

# Physician Specialty and Variations in Adoption of Electronic Health Records

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## Keywords

Electronic health records, specialization, health policy, ambulatory care, United States

## Summary

**Objective:** Efforts to promote adoption of electronic health records (EHRs) have focused on primary care physicians, who are now expected to exchange data electronically with other providers, including specialists. However, the variation of EHR adoption among specialists is underexplored.

**Methods:** We conducted a retrospective cross-sectional study to determine the association between physician specialty and the prevalence of EHR adoption, and a retrospective serial cross-sectional study to determine the association of physician specialty and the rate of EHR adoption over time. We used the 2005–2009 National Ambulatory Medical Care Survey. We considered fourteen specialties, and four definitions of EHR adoption (any EHR, basic EHR, full EHR, and a novel definition of EHR sophistication). We used multivariable logistic regression, and adjusted for several covariates (geography, practice characteristics, revenue characteristics, physician degree).

**Results:** Physician specialty was significantly associated with EHR adoption, regardless of the EHR definition, after adjusting for covariates. Psychiatrists, dermatologists, pediatricians, ophthalmologists, and general surgeons were significantly less likely to adopt EHRs, compared to the reference group of family medicine / general practitioners. After adjustment for covariates, these specialties were 44 – 94% less likely to adopt EHRs than the reference group. EHR adoption increased in all specialties, by approximately 40% per year. The rate of EHR adoption over time did not significantly vary by specialty.

**Conclusions:** Although EHR adoption is increasing in all specialties, adoption varies widely by specialty. In order to insure each individual's network of providers can electronically share data, widespread adoption of EHRs is needed across all specialties.

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## 1. Background

The United States (U.S.) federal government has committed more than \$20 billion to encourage physicians to adopt electronic health records (EHRs) [8]. Driving these incentives is the expectation that large scale appropriate use of EHRs will facilitate coordination of care, improve health care quality, and lower national health care costs [5, 9]. To receive incentive payments, physicians must purchase and install a certified EHR, then demonstrate “meaningful use” by meeting specific criteria. Example criteria include use of software to reduce medical errors (i.e. electronic prescribing), collection of data relevant for clinical quality measurement (i.e. smoking status), and maintenance of patient summaries to facilitate sharing of data among providers (i.e. electronic problem lists and medication lists) [10].

Several previous initiatives, such as national recognition programs for the Patient-Centered Medical Home, have encouraged adoption of EHRs among primary care physicians [17]. Many of the most common quality measures, including those for EHRs, also focus on primary care [24]. However, there is an increasing effort to facilitate electronic exchange of clinical data across providers caring for common patients (such as a primary care physician and a cardiologist who both care for the same individual).

Such electronic exchange will depend on the adoption and use of EHRs by specialists. Although the overall prevalence of EHR adoption has increased in recent years [21], the prevalence of EHR adoption could vary widely among specialties, particularly given differences in the confidentiality, workflow, and information needs of different specialties [12, 13, 16, 23, 26, 31-33, 42]. The actual variation of EHR adoption among specialties is unclear.

For example, some studies have found specialty practices less likely to adopt EHRs than primary care practices [26, 32, 42], others more likely [31], while others found no difference [15]. Older work (2001-2003) suggested orthopedics and cardiology were the most likely to adopt EHRs, and dermatology and psychiatry the least [12]; whereas more recent work (2008) found pediatrics, obstetrics and gynecology, psychiatry, “other medical specialties”, and “other surgical specialties” were less likely than general practitioners to adopt EHRs [26].

In addition, methodological variability complicates comparison between studies. For example, different studies use different definitions of “EHR adoption”. Some count any EHR use [12, 31, 33], others use published criteria [15] for basic [26] or fully functional [15] EHRs, and others use multiple definitions [21]. Some divide specialty into 14-15 categories [12, 26], some into 8 categories [31], others into 2-3 groups [15, 33]. Several specialist societies have polled their members about EHR adoption [13, 16, 23], but their surveys differ in methodology, and do not include reference groups.

