Area-level factors associated with electronic health record adoption and meaningful use in the Regional Extension Center Program

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Received 10 September 2013

Revised 23 March 2014

Accepted 6 April 2014

Published Online First

5 May 2014

ABSTRACT

Objective To identify area-level correlates of electronic health record (EHR) adoption and meaningful use (MU) among primary care providers (PCPs) enrolled in the Regional Extension Center (REC) Program.

Materials and methods County-level data on 2013 EHR adoption and MU among REC-enrolled PCPs were obtained from the Office of the National Coordinator for Health Information Technology and linked with other county-level data sources including the Area Resource File, American Community Survey, and Federal Communications Commission's broadband availability database. Hierarchical models with random intercepts for RECs were employed to assess associations between a broad set of area-level factors and county-level rates of EHR adoption and MU.

Results Among the 2715 counties examined, the average county-level EHR adoption and MU rates for REC-enrolled PCPs were 87.5% and 54.2%, respectively. Community health center presence and Medicaid enrollment concentration were positively associated with EHR adoption, while metropolitan status and Medicare Advantage enrollment concentration were positively associated with MU. Health professional shortage area status and minority concentration were negatively associated with EHR adoption and MU.

Discussion Increased financial incentives in areas with greater concentrations of Medicaid and Medicare enrollees may be encouraging EHR adoption and MU among REC-enrolled PCPs. Disparities in EHR adoption and MU in some low-resource and underserved areas remain a concern.

Conclusions Federal efforts to spur EHR adoption and MU have demonstrated some early success; however, some geographic variations in EHR diffusion indicate that greater attention needs to be paid to ensuring equitable uptake and use of EHRs throughout the US.

INTRODUCTION

Research suggests that practices using electronic health records (EHR) experience several benefits including improvements in efficiency, care quality, and patient outcomes.^{1–5} Still, rates of EHR adoption and use have generally been low in the US compared to other developed nations.^{6–7} Providers in small practices, rural and non-teaching hospitals, and hospitals with a larger share of Medicaid and minority patients have especially lagged in EHR implementation.^{8–9} Several factors contribute to historically lower rates of EHR adoption and use in the US, including financial barriers, provider attitudes, lack of EHR interoperability, and misaligned incentives.^{10–11}

To spur widespread adoption and meaningful use (MU) of EHRs throughout the US, the Health Information Technology for Economic and Clinical Health (HITECH) Act was passed in 2009.¹² Among its many provisions, HITECH established the Regional Extension Center (REC) Program. The REC Program is administered through the Office of the National Coordinator for Health Information Technology (ONC) and consists of 62 grantee organizations throughout the US that promote EHR adoption and MU through outreach and the provision of EHR implementation technical assistance. The program employs three key milestones: milestone 1 (provider enrollment/engagement), milestone 2 (EHR adoption), and milestone 3 (MU of the EHR). Although RECs are permitted to offer services to all providers within their regional jurisdiction, HITECH prioritizes primary care providers (PCPs) based in small practices and facilities that predominantly care for medically underserved populations.¹² A recent study found that RECs have been very successful in engaging PCPs from rural and health professional shortage areas (HPSAs).¹³

Much of the literature on facilitators and barriers to EHR adoption has focused on provider- and practice-level factors, with less attention given to potential area-level factors associated with EHR adoption. Moreover, there is limited evidence on the extent of geographic variations in MU. The diffusion of innovation literature suggests that contextual factors might also impact EHR diffusion.^{14–15} For example, limited broadband capability in an area can inhibit EHR use and health information exchange (HIE).¹⁶ Providers located in low-resource communities, such as rural areas, may be less inclined to invest in expensive innovations like EHRs.^{11–17–18} Providers' access to and eligibility for EHR-related financial incentives in a given geographic area can stimulate EHR adoption and MU.^{11–19} In addition, increased exposure and engagement with EHRs and other forms of health information technology (IT) within the local provider community may motivate adoption and MU.^{20–21}

Information about the area-level correlates of EHR adoption and MU in the current HITECH era is beginning to emerge. One recent and noteworthy study reported substantial progress towards EHR adoption and MU among REC-enrolled PCPs based in underserved settings, assessing EHR adoption and MU patterns by practice setting, provider type, and geographic area;²² however, this study focused on a limited set of area-level characteristics

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To cite: Samuel CA. *J Am Med Inform Assoc* 2014;**21**:976–983.

and did not assess the potential contributions of other HITECH initiatives to EHR adoption and MU.

