate to physician use of clinical IT overall and for specific IT functions. We found that practices with higher shares of revenue from Medicaid were more likely to use clinical IT overall and for 4 of the 5 IT functions. On average, greater capitation revenues had a small-but-significant positive association with clinical IT use overall, although the relationship was significantly larger for some types of physicians and practices. The revenues from noncapitated managed care and from Medicare had no relationship with clinical IT use.

Our results for Medicaid are consistent with expectations based on the care management and quality improvement initiatives Medicaid has undertaken. Medicaid's value-based purchasing initiatives with managed care organizations often involve the use of information-based performance incentives.[23,25,30] Thus, practices with more Medicaid patients might find it more advantageous to adopt clinical IT to help them to track and monitor their performance. In fact, we found that the relationship between Medicaid revenues and

TABLE 2. Physician Use of Clinical IT by Sources of Practice Revenue Among Physician-Owned Practices

	Guidelines	Formularies	Notes	Prescribing	Exchange	Count
Overall, physician-owned practices (%)	48.8	25.9	30.5	9.6	32.8	1.48
Revenue from capitation (%)						
None (0)	47.6	24.2	29.7	8.8	31.3	1.42
Below-average (1–10)	49.2	25.9	31.8	7.9	34.6	1.49
Above-average (11–100)	51.8‡	30.4‡	31.5	12.5‡	35.5†	1.62‡
Revenue from managed care, noncapitated (%)						
Very-low (0–5)	49.1	27.7	33.1	10.9	32.9	1.54
Below-average (6–31)	49.3	26.5	31.6	9.7	34.0	1.51
Above-average (32–100)	48.2	24.3	28.1†	8.7	31.8	1.41‡
Revenue from Medicaid (%)						
Very-low (0–5)	46.6	21.7	25.3	7.4	27.9	1.29
Below-average (6–12)	49.8*	28.9‡	34.6‡	11.0‡	36.3‡	1.61‡
Above-average (13–100)	51.4†	30.3‡	35.4‡	11.8‡	37.7‡	1.67‡
Revenue from Medicare (%)						
Very-low (0–5)	45.0	19.1	25.5	6.6	27.4	1.24
Below-average (6–34)	48.0	26.7‡	28.9*	10.5‡	32.2†	1.46‡
Above-average (35–100)	50.7‡	27.6‡	33.3‡	9.8†	35.1‡	1.57‡

Values are percentages that reflect nationally representative weighted means.
Risks denote significant difference from referent group, the first listed for each revenue type.
*$P < 0.10$, †$P < 0.05$, ‡$P < 0.01$.
Count is defined as the count of the 5 individual IT functions used by the physician's practice.

use of IT for patient notes tended to be larger where Medicaid HMOs were more prevalent. By contrast, Medicaid's positive associations with use of IT for prescribing and exchange were larger where Medicaid HMOs were less prevalent. This might have resulted from Medicaid agencies' disease management programs, which have included collaboration with clinical IT vendors.[31,32]

In addition to these potential effects caused by Medicaid's initiatives, differences in patient characteristics may make use of clinical IT more attractive to physicians in practices with high percentages of Medicaid patients. For example, physicians might have greater difficulty communicating with Medicaid patients to discern medical history, symptoms, current medications, or adherence.[33] This enhances the importance of using IT for clinical data exchange with other clinicians and pharmacists directly or to access patient notes rather than relying on communication with patients. Similarly, greater use of clinical IT might reflect the demands of managing a population with more chronic illnesses rather than any incentives of the Medicaid program per se.

Other noncausal mechanisms might generate positive associations between Medicaid revenues and use of clinical IT. For example, affiliation with an academic medical center might lead some practices to have higher clinical IT use as well as greater participation in Medicaid. To address this concern, we excluded physicians based in medical schools or universities. Further work should consider whether there were specific changes in states' care management programs that promoted IT adoption.

The relationship between capitation and use of clinical IT was positive but small overall, yet it was larger among specialists and those in group practices or multispecialty practices. Specialists are more likely to treat patients on multiple medications due to complex chronic medical problems. Thus, specialists receiving capitation may benefit more from the availability of electronic prescribing tools that can track patient medications, refills, and adverse drug reactions. Specialists with capitation might also benefit more from IT that permits them to access patient notes and exchange data to coordinate care with other providers.