## 2. Objectives

This study aims to identify if there are variations in the prevalence of EHR adoption based on physician specialty, and if so, which physician specialties are more or less likely to adopt an EHR. We performed multiple analyses in order to address discrepancies among specialties found in previous studies. We analyzed data from a national survey with detailed information about physician specialty and EHR adoption. We used four definitions of EHR adoption: three previously described binary outcomes (any EHR, basic EHR, and fully functional EHR) [15] and one novel ordinal outcome (EHR sophistication). We examined the odds of EHR adoption in 2009, as well as the rate of EHR adoption over time from 2005-2009.

## 3. Methods

### 3.1. Study Design

We used a retrospective cross-sectional study design to explore the association between physician specialty and EHR adoption, and a retrospective serial cross-sectional study design to examine the rate of EHR adoption over time among specialties.

### 3.2. Data Source

We analyzed the National Ambulatory Medical Care Survey (NAMCS), which conducts yearly in-person interviews and mail surveys to create a nationally representative weighted sample of ambulatory visits in the U.S. The National Center for Health Statistics (NCHS) conducts NAMCS. We obtained the data for free from the Inter-University Consortium for Political and Social Research [7].

We included data from 2005-2009. The publically available datasets include physician weights, based on the multistage probability sampling strategy used by NAMCS. These weights allow national estimates of nonfederal, office-based physicians, excluding radiologists, anesthesiologists, and pathologists. Our analysis was based on surveys completed by more than 1000 physicians per year (range 1058 – 1291) from 2005 – 2009, which represents a response rate of 53 – 56% of eligible physicians per year [1-4, 6].

### 3.3. Data

#### 3.3.1. Independent Variable: Specialty

NCHS classified each respondent's specialty into one of fourteen groups: family medicine/general practice, internal medicine, pediatrics, general surgery, obstetrics and gynecology, orthopedic surgery, cardiovascular diseases, dermatology, urology, psychiatry, neurology, ophthalmology, otolaryngology, and other specialties.

#### 3.3.2. Dependent Variable: EHR adoption

Any EHR adoption was assessed from 2005-2009 with the question "Does your practice use electronic medical records (not including billing records)?" We considered either of two answers as positive: "Yes, all electronic" or "Yes, part paper and part electronic". From 2007 - 2009, NAMCS used the same set of items to assess EHR functionality, allowing comparisons over time. *Basic EHR* functionality requires six components [15]: patient demographics, problem lists, clinical notes, prescriptions orders, laboratory results, and imaging results. *Full EHR* functionality requires all the basic EHR components, plus eight [15]: notes include medical history and follow up, computerized order entry, laboratory orders sent electronically, prescriptions sent electronically to a pharmacy, radiology image review, warnings of drug interactions or contraindications, out-of-range test levels highlighted, and reminders of guideline-based interventions or screening. *EHR sophistication* is an ordinal measurement of EHR adoption, which grades each physician's EHR adoption along a four-tiered scale: no EHR, any EHR, basic EHR, or full EHR.

Of note, our working definition of "basic EHR" differs from the original 2008 definition [15], which also included "electronic lists of medications taken by patients." The NAMCS instrument did not include a question about this functionality.

#### 3.3.3. Covariates

We included covariates describing physician geography (Northeast, Midwest, South, or West), physician practices, revenue characteristics, and professional degree (MD vs. DO). Each is known to associate with EHR adoption [11, 15, 26, 39].

## 3.4. Analysis

### 3.4.1. Covariate definition

We used three variables to describe physician practices. We collapsed *office setting* into a categorical variable with five values: private solo or group practice, freestanding clinic/urgicenter, community health center, HMO/other prepaid practice, or other. We collapsed *practice ownership* into a categorical variable with five values: physician or physician group, HMO, community health center, medical-academic center, or other. We included *solo practice* as a binary variable. Note that *solo practice* was not collinear with “physician or physician group” – several solo practitioners worked in practices they did not own. Four physicians with missing data about their practices were removed from all analyses.