This study broadens the set of area-level factors considered to examine associations between a range of contextual factors, including county-level indicators of underservice, the presence of EHR-related incentives, technological infrastructure and capability, and exposure and engagement with health IT, and rates of EHR (1) adoption and (2) MU among REC-enrolled PCPs. Such information should help policymakers maximize the uptake and use of EHRs.

METHODS

Data sources

County-level performance data on REC enrollment (milestone 1), EHR adoption (milestone 2), and MU (milestone 3) among REC-enrolled PCPs, as well as estimated counts of PCPs, were obtained from ONC's Health IT Dashboard website.²³ REC performance data are self-reported by RECs, who collect documentation of milestone achievements from providers and retain records for program management and federal auditing purposes.^{24–25} Documentation of milestone 1 consists of a signed technical assistance contract between each REC and individual provider. To verify milestone 2, providers or their representatives typically submit a copy of an electronic prescribing summary from their EHR along with a signed affidavit indicating that an EHR with enabled quality reporting and electronic prescribing capabilities has been implemented. Milestone 3 is documented based on certification of MU attestation from the Centers for Medicare and Medicaid Services (CMS).^{24–26}

Counts of PCPs within each county were computed by ONC using data from the 2011 SK&A Office-based Providers Database (SK&A Information Services, Irvine, California, USA, 2012). PCPs were defined as physicians, physician assistants, and nurse practitioners with specialties of Family Practice, General Practice, Internal Medicine, Geriatrics, Obstetrics and Gynecology, Pediatrics, and Adolescent Medicine.

Additional county-level data on metropolitan status, federally qualified health center (FQHC) presence, primary care HPSA status, Medicaid enrollment, and Medicare enrollment were obtained from the 2011–2012 Area Resource File. County population and racial composition data were obtained from the 2006–2010 (5-year estimate) American Community Survey. Information on 2011 county-level broadband availability was obtained from the Federal Communications Commission's Local Telephone Competition and Broadband Deployment database.²⁷ Addresses for major teaching hospitals and ONC HITECH grantees were obtained from the Council of Teaching Hospitals and Health Systems and ONC's Health IT Dashboard, respectively.

Cohort

The REC provider cohort consisted of PCPs enrolled with a REC as of October 2013, excluding PCPs located in the US territories. Counties with no PCPs were excluded. The final cohort included 130 397 REC-enrolled PCPs spanning 2715 counties and 59 RECs.

Measures

Outcome measures

Outcome measures included county-level rates (expressed as percentages) of EHR (1) adoption and (2) MU among REC-enrolled PCPs.

Explanatory measures

Underserved area status

County-level indicators of underserved area status and low-resource availability included metropolitan status (metropolitan (urban) vs non-metropolitan (rural)), FQHC presence (at least one FQHC in county vs none), HPSA status (whole county HPSA, population group HPSA, geographic area HPSA, or non-HPSA), and minority concentration (proportion of minorities within total county population).

Potential eligibility for CMS EHR incentives

The CMS EHR Incentive Programs were also established under HITECH and provide incentive payments to non-hospital-based health professionals that demonstrate EHR MU.²⁸ To qualify as a 'Medicaid eligible' health professional for the Medicaid EHR Incentive Program, providers must demonstrate a Medicaid or 'needy individual' patient volume of at least 30% (20% for pediatricians) in addition to meeting other credential criteria.^{12–29} Eligibility for the Medicare EHR Incentive Program depends on the type of Medicare program applicable to a provider. In the case of Medicare's managed care program, Medicare Advantage, providers contracting with a Medicare Advantage Organization (MAO) must provide at least 80% of Medicare patient services to enrollees of their MAO to qualify as a 'Medicare Advantage eligible' health professional.³⁰ There are no patient volume requirements for traditional fee-for-service (FFS) Medicare.^{12–31} However, 'Medicare FFS eligible' health professionals who fail to demonstrate MU by 2015 will face successive payment reductions.¹²