Group practices may be more likely to adopt clinical IT in response to capitation. First, many clinical IT functions can be shared by all of the providers in a group so that the cost per provider is less for physicians in group practice. Second, physicians in group practice may share responsibility for a larger number of patients and have a greater need to communicate with other physicians in the practice. Therefore, clinical IT that facilitates information sharing may be more valued by group practices with capitated contracts. Similarly, multispecialty group practices receiving capitation are more likely to value clinical IT because of the greater complexity of coordinating care for patients across a range of services.

As with Medicaid, the potential for unobserved differences limit our ability to draw causal inferences about the relationship between capitation and use of clinical IT. For example, physician groups that have adopted IT might have greater ability to identify and control their costs of care, increasing their willingness to accept capitation and to assess the profitability of their capitated contracts when they are up for renewal. This could increase capitation's share of revenues either through higher volume of capitated patients or through higher negotiated capitation payment rates.

We took several steps to reduce the potential for unobserved differences to bias our results. First, we limited the analysis to physicians in private practice and controlled for a variety of physician and practice characteristics. We also only

TABLE 3. Practice Revenue and Use of Clinical IT among Physicians in Physician-Owned Practices

	Adjusted Odds Ratio (95% Confidence Interval)					Incidence Density Ratio (95% Confidence Interval) Count
	Guidelines	Formularies	Notes	Prescribing	Exchange	
Practice revenues						
Type						
Capitation (%)						
None (0)	—	—	—	—	—	—
Below-average (1–10)	1.12 (0.91–1.38)	1.01 (0.79–1.30)	0.98 (0.80–1.21)	0.83 (0.59–1.18)	1.00 (0.82–1.21)	1.01 (0.92–1.10)
Above-average (11–100)	1.26 (1.05–1.53)	1.17 (0.93–1.47)	1.03 (0.80–1.32)	1.18 (0.85–1.65)	1.19 (0.94–1.50)	1.10 (1.02–1.19)
Managed care, noncapitated (%)						
Very-low (0–5)	—	—	—	—	—	—
Below-average (6–31)	1.04 (0.86–1.24)	0.94 (0.77–1.15)	0.88 (0.72–1.08)	0.96 (0.70–1.32)	1.01 (0.82–1.25)	0.99 (0.92–1.06)
Above-average (32–100)	1.16 (0.95–1.41)	0.95 (0.76–1.19)	0.86 (0.69–1.07)	0.99 (0.69–1.42)	1.04 (0.86–1.26)	1.01 (0.93–1.09)
Source						
Medicaid (%)						
Very-low (0–5)	—	—	—	—	—	—
Below-average (6–12)	1.04 (0.90–1.22)	1.39 (1.13–1.69)	1.32 (1.07–1.63)	1.37 (1.06–1.77)	1.20 (1.00–1.44)	1.14 (1.07–1.21)
Above-average (13–100)	1.10 (0.92–1.32)	1.46 (1.21–1.76)	1.48 (1.24–1.76)	1.42 (1.09–1.85)	1.48 (1.22–1.80)	1.20 (1.12–1.30)
Medicare (%)						
Very-low (0–5)	—	—	—	—	—	—
Below-average (6–34)	1.02 (0.81–1.29)	1.37 (0.98–1.92)	0.85 (0.66–1.11)	1.48 (1.06–2.06)	1.00 (0.76–1.31)	1.05 (0.94–1.17)