*Revenue sources* collected in 2005-2009 included Medicare, Medicaid, private insurance, and “other sources”. Five additional *revenue methods* were also collected in 2006-2009: patient payment, fee-for-service, discounted fee-for-service, capitation, and case rates. Because these revenue sources and methods are not mutually exclusive, we collapsed them into nine binary variables indicating if more or less than half of a physician’s revenue came from that source or via that method. In our primary analysis, we used dummy variables to address nonresponse to revenue questions.

We identified respondents who did not fully answer revenue source questions via a separate binary variable “revenue source non-responder”, and set all the revenue source variables to “less than 50%” (the most likely response in each case). Similarly, we identified non-responders to revenue method questions via a separate binary variable “revenue method non-responder”, and set all the revenue method variables to “less than 50%”. In a sensitivity analysis, we removed “revenue source non-responders” and “revenue method non-responders”.

### 3.4.2. Weighted Ratios

Our calculations of the prevalence of EHR adoption for each specialty adjusted for physician level survey weights [28, 30].

### 3.4.3. Trends in Specialty Prevalence

Anticipating our analyses of EHR adoption by specialties over time, we assessed for a significant change in the relative proportion of each specialty over the five years of NAMCS data. We modified the test of correlation to account for survey weights as follows: we calculated the yearly weighted proportion of physicians in each specialty and then calculated a Pearson correlation (year vs. proportion) to test for significance.

### 3.4.4. Association of Specialty and EHR Adoption

To assess the association of specialty and EHR adoption in 2009, we evaluated eight logistic regression models: an unadjusted and adjusted analysis for each of four outcomes. The unadjusted models examined if EHR adoption significantly varied among specialties. The adjusted models examined if the variation among specialties was independent of other covariates.

We used four versions of EHR adoption for the dependent variable: three binary outcomes (any EHR, basic EHR, and full EHR) and one ordinal outcome (“EHR sophistication”).

In the unadjusted models, specialty was the only independent variable. In the adjusted models, we included several covariates: region, office setting, solo practice, practice ownership, MD vs. DO, revenue source, and revenue methods. Specialty was treated as a categorical variable with the largest group, “family medicine / general practice”, as the reference category [26].

For each regression model, we selected a statistical omnibus test to examine the hypothesis that EHR adoption was associated with specialty. For the three binary outcomes, we evaluated logistic regression models via a weighted likelihood ratio test constructed to account for complex survey design (Rao-Scott statistics) [29, 30, 38]. For the ordinal outcome (“EHR sophistication”), we evaluated a cumulative logit model assuming proportional odds and adjusting for complex survey design; we assessed significance by comparing the change in deviance to an F distribution (Wald statistics). If the omnibus test was significant, we then examined which specialties were significantly more or less likely to adopt an EHR, compared with family medicine / general practice, by calculating odds ratios (or adjusted odds ratios), Wald 95% confidence intervals, and p-values.

For the EHR sophistication analysis, we evaluated the proportional odds assumption in the weighted cumulative logit model by inspecting the coefficients (slope) of independent variables in separate parallel logistic regressions of cumulative logits [29, 30, 38].

### 3.4.5. Reliability of estimates and sensitivity analysis

NCHS requires estimates from NAMCS to have a relative standard error of less than 30 percent to be considered reliable. They provide a table containing the smallest reliable estimate for each specialty [6]. Several of the 2009 estimates of full EHR adoption were below this threshold. We thus performed a sensitivity analysis on a larger sample by repeating the regression analysis in section 3.4.4 on pooled data from 2007 – 2009. In the pooled analysis, we used the weights assigned to each physician from each year. There was no overlap in surveyed physicians from year to year.

### 3.4.6. Rate of EHR Adoption over Time

To estimate the yearly change in EHR adoption, we considered NAMCS survey data from 2005-2009. We evaluated a logistic regression model with “any EHR” as the dependent variable and year as a continuous independent variable, and reported the coefficient for year as an odds ratio. We used Rao-Scott statistics to account for complex survey design [29, 30, 38]. We used the same technique to estimate the yearly change in basic and full EHR adoption from 2007 – 2009.