The Medicaid EHR Incentive Program also offers incentive payments to 'Medicaid eligible' providers that adopt, implement, or upgrade (AIU) an EHR. As a result, Medicaid incentives may be more salient to EHR adoption than Medicare, which only pays providers for MU. Medicare incentives (and disincentives) are thus more likely to have more of an effect on MU than EHR adoption. Because the impact of the Medicare and Medicaid EHR Incentive Programs and Medicare payment penalties is to some extent dependent on each provider's payer mix, geographic variations in the concentration of Medicaid and Medicare enrollees are likely to be associated with EHR adoption and MU patterns. To account for the potential impact of geographic variations in provider eligibility for CMS EHR financial incentives on differences in EHR adoption and MU across counties, county-level indicators of Medicaid enrollment concentration (proportion of Medicaid enrollees within total county population), Medicare FFS enrollment concentration, and Medicare Advantage enrollment concentration were examined. Medicare FFS and Medicare Advantage enrollment were examined as separate variables in this analysis because past research indicates that managed care penetration in an area is positively associated with EHR adoption;¹⁷ thus, the association between Medicare enrollment and EHR adoption, and potentially MU, may differ depending on the concentration of each type of Medicare program within the county.

Technological infrastructure and capability

County-level broadband internet technology infrastructure and capability was measured by the number of broadband connections per 1000 households.

Exposure and engagement with health IT

Provider exposure and engagement with health IT varies geographically and may contribute to variations in EHR diffusion. For

example, in addition to the REC program, ONC oversees other HITECH programs that promote EHR adoption and MU in different geographic areas. These ONC HITECH programs include the State HIE Cooperative Agreement which is helping to build capacity for HIE among states, the Strategic Health IT Advanced Research Projects which support EHR adoption and MU through innovative research, Community College and University-Based Training Programs which are tasked with training a skillful health IT workforce, and the Beacon Communities which are leveraging health IT to improve healthcare delivery and quality. Furthermore, past research indicates that teaching hospitals are more likely to adopt EHRs than non-teaching hospitals;^{8 32} thus, teaching hospital presence may contribute to greater awareness and interest in EHRs among providers within a given area.

The level of health IT exposure and engagement within each county was represented by proximity to the nearest major academic teaching hospital, proximity to the nearest ONC HITECH program grantee, and the REC enrollment rate among all PCPs in the county. Distances were computed using the 'Near' spatial analysis tool in ArcMap 10.1³³ and reflect the distance from the county centroid to the point of interest (eg, nearest teaching hospital).

To facilitate comparisons of EHR adoption and MU across county characteristics, all explanatory measures were coded as dichotomous variables. In the case of continuous measures reflecting population concentrations/rates (eg, minority concentration), four dichotomous variables corresponding to quartile values for each measure were generated (eg, Q1—quartile group for counties with lowest concentrations; Q4—quartile group for counties with highest concentrations).

Analysis

In descriptive analyses, mean county unadjusted EHR adoption and MU rates were computed for each category of county characteristics and compared using one-way ANOVA tests.

Within the REC program, each REC is assigned to a collection of counties within a specific state or group of states, making RECs a potential source of variation in this analysis. To assess the proportion of the total variance in EHR (1) adoption and (2) MU that is attributable to differences across RECs, a hierarchical linear model with random intercepts for RECs, but no covariates (model 1), was estimated for each outcome measure followed by computation of the intraclass correlation.

Model 1: Unadjusted random intercepts model

$$\text{Equation 1: } Y_{ij} = \beta_{0j} + e_{0ij}$$

$$\text{Equation 2: } \beta_{0j} = \beta_0 + u_{0j}$$

$$\text{Random part (level 2): } u_{0j} \sim N(0, \sigma_{u0}^2)$$

$$\text{Random part (level 1): } e_{0ij} \sim N(0, \sigma_{e0}^2)$$

i = County

j = REC

$$\text{Intraclass correlation} = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_{e0}^2}$$

$$\sigma_{u0}^2 + \sigma_{e0}^2 = \text{total variance in outcome}$$

where β_{0j} represents the intercept for REC j consisting of β_0 (the mean intercept value) and u_{0j} (the REC-specific random effect), e_{0ij} represents the residual term for county i of REC j, σ_{u0}^2 represents the amount of variance in outcome Y_{ij} (eg, county-level EHR adoption rate) that is attributable to REC-level differences, and σ_{e0}^2 represents the amount of variance in outcome Y_{ij} that is attributable to county-level differences.

To examine associations between county-level characteristics and county-level EHR (1) adoption and (2) MU, fixed effect covariates for the county-level explanatory measures (ie, metropolitan status, FQHC presence, HPSA status, concentration of minorities, Medicaid enrollees, Medicare FFS enrollees, and Medicare Advantage enrollees, broadband connections per 1000 households, distance to nearest teaching hospital, distance to nearest ONC HITECH grantee, and REC enrollment rate among PCPs) were added to Equation 1 of the unadjusted random intercepts models of EHR adoption and MU. These adjusted random intercepts models (model 2) estimate associations between county-level characteristics and each outcome measure while allowing for random variation in intercepts at the REC level.