Above-average (35–100)	1.08 (0.85–1.36)	1.36 (0.99–1.87)	0.90 (0.66–1.23)	1.34 (0.89–2.03)	1.06 (0.81–1.38)	1.06 (0.94–1.21)
Perceived competition						
Not at all	—	—	—	—	—	—
Somewhat	1.22 (1.04–1.43)	1.27 (1.03–1.56)	1.13 (0.96–1.34)	0.98 (0.77–1.25)	1.42 (1.19–1.70)	1.13 (1.06–1.21)
Very competitive	1.27 (1.03–1.55)	1.45 (1.13–1.87)	1.00 (0.80–1.26)	1.10 (0.76–1.59)	1.20 (0.96–1.51)	1.12 (1.03–1.22)
Physician characteristics						
Younger than 35 years	1.95 (1.36–2.80)	0.90 (0.55–1.47)	1.34 (0.87–2.07)	2.21 (0.90–5.41)	1.34 (0.94–1.90)	1.26 (1.05–1.51)
35–44	1.73 (1.25–2.40)	0.83 (0.56–1.23)	1.12 (0.80–1.57)	1.93 (1.11–3.36)	1.30 (0.94–1.79)	1.18 (1.00–1.39)
45–54	1.67 (1.25–2.23)	1.00 (0.71–1.40)	1.06 (0.74–1.51)	1.86 (1.12–3.09)	1.13 (0.84–1.50)	1.16 (1.00–1.36)
55–64	1.50 (1.06–2.11)	1.17 (0.81–1.69)	1.02 (0.71–1.47)	1.37 (0.79–2.37)	0.94 (0.68–1.30)	1.12 (0.94–1.33)
Older than 65	—	—	—	—	—	—
Female	0.90 (0.77–1.06)	0.91 (0.72–1.15)	0.81 (0.66–1.00)	0.87 (0.65–1.17)	0.73 (0.59–0.90)	0.90 (0.83–0.98)
Black	0.88 (0.51–1.51)	0.97 (0.66–1.43)	1.52 (0.92–2.49)	1.40 (0.58–3.37)	0.99 (0.63–1.55)	1.05 (0.91–1.22)
Specialty						
Family practice	—	—	—	—	—	—
Pediatrics	0.82 (0.64–1.05)	0.69 (0.52–0.93)	0.65 (0.47–0.90)	0.62 (0.40–0.96)	1.04 (0.76–1.42)	0.85 (0.75–0.96)
Internal medicine	0.90 (0.72–1.11)	0.98 (0.78–1.22)	1.15 (0.92–1.43)	0.63 (0.45–0.88)	1.14 (0.90–1.44)	0.98 (0.90–1.08)
Medical specialty	1.56 (1.18–2.08)	1.22 (0.91–1.64)	1.57 (1.23–2.00)	0.72 (0.49–1.05)	1.70 (1.41–2.04)	1.21 (1.09–1.34)
Surgical specialty	0.78 (0.62–0.97)	0.87 (0.68–1.13)	1.47 (1.13–1.90)	0.51 (0.33–0.78)	1.62 (1.30–2.03)	1.02 (0.93–1.11)
Obstetrics/gynecology	0.62 (0.45–0.85)	0.88 (0.62–1.24)	0.78 (0.54–1.14)	0.23 (0.13–0.43)	0.86 (0.59–1.26)	0.78 (0.68–0.90)
Psychiatry	1.11 (0.75–1.65)	0.98 (0.65–1.47)	1.81 (1.16–2.82)	0.56 (0.35–0.90)	1.36 (0.92–2.03)	1.10 (0.92–1.30)
Board certified	0.98 (0.80–1.21)	1.06 (0.84–1.34)	0.97 (0.72–1.30)	0.78 (0.55–1.11)	0.89 (0.71–1.12)	0.97 (0.87–1.08)
Osteopath	0.75 (0.59–0.95)	0.73 (0.54–0.99)	0.66 (0.50–0.88)	0.99 (0.65–1.49)	0.90 (0.69–1.17)	0.86 (0.76–0.97)
International medical graduate	0.96 (0.76–1.21)	1.61 (1.31–1.99)	1.36 (1.10–1.69)	1.22 (0.89–1.66)	0.89 (0.72–1.09)	1.09 (1.00–1.19)
Practice characteristics						
Size						
Solo	—	—	—	—	—	—
2–5	1.20 (0.99–1.45)	1.54 (1.20–1.96)	1.36 (1.08–1.71)	1.85 (1.36–2.52)	1.15 (0.97–1.36)	1.20 (1.10–1.31)
6–19	1.00 (0.84–1.21)	1.39 (1.08–1.77)	2.16 (1.66–2.81)	1.45 (1.00–2.10)	1.79 (1.48–2.16)	1.28 (1.18–1.40)
20–49	1.21 (0.84–1.74)	1.20 (0.79–1.82)	3.25 (2.34–4.51)	1.10 (0.54–2.23)	2.04 (1.40–2.97)	1.38 (1.22–1.57)
50 or more	1.47 (1.05–2.06)	2.63 (1.72–4.01)	4.00 (2.82–5.68)	2.97 (1.83–4.83)	3.50 (2.52–4.86)	1.71 (1.52–1.92)
Multispecialty	0.95 (0.74–1.21)	1.03 (0.82–1.30)	1.00 (0.81–1.23)	0.86 (0.59–1.25)	1.22 (0.99–1.52)	1.01 (0.93–1.09)
No. observations (weighted):	249,466	249,466	249,466	249,466	249,466	249,466
Likelihood-Ratio χ^2:	414.8	518.4	716.2	343.5	746.9	970.0