To assess if the rate of adoption of EHRs over time was different among specialties from 2005 - 2009, we tested for an interaction between year and specialty. We built a logistic regression model with “any EHR” as the dependent variable, and three groups of independent variables: *year* as a continuous variable, *specialty* as a categorical variable, and an interaction term *year* × *specialty*. We then used a weighted likelihood ratio test modified to account for complex survey design (Rao-Scott statistics) to compare a logistic regression model with the interaction term to one without it [29, 30, 38]. We used the same technique to evaluate for interactions between basic EHR adoption and time, and between full EHR adoption and time, from 2007 – 2009.

All analyses used physician weights to adjust for complex survey design. We considered  $p < 0.05$  to be statistically significant. We employed multiple testing corrections wherever appropriate.

### 3.4.7. Statistical Tools

Statistical analysis was performed using the R software package version 2.15.1 (Vienna, Austria), supplemented by the “survey”, “ggplot2”, and “car” packages [18, 28, 30, 45]. The “survey” package produces estimates identical to those in commercial software packages, such as Stata, SAS, or SU-DAAN, though standard errors may be marginally different among these packages [14].

## 4. Results

### 4.1. Distribution of specialists and covariates

The weighted proportion of physicians in each specialty remained stable from 2005-2009 (► Table 1). The distribution of otolaryngologists over time had an unadjusted  $p$ -value of 0.01, but this was not significant after Bonferroni correction.

The surveyed physicians’ responses were weighted to represent the half million ambulatory based physicians throughout the US. Most worked in private practices (89%) owned by physicians (81%), and many worked as solo practitioners (34%). The majority were MDs (93%). A third (35%) derived most of their revenue from private insurance, 58% from a fee-for-service payment model. Respondents representing 3.7% of the population did not fully answer questions about revenue sources (i.e. insurance), and those representing 8.4% did not respond to questions about payment models. (► Table 2)

### 4.2. Prevalence of EHR Adoption, by Specialty

EHR adoption prevalence in 2009 varied widely among specialties for three definitions of EHR adoption. Any EHR adoption ranged from a high of 62% (cardiology) to a low of 33% (psychiatry).

Basic EHR adoption was highest in cardiology, family medicine, otolaryngology, and urology (25-27%) and lowest for dermatology and psychiatry (<10%). Full EHR adoption was highest for internal medicine, family medicine, and pediatrics (9.9 - 11%), and as low as 1% for orthopedics. (► Figure 1)

Within some specialties, the choice of definition for EHR adoption lead to different impressions about the prevalence of EHR adoption. For example, in orthopedics, any EHR adoption was above the mean, whereas full EHR adoption was notably below the mean. Conversely, in pediatrics, any EHR adoption was below the mean, whereas full EHR adoption was above the mean (► Figure 1).

Of note, the estimates of full EHR adoption were below the statistical threshold for reliability set by NCHS for five specialties: orthopedics, otolaryngology, general surgery, ophthalmology, and dermatology.

### 4.3. Specialty and the odds of EHR adoption

The unadjusted logistic regression analyses demonstrated that EHR adoption was significantly associated with specialty for all four definitions of EHR adoption (any EHR  $p = 0.02$ , basic EHR  $p = 0.03$ , full EHR  $p = 0.02$ , EHR sophistication  $p = 0.001$ ) (► Table 3). These associations remained significant after adjustment for covariates (any EHR  $p = 0.004$ , basic EHR  $p = 0.008$ , full EHR  $p = 0.02$ , EHR sophistication  $p = 0.0001$ ) (► Table 4). In a sensitivity analysis, all eight models remained significant after revenue non-responders were removed from the sample (data not shown).

Psychiatrists, dermatologists, and pediatricians were less likely to adopt EHRs in 3 of 4 adjusted analyses; ophthalmologists and general surgeons in 2 of 4. After adjustment for covariates, these specialties were 44 - 94% less likely to adopt an EHR, depending on the specialty and definition of EHR adoption, compared to the reference group of family medicine / general practitioners.