All analyses were conducted using SAS V9.3.³⁴

RESULTS

Descriptive analyses

Table 1 presents descriptive data for the 2715 counties included in this study. About two-thirds of study-eligible counties were non-metropolitan, one-half of counties were served by at least one FQHC, and the majority of counties were designated as a HPSA of some type. On average (ie, in the average county), about one-fifth of the population were minorities, one-fifth were enrolled in Medicaid, one-sixth were enrolled in Medicare FFS, and 2.9% were enrolled in Medicare Advantage. The majority of counties exhibited broadband capabilities in excess of 400 connections per 1000 households. On average, PCPs in each county were about 94.8 miles away from the nearest major teaching hospital and 70.5 miles away from the nearest ONC HITECH grantee. The average REC enrollment rate among PCPs in each county was 53.8%.

Table 2 presents unadjusted comparisons of county-level rates of EHR adoption and MU among REC-enrolled PCPs for each category of county-level characteristics. On average, about 87.5% (IQR 12.9; SD 24.4) of REC-enrolled PCPs have adopted an EHR. Metropolitan counties, counties with FQHC presence, non-HPSA counties, counties with higher Medicaid enrollment rates, counties with lower Medicare FFS enrollment, counties with higher Medicare Advantage enrollment, and counties located in closer proximity to major teaching hospitals and ONC HITECH grantees had higher EHR adoption rates. Approximately 54.2% (IQR 54.8; SD 33.8) of REC-enrolled PCPs have achieved MU. MU rates were higher in metropolitan counties, non-HPSA counties, counties with lower Medicare FFS enrollment, higher Medicare Advantage enrollment, greater broadband availability, and lower REC enrollment rates, as well as in counties located in closer proximity to major teaching hospitals and ONC HITECH grantees.

Hierarchical models

Approximately 5% of the total variance in county-level EHR adoption rates among REC-enrolled PCPs was explained by differences at the REC level, while 12% of the total variance in MU rates was attributable to REC differences (see table 3 for covariance parameter estimates for model 1). Compared with the 23.6 percentage point SD in county-level EHR adoption rates and the 31.6 percentage point SD in county-level MU rates within RECs (σ_{e0}), the REC-level SD in EHR adoption and MU rates (σ_{u0}) were 5.6 and 11.7 percentage points, respectively. Thus, RECs accounted for a modest amount of the variation in county-level EHR adoption, but a somewhat larger amount of the variation in MU rates.

Table 1 Geographic and population characteristics of US counties (excludes US territories)

Characteristics	US counties (N=2715) (%)
Underserved area status and resource availability	
Metropolitan status	
Metropolitan (urban)	37.8
Non-metropolitan (rural)	62.2
FQHC presence	
No FQHC in county	50.0
At least one FQHC in county	50.0
HPSA status	
Non-HPSA	35.3
Population group HPSA	34.8
Geographic area HPSA	9.8
Whole county HPSA	20.1
Minority concentration	
Mean proportion minorities in population	21.6
Eligibility for EHR incentives	
Medicaid enrollment concentration	
Mean proportion of Medicaid enrollees in population	20.4
Medicare FFS enrollment concentration	
Mean proportion of Medicare FFS enrollees in population	15.4
Medicare Advantage enrollment concentration	
Mean proportion of Medicare Advantage enrollees in population	2.9
Technological infrastructure and capacity	
Broadband connections per 1000 households	
≤200	7.0
>200 to ≤400	28.0
>400 to ≤600	41.8
>600	23.2
Exposure and engagement with health IT	
Distance to nearest major teaching hospital	
Mean distance in miles	94.8
Distance to nearest ONC HITECH grantee	
Mean distance in miles	70.5
REC enrollment rate	
Mean proportion of PCPs enrolled with an REC	53.8

EHR, electronic health record; FFS, fee-for-service; FQHC, federally qualified health center; HITECH, Health Information Technology for Economic and Clinical Health Act; HPSA, health professional shortage area; ONC, Office of the National Coordinator for Health Information Technology; PCP, primary care provider; REC, Regional Extension Center.