Each regression includes a full set of Community Tracking Study site dummies.
Values account for complex survey design.
Count is defined as the count of the 5 individual functions used by the physician's practice.

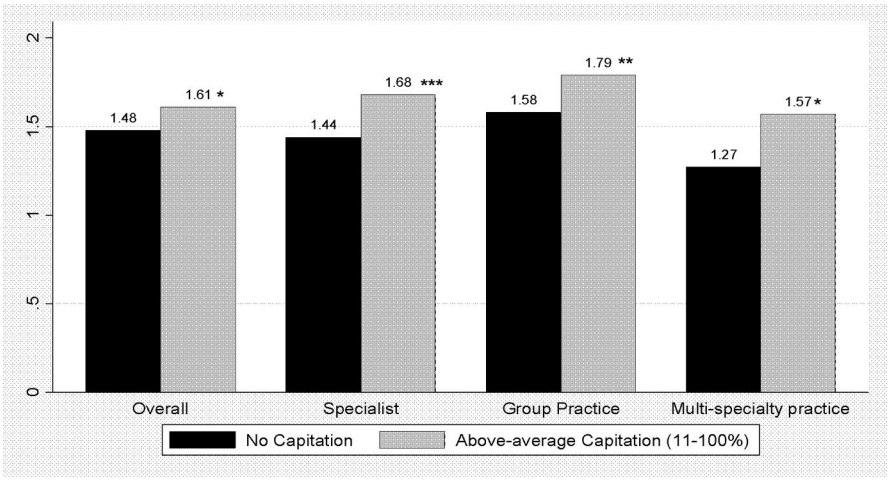

FIGURE 1. Regression-adjusted count of IT functions between no and above-average capitation revenues by physician and practice characteristics. Regressions are identical to those reported in Table 3 except capitation categories were interacted with the physician and practice characteristics. Count is defined as the count of the 5 individual IT functions used by the physician's practice. Asterisks indicate whether above-average capitation was significantly different from no capitation. *Significantly different at $0.10 > P > 0.05$. **Significantly different at $0.05 > P > 0.01$. ***Significantly different at $P < 0.01$.

compared physicians with others in the same geographic area to minimize differences in geographic factors and to eliminate differences in state Medicaid policy. Further investigation of the causal impact of revenues on IT use in this paper is limited by several factors. By construct, all of the revenue variables are potentially endogenous, limiting the ability to find unique instrumental variables for each. Because we analyze differences within each CTS site, any variables that identify exogenous variation in revenues but do not directly influence clinical IT adoption themselves would have to vary across practices within the site. The cross-sectional CTS data provide few candidates to identify such variation.

Although we could not directly address these concerns, our results were robust across a number of specifications. In unreported results, we found that lagged revenue shares from the 1998 to 1999 CTS Physician Survey had larger relationships with clinical IT use in 2000 to 2001, particularly for capitation. This finding is provocative because it suggests that previously higher levels of capitation in some practices may have prompted them to adopt clinical IT that was still in use in later years, even though capitation itself had receded.[34] This finding suggests that once clinical IT is adopted and physicians become comfortable with its use, they may continue to use IT even after the initial impetus is removed. For most clinical IT, the major costs occur at the time of implementation from the initial capital investment and from lost productivity because of changes in workflow. We found qualitatively similar results to those reported here when we omitted the CTS site dummies, included practices outside the 60 sites, or when we used continuous measures of revenue shares.