Obstetricians and gynecologists, otolaryngologists, and orthopedic surgeons were each less likely in 1 of 4 adjusted analyses. EHR adoption was not significantly different than family medicine / general practitioners in any adjusted analysis for internal medicine, urology, cardiology, neurology, and "other specialties".

In a sensitivity analysis pooling data from 2007-2009, the same five specialties (psychiatry, dermatology, pediatrics, ophthalmology, and general surgery) were significantly less likely to adopt an EHR compared to the reference group in at least two of the four regression analyses (data not shown). The sensitivity analysis also found orthopedic surgery was less likely to adopt a basic and full EHR, although the odds of adopting any EHR was not different than for the reference group (adjusted odds ratio 1.01 [95%CI 0.7 - 1.45]). Thus these sensitivity analyses were consistent with our main findings.

### 4.4. Rate of EHR adoption over time

EHR adoption increased over time for all specialties, by all definitions (► Figure 2). The odds that a physician adopted any EHR increased on average by 35% [95%CI 29 - 42] per year (2005 - 2009). Similarly, the odds of adoption of a basic or a full EHR increased each year on average by 43% [95% CI 26 - 63] and 41% [95% CI 11 - 79], respectively (2007 - 2009). No evidence suggested different specialties adopted EHRs at different rates over time (significance of interaction between specialty and year: any EHR, 2005-2009,  $p = 0.5$ ; basic EHR, 2007-2009,  $p = 0.66$ ; full EHR, 2007-2009,  $p = 0.43$ ).

## 5. Discussion

### 5.1 Summary of Findings

We found the odds of adoption of an EHR by an ambulatory based physician depended on the physician's specialty. This association persisted across four definitions of EHR adoption, after adjusting for potential confounders, and after accounting for missing data. We consistently found that psychiatrists, dermatologists, pediatricians, ophthalmologists, and general surgeons were less likely to

adopt EHRs (compared with family medicine / general practitioners). No specialties were more likely to adopt. Finally, we found that there was no significant difference in the rate of EHR adoption among specialties over time; the odds increased in all specialties, by about 40% per year. These results demonstrate that EHR adoption varies among specialties, but the rate of adoption of EHRs over time is roughly uniform throughout all fields of medicine.

Our analysis agrees with previous work showing psychiatrists [12, 26], ophthalmologists [13], dermatologists [12], and pediatricians [23, 26] each have a relatively low prevalence of EHR adoption, compared with generalists. Our findings build on this work by examining all specialties simultaneously, add robustness via analysis of four measures of EHR adoption, and illustrate the gains made in all specialties over time.

## 5.2 Potential explanations for EHR adoption variability among physician specialties

The theory of diffusion of innovation [40] suggests that different physicians will adopt new technologies at different rates. Understanding specialty specific facilitators and barriers to adoption may provide important insight into future strategies to further encourage EHR adoption. Although NAMCS did not contain items exploring the reasons for EHR adoption, there are several possibilities that might explain why certain specialties adopted early, while others have lagged.

There may have been facilitating factors to explain increased adoption among some generalists (family medicine, internal medicine) and some specific specialties (urology, cardiology, and neurology). Though the research on EHRs in the ambulatory setting has largely focused on generalists [20], several publications describe financial benefits for urologists [34] and cardiologists [27], suggesting some physicians adopted an EHR based on evidence of benefit. Cardiologists and neurologists regularly use digital analysis of physiologic signals (EKG and EEG) in patient care, suggesting they may be more comfortable integrating computers into their practices compared with other specialists.

For specialists with lower prevalence of EHR adoption (psychiatrists, ophthalmologists, dermatologists, pediatricians, and general surgeons), there may be specialty-specific barriers preventing adoption. These specialties have specific privacy, workflow, and information needs that may set them apart from other specialists. Psychiatrists, for example, are particularly sensitive to preserving patient confidentiality; the Health Insurance Portability and Accountability Act places additional protections on both the “process note” and any substance abuse information [35, 41]. Psychiatrists also worry that patients may adjust what they discuss during psychiatric visits based on the perceived privacy of the record [41]. Ophthalmology and dermatology both have high patient volume, require the integration of specialized images and hand written drawings, and typically include both a busy outpatient practice and surgical procedures [13, 19, 22, 44]. Pediatricians have many specific information needs that differ from those of physicians who care for adults, including immunization management, documentation of growth, and weight and age based dosing [43].