Underserved area status

Table 3 presents results from the adjusted hierarchical models of EHR adoption and MU among REC-enrolled PCPs (model 2). In adjusted analyses, FQHC presence, HPSA status, and minority concentration were each associated with county-level EHR adoption among REC-enrolled PCPs. On average, EHR adoption rates among counties with FQHC presence were 3.3 percentage points ($p=0.002$) higher than adoption rates in otherwise similar counties with no FQHC presence. Compared with non-HPSA counties, EHR adoption rates were, on average, 3.6 percentage points lower in population group HPSAs ($p=0.004$) and 4.9 percentage points lower in whole county HPSAs ($p<0.001$). Moreover, counties in the highest quartile of minority concentration exhibited EHR adoption rates that were, on average, 4.0 percentage points ($p=0.03$) lower than adoption rates in counties with the lowest concentration of minorities.

Metropolitan status, HPSA status, and minority concentration were associated with county-level MU rates. On average, MU rates among metropolitan counties were 4.3 percentage points ($p=0.01$) higher than MU in non-metropolitan counties. MU rates were also about 10.1 percentage points ($p<0.0001$) lower in whole county HPSAs relative to non-HPSA counties and 7.5 percentage points ($p=0.004$) lower in counties with the highest minority concentrations relative to counties with the lowest minority concentrations.

Potential eligibility for EHR incentives

Concentration of Medicaid enrollees was associated with county-level EHR adoption rates, while Medicaid Advantage enrollment concentration was associated with MU. Compared with counties with the lowest concentration of Medicaid enrollees, counties with the highest concentration of Medicaid enrollees exhibited EHR adoption rates that were, on average, 6.9 percentage points ($p<0.001$) higher. Counties with higher Medicare Advantage enrollment concentrations (Q2–Q4) exhibited MU rates that were, on average, 4.1–5.4 percentage points ($p<0.05$) higher than MU rates among counties with the lowest concentration of Medicare Advantage enrollment. County-level Medicare FFS enrollment was not associated with EHR adoption or MU in adjusted analyses.

Technological infrastructure and capability

County-level broadband internet access was not associated with county-level EHR adoption or MU in adjusted analyses.

Exposure and engagement with health IT

Distance to the nearest teaching hospital was not associated with EHR adoption; however, compared with counties in closest proximity to a teaching hospital (<30 miles), counties within 31–60 miles of a major teaching hospital exhibited MU rates that were about 4.5 percentage points ($p=0.03$) higher.

Neither distance to the nearest ONC HITECH grantee nor rates of REC enrollment were associated with EHR adoption or MU in adjusted analyses.

DISCUSSION

In 2013, nearly 90% of REC-enrolled PCPs had adopted an EHR and roughly half of REC-enrolled PCPs demonstrated MU. These impressive rates of EHR adoption and MU within the REC program may reflect the successful efforts of REC program staff to engage, educate, and train health providers and staff on the benefits and effective implementation of EHRs. County-level rates of EHR adoption and MU among REC-enrolled PCPs also varied widely across geographic areas. Most of this variation was attributable to differences at the county-level in this study, although REC differences accounted for 5% and 12%, respectively, of the total variation in county-level EHR adoption and MU. Thus, compared with REC-level variations in EHR adoption, there was slightly more variation in MU rates at the REC level.

Compared with EHR adoption, which is largely affected by the availability of financial, administrative, and technical support resources,^{10 11} MU also necessitates greater investment in clinician behavior change.³⁵ Differences in the mechanisms driving EHR adoption and MU may help explain some of the observed geographic patterns in EHR diffusion among REC-enrolled PCPs. For example, rates of EHR adoption and MU were lower in counties with the greatest concentration of minorities and across most HPSA types, particularly in whole county HPSAs. These findings are in line with other research on

Table 2 Unadjusted county-level EHR adoption and meaningful use rates among REC-enrolled PCPs by geographic and population characteristics of US counties (excludes US territories)