Contrary to the hypothesis, we did not find any relationship between noncapitated managed care and use of clinical IT. This result also is contrary to previous findings that managed care slowed the adoption of hospital-based technologies such as MRIs and neonatal intensive care units.[35,36] In addition to the difference in setting and type of technology, our ability to control for the degree of capitation apart from managed care might also explain our lack of findings in light of the existing research. Likewise, we found no relationships between Medicare's share of practice revenues and use of clinical IT, which is consistent with previous research.[37] Although few initiatives were in place during the time of our study, recent and future changes might strengthen Medicare's role in promoting clinical IT adoption. For example, CMS has made online versions of all Medicare Part D

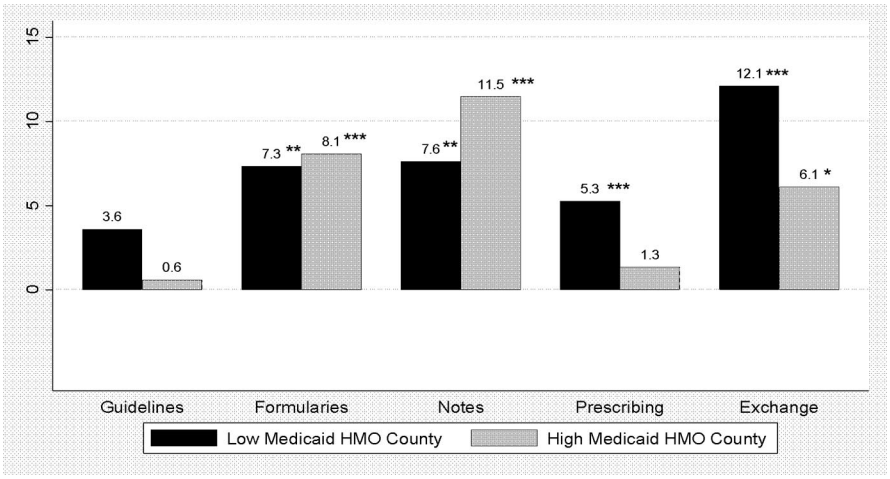

FIGURE 2. Regression-adjusted percentage point difference in adoption between very-low and above-average Medicaid participation by county Medicaid HMO penetration. Regressions are identical to those reported in Table 3 except Medicaid revenue categories were interacted with a dummy variable for whether the county had above-average county-level Medicaid HMO penetration. Asterisks indicate whether practices with above-average Medicaid revenues were significantly different from those with very-low Medicaid, by county HMO penetration. *Significantly different at $0.10 > P > 0.05$. **Significantly different at $0.05 > P > 0.01$. ***Significantly different at $P < 0.01$.

formularies available for download to a PC or handheld device.[38]

Our study does not address several questions about the relationship between physician revenue and clinical IT adoption. Although our analysis considers revenue shares at the practice-level, practices differ in how individual physicians within the practice are reimbursed. We are unable to distinguish between compensation to the practice and to individual physicians. These internal incentives may themselves be responses to revenue type and source, and they might also create differences in clinical IT use.[21] The CTS survey asks whether IT is used within the practice, rather than by the practice's individual members. This is appropriate to the extent that adoption decisions are made at the practice level; however, it may overlook important variations across physicians within a practice. Additionally, we cannot examine whether the incentives of one payer influence the use of clinical IT only for that payer's enrollees or whether there are spillovers to other patients as well. Finally, we did not attempt to estimate the costs and benefits of various reimbursement mechanisms or disease management programs and any concomitant adoption of clinical IT.

The findings from our study highlight the role that capitation and public payers might play in influencing the adoption of clinical IT by physician-owned practices. Yet despite the positive relationships between some types and sources of revenues and IT adoption, the use of clinical IT in private practices remains low. To further promote adoption, public and private insurers are both actively developing incentives aimed at quality improvement, including pay-for-performance (P4P).[39] Some P4P initiatives include financial incentives explicitly intended to promote physician use of clinical IT.[40,41] The National Conference of State Legislatures has identified health IT as a key principle in its Medicaid reform initiatives.[42] Likewise, MedPAC has targeted physicians to be the first Medicare P4P program with higher reimbursements for using clinical IT in specific clinical functions such as reminders for follow-up and preventive care.[43] Similar incentives are built into the P4P program underway in California's private sector.[44] Although our findings do not estimate the impact of such focused incentives, they suggest that payers might play an important role in promoting physician adoption of clinical IT.

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