For general surgeons, however, it is unclear how to interpret the lower odds of EHR adoption in the ambulatory setting, as they spend significant time in hospitals and operating rooms. Full understanding of general surgeons’ adoption of EHRs would require an assessment of preoperative, perioperative, operative, and postoperative settings [43].

The inconsistent findings for obstetricians and gynecologists, otolaryngologists, and orthopedic surgeons are of unclear significance. If these specialties are truly behind in EHR adoption, the gap is small.

## 5.3 Implications for clinical practice and public health

From a clinical perspective, effective communication with specialists is fundamental to good clinical care, especially given the complexity of care coordination in a busy primary care practice [36]. Federal incentive programs explicitly encourage physicians to share clinical data electronically with one another to insure all have a full understanding of a patient’s medical history – this cannot occur as easily if specialists are not using EHRs.

From a public health perspective, adoption and use of EHRs by these specialties will improve measurement of quality. In order to qualify for EHR incentives, physicians must choose and report clinical quality measures from a list provided by The Center for Medicare and Medicaid Services (CMS). These measures include quality assessments by specialties with lower prevalence of EHR adoption, such as: rates of substance abuse treatment (psychiatry), eye exams in patients with diabetes (ophthalmology), continuity of care for patients with melanoma (dermatology), and immunization and obesity in children (pediatrics) [25]. The ability to measure these quality assessments will be greatly enhanced if specialists adopt EHRs and work to meet the criteria for meaningful use incentives.

In order for EHR adoption to increase across all specialties, some specialists may need additional encouragement. Collaboration among regional extension centers, vendors, and professional societies has already occurred in some specialties [37], and should be encouraged.

## 5.4 Limitations

We were unable to control for some factors known to associate with EHR use, such as physician age or comfort with technology. Cross-sectional study designs limit causal inference. Our working definition of “basic EHR” differs slightly from the original 2008 definition [15]. Further work is needed to extend our 2005 – 2009 analysis to include subsequent rounds of the NAMCS data, particularly to understand the effect of the federal meaningful use program on the adoption of EHRs by different specialties.

## 6. Conclusions

Our results emphasize that EHR adoption varies widely by specialty. Although EHR adoption is increasing in all specialties, the prevalence of adoption for ophthalmologists, dermatologists, psychiatrists, pediatricians, and general surgeons is significantly lower than for family medicine and general practice physicians. In order to insure each individual’s network of providers can electronically share data, widespread adoption of EHRs is needed across all specialties.

### Clinical Relevance

Achieving the expected benefits of EHRs to the U.S. Health system depends on EHR adoption by physicians from all specialties. We found that EHR adoption varies significantly by physician specialty. Although all specialties are making gains, the prevalence of adoption for ophthalmologists, dermatologists, psychiatrists, pediatricians, and general surgeons is significantly lower than for family medicine and general practice physicians. In order to insure each individual’s network of providers can electronically share data, widespread adoption of EHRs is needed across all specialties.