	County-level EHR adoption rate (%)	p Value	County-level meaningful use rate (%)	p Value
Mean county-level EHR adoption rate	87.5		54.2	
Underserved area status and resource availability				
Metropolitan status		<0.0001		<0.0001
Metropolitan (urban)	89.9		60.5	
Non-metropolitan (rural)	85.9		50.3	
FQHC presence		<0.0001		0.0538
No FQHC in county	84.6		52.9	
At least one FQHC in county	90.3		55.4	
HPSA status		0.0173		<0.0001
Non-HPSA	89.0		58.5	
Population group HPSA	86.4		54.5	
Geographic area HPSA	89.4		54.0	
Whole county HPSA	85.6		46.0	
Minority concentration		0.5673		0.1625
Q1 (<6.0%)	86.7		54.7	
Q2 (6.0–14.2%)	86.8		54.3	
Q3 (14.3–32.6%)	88.0		55.9	
Q4 (32.7–98.8%)	88.2		51.9	
Eligibility for EHR incentives				
Medicaid enrollment concentration		0.0019		0.3662
Q1 (<14.4%)	85.1		55.8	
Q2 (14.4–19.3%)	86.6		52.8	
Q3 (19.4–25.2%)	88.2		53.4	
Q4 (25.3–62.9%)	89.9		54.8	
Medicare FFS enrollment concentration		0.0003		<0.0001
Q1 (<12.1%)	88.6		56.5	
Q2 (12.1–15.3%)	89.9		57.7	
Q3 (15.4–18.3%)	86.6		52.9	
Q4 (18.4–37.2%)	84.6		49.5	
Medicare Advantage enrollment concentration		0.0004		0.0001
Q1 (<1.3%)	85.0		49.1	
Q2 (1.3–2.3%)	86.4		55.5	
Q3 (2.4–4.0%)	88.1		55.7	
Q4 (4.1–14.1%)	90.3		56.4	
Technological infrastructure and capacity				
Broadband connections per 1000 households		0.5730		0.0009
≤200	88.5		50.0	
>200 to ≤400	86.7		51.8	
>400 to ≤600	87.2		54.2	
>600	88.4		58.4	
Exposure and engagement with health IT				
Distance to nearest major teaching hospital		<0.0001		<0.0001
≤30 miles	90.6		60.6	
31–60 miles	89.7		59.4	
61–90 miles	86.6		54.2	
>90 miles	83.9		45.1	
Distance to nearest ONC HITECH grantee		<0.0001		<0.0001
≤30 miles	89.9		60.2	
31–60 miles	88.4		55.8	
61–90 miles	88.1		55.1	
>90 miles	83.8		46.8	
REC enrollment rate		0.2246		<0.0001
Q1 (<31.0%)	88.1		58.1	
Q2 (31.0–50.0%)	87.3		56.6	
Q3 (50.1–80.0%)	88.4		54.9	
Q4 (80.1–100%)	85.9		47.1	

Boldface values are statistically significant at the $p < 0.05$ level.

EHR, electronic health record; FFS, fee-for-service; FQHC, federally qualified health center; HITECH, Health Information Technology for Economic and Clinical Health Act; HPSA, health professional shortage area; ONC, Office of the National Coordinator for Health Information Technology; PCP, primary care provider; REC, Regional Extension Center.

Table 3 Random intercepts models estimating county-level EHR adoption and meaningful use among REC-enrolled PCPs