### Conflicts Of Interest

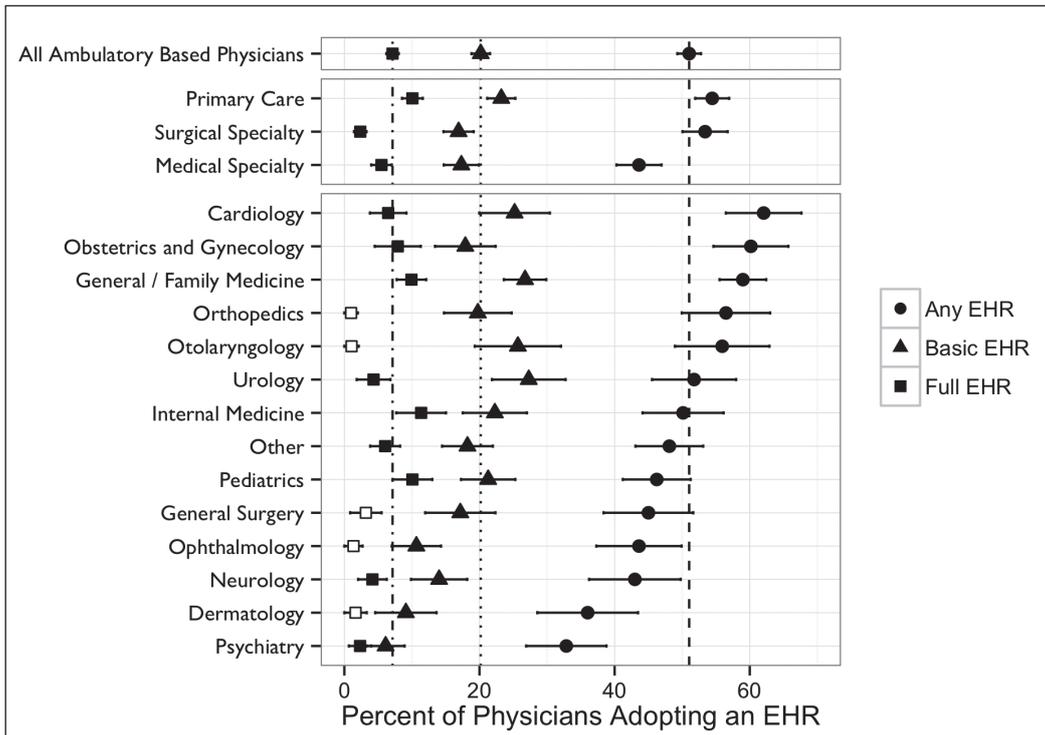
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### Protection Of Human And Animal Subjects

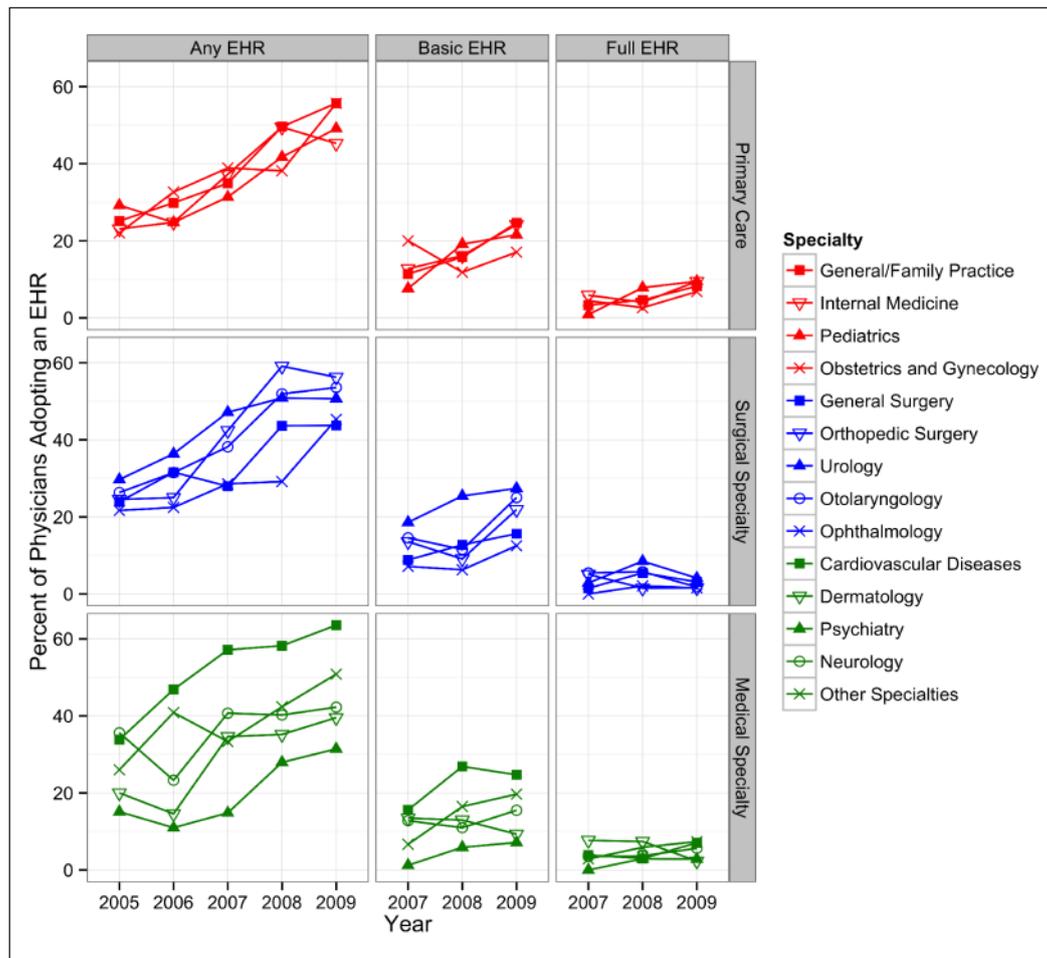
The National Center for Health Statistics Research Ethics Review Board approved the study. The Weill Cornell Institutional Review Board exempted from review our analysis of publicly available, de-identified data.