	EHR adoption		Meaningful use	
	Unadjusted model 1 β Coefficient (SE)	Adjusted model 2 β Coefficient (SE)	Unadjusted model 1 β Coefficient (SE)	Adjusted model 2 β Coefficient (SE)
Intercept	88.17 (0.93)	87.35 (3.51)	54.51 (1.75)	54.28 (4.85)
Underserved area status and resource availability				
Metropolitan status				
Non-metropolitan (rural)		Reference		Reference
Metropolitan (URBAN)		1.13 (1.28)		4.34 (1.70)
FQHC presence				
No FQHC in county		Reference		Reference
At least one FQHC in county		3.25 (1.04)		−0.85 (1.39)
HPSA status				
Non-HPSA		Reference		Reference
Population group HPSA		−3.55 (1.23)		−2.51 (1.65)
Geographic area HPSA		−1.75 (1.71)		−4.40 (2.29)
Whole county HPSA		−4.85 (1.44)		−10.05 (1.93)
Minority concentration				
Q1 (<6.0%)		Reference		Reference
Q2 (6.0–14.2%)		−0.84 (1.36)		−2.46 (1.82)
Q3 (14.3–32.6%)		−1.59 (1.57)		−3.30 (2.14)
Q4 (32.7–98.8%)		−3.99 (1.87)		−7.50 (2.58)
Eligibility for EHR incentives				
Medicaid enrollment concentration				
Q1 (<14.4%)		Reference		Reference
Q2 (14.4–19.3%)		1.40 (1.38)		−3.26 (1.85)
Q3 (19.4–25.2%)		2.92 (1.57)		−3.28 (2.11)
Q4 (25.3–62.9%)		6.88 (1.85)		1.96 (2.51)
Medicare FFS enrollment concentration				
Q1 (<12.1%)		Reference		Reference
Q2 (12.1–15.3%)		1.43 (1.39)		0.91 (1.86)
Q3 (15.4–18.3%)		−1.65 (1.58)		−3.22 (2.12)
Q4 (18.4–37.2%)		−1.62 (1.74)		−2.80 (2.34)
Medicare Advantage enrollment concentration				
Q1 (<1.3%)		Reference		Reference
Q2 (1.3–2.3%)		−0.33 (1.37)		4.12 (1.83)
Q3 (2.4–4.0%)		0.92 (1.45)		4.19 (1.95)
Q4 (4.1–14.1%)		2.80 (1.60)		5.41 (2.18)
Technological infrastructure and capacity				
Broadband connections per 1000 households				
≤200		Reference		Reference
<200 to ≤400		−1.31 (1.98)		1.67 (2.64)
<400 to ≤600		0.81 (2.05)		5.04 (2.75)
>600		0.38 (2.34)		5.17 (3.14)
Exposure and engagement with health IT				
Distance to nearest major teaching hospital				
≤30 miles		Reference		Reference
31–60 miles		0.03 (1.57)		4.54 (2.10)
61–90 miles		−2.44 (1.83)		1.37 (2.44)
>90 miles		−3.20 (1.92)		−2.81 (2.60)
Distance to nearest ONC HITECH grantee				
≤30 miles		Reference		Reference
31–60 miles		−0.06 (1.55)		−1.95 (2.07)
61–90 miles		1.01 (1.71)		0.51 (2.28)
>90 miles		−1.07 (1.84)		−0.58 (2.46)
REC enrollment rate				
Q1 (<31.0%)		Reference		Reference
Q2 (31.0–50.0%)		−0.06 (1.30)		0.93 (1.74)
Q3 (50.1–80.0%)		2.22 (1.35)		2.28 (1.81)
Q4 (80.1–100%)		0.94 (1.40)		−1.44 (1.89)

Continued

Table 3 Continued

	EHR adoption		Meaningful use	
	Unadjusted model 1 β Coefficient (SE)	Adjusted model 2 β Coefficient (SE)	Unadjusted model 1 β Coefficient (SE)	Adjusted model 2 β Coefficient (SE)
Covariance parameter estimates				
σ_{c0}^2 : county-level variance	558.19	546.44	1001.51	963.04
σ_{u0}^2 : REC-level variance	31.68	31.55	137.01	114.38
$\sigma_{c0}^2 + \sigma_{u0}^2$: total variance	589.87	577.99	1138.52	1077.42
Intraclass correlation (ICC): $\sigma_{u0}^2 / (\sigma_{u0}^2 + \sigma_{c0}^2)$	0.05		0.12	

Boldface values are statistically significant at the $p < 0.05$ level.

EHR, electronic health record; FFS, fee-for-service; FQHC, federally qualified health center; HITECH, Health Information Technology for Economic and Clinical Health Act; HPSA, health professional shortage area; ONC, Office of the National Coordinator for Health Information Technology; PCP, primary care provider; REC, regional extension center.

EHR diffusion in underserved areas,^{8 9 36} and suggest that PCPs in these counties may face challenges to EHR adoption and MU not easily overcome by engagement with an REC, such as tight operating budgets, staff shortages, and limited capacity for integrating EHR training into the clinical workflow.^{11 37} Moreover, gaps in MU by minority concentration and HPSA status were much larger than gaps in EHR adoption by these area-level characteristics, highlighting the added behavioral challenge of inducing these providers to integrate EHRs into clinical practice. As the administrator of the REC program, ONC should work with RECs to conduct comprehensive needs assessments among REC-enrolled PCPs located in HPSAs and high-minority areas and develop tailored strategies to address the specific barriers to EHR adoption and MU faced by these provider groups.

Consistent with previous research on EHR adoption among FQHC providers,^{6 22 38} FQHC presence in a county was positively associated with EHR adoption. This association may be due to the range of health IT-related resources that have been offered to FQHCs in recent years, including REC technical support services and additional health IT-related funding and support from the Health Resources Services Administration (HRSA).¹² In addition, EHR adoption rates were comparable across metropolitan and non-metropolitan areas, an encouraging finding that runs contrary to evidence from most previous studies^{8 9} and suggests that RECs and/or other HITECH initiatives are helping to address the longstanding urban–rural divide in EHR adoption.^{13 22} Still, gaps in MU by metropolitan status remain, and should be a focal point of future outreach efforts.

Despite previous research documenting negative associations between EHR adoption and the proportion of poor and Medicaid patients treated at a facility,^{9 17} the concentration of Medicaid enrollees in a county was positively associated with EHR adoption. This finding is likely due to recent implementation of the Medicaid EHR Incentive Program which provides up to \$63 750 to Medicaid eligible health professionals for AIU and/or demonstrated MU of a certified EHR.³⁹ Rates of EHR adoption were particularly elevated in counties with the highest concentration of Medicaid enrollment (>25.2%). Additional analyses also revealed no differences in EHR adoption according to county-level poverty concentration after accounting for Medicaid enrollment concentration in the county (data not shown). Thus, it appears that the Medicaid EHR Incentive Program has been successful in promoting EHR adoption among providers that have historically been less likely to adopt health information technologies. Future research should explore the role of other incentive-based programs in promoting diffusion of medical innovations among providers serving vulnerable patient populations and the impact of such programs on healthcare disparities.

HITECH established both EHR MU incentives and disincentives for Medicare providers. Medicare FFS eligible providers who fail to demonstrate MU of an EHR by 2015 risk payment reductions proportional to the volume of Medicare patients they serve. As a result, providers based in counties with the highest concentration of Medicare FFS enrollment face greater payment reductions. Interestingly, Medicare FFS and Advantage enrollment concentration in counties were not associated with county-level EHR adoption among REC-enrolled PCPs; however, county-level Medicare Advantage enrollment was positively associated with MU. It is unclear whether this association is primarily explained by mechanisms related to the Medicare EHR Incentive Program, which only pays Medicare eligible providers for MU, or managed care presence in the market, although past research indicates that providers located in markets with higher managed care penetration were more likely to adopt EHRs.¹⁷

Finally, the expected directional association between teaching hospital proximity and MU was not borne out in the data. This may be due to unobservable factors correlated with teaching hospital proximity which were unaccounted for in this analysis.

Limitations

Limitations of this study include the focus on REC-enrolled PCPs and not the general population of health providers; thus, it is unclear whether the findings from this study would generalize to other health professionals, such as specialist providers. Furthermore, it is possible that REC-enrolled providers differ from the general population of providers with respect to geographic location and willingness to adopt and meaningfully use EHRs. Additional information on the characteristics and geography of REC-enrolled providers and providers not enrolled with an REC would help shed light on whether this study's findings extend to the general population of health providers.

Second, for reasons related to data unavailability, this study does not consider the possible influence of EHR adoption rates among non-REC providers in a county on REC-enrolled providers' adoption patterns. Because an EHR is a network good with a value that increases as the number of users increases, an REC-enrolled health provider based in a county with a higher concentration or 'critical mass' of health providers with EHRs may be more likely to adopt and use an EHR than their counterpart located in a county that has yet to reach this 'critical mass' state.⁴⁰

Third, this study is a county-level analysis that does not account for provider- and practice-level factors that might contribute to variations in EHR adoption and MU, such as provider age and openness to new technologies, and practice size and

staff composition. Lastly, it is unclear from this study which REC-level factors may be associated with EHR adoption and MU, such as organizational characteristics, partnerships, and outreach strategies, although the observed REC effects were modest.

Despite these limitations, this study adds to the EHR and diffusion literature by providing insight into EHR adoption and MU patterns in the context of a large scale federally-funded program. It will be important for future research to assess the direct and indirect impact of RECs on EHR adoption and MU across the entire population of health providers. Moreover, few studies have assessed the contribution of area-level factors to the diffusion of EHRs; thus, this study helps to fill an important gap in the research literature. Additional research is needed to determine whether these associations hold true for other provider groups.

CONCLUSIONS

EHRs have the potential to transform healthcare delivery by facilitating improvements in care quality, continuity, and efficiency. Recent legislative and programmatic efforts to spur the adoption and use of EHRs in the US have demonstrated some early success; however, some geographic variations in EHR adoption and MU indicate that greater attention needs to be paid to ensuring equitable uptake of this form of health IT throughout the US.

Acknowledgements I would like to thank Professors Thomas McGuire, Alan Zaslavsky, and Nancy Keating, in the Department of Health Care Policy at the Harvard Medical School, and Michael Furukawa, in the Office of Economic Analysis, Evaluation and Modeling within the Office of the National Coordinator for Health Information Technology, for providing very helpful feedback on a draft of the manuscript.

Funding This work was supported by the Harvard University Graduate Prize Fellowship.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

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