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**Fig. 1** Prevalence of EHR Adoption Among US Ambulatory Physicians, by Specialty, 2009. Empty symbols indicate the prevalence is lower than the smallest reliable estimate determined by the National Center for Health Statistics. Vertical lines illustrate average adoption for any EHR (dashed), basic EHR (dotted), and full EHR (dot-dash). Percentages have been adjusted for survey weights. Error bars indicate 1 SE.



**Fig. 2** Prevalence of EHR Adoption Among US Ambulatory Physicians, by Specialty, 2005–2009. Any EHR adoption data reflects the years 2005 – 2009, basic and full EHR adoption data reflect the years 2007–2009. Error bars are suppressed for readability. Percentages have been adjusted for survey weights.

**Table 1** Sample Size in Specialist Strata, Prevalence of Specialists, and Secular Trends in Distribution of Specialists Among US Ambulatory Physicians, NAMCS 2005–2009

Year	2005	2006	2007	2008	2009	Trend†
<b>Number of Physicians Surveyed</b>	1058	1220	1291	1188	1291	
<b>Specialty</b>	<b>Number of surveyed physicians in strata (representing this % of US ambulatory based physicians)</b>					
<b>Primary Care</b>	<b>376 (50.8%)</b>	<b>571 (49.9%)</b>	<b>581 (50.1%)</b>	<b>546 (52.1%)</b>	<b>568 (52.1%)</b>	<b>p = 0.87</b>
Family Medicine / General Practice	167 (18.7%)	249 (18.8%)	272 (18.3%)	260 (19.6%)	280 (19.6%)	p = 0.21
Internal Medicine	65 (15.3%)	117 (13.1%)	102 (13.8%)	100 (13.9%)	95 (13.9%)	p = 0.41
Pediatrics	89 (10.3%)	109 (10.2%)	118 (9.8%)	115 (10.5%)	116 (10.5%)	p = 0.57
Obstetrics and Gynecology	59 (7.1%)	98 (8%)	90 (8%)	76 (8.5%)	88 (8.5%)	p = 0.43
<b>Surgical Specialty</b>	<b>329 (21.9%)</b>	<b>301 (21.1%)</b>	<b>349 (22.6%)</b>	<b>303 (21%)</b>	<b>350 (21%)</b>	<b>p = 0.35</b>
General Surgery	67 (3.7%)	57 (3.5%)	68 (3.8%)	55 (3.6%)	64 (3.6%)	p = 0.21
Orthopedic Surgery	53 (4.7%)	56 (5%)	59 (5%)	66 (4.9%)	64 (4.9%)	p = 0.43
Urology	64 (2.1%)	55 (2.2%)	70 (1.9%)	59 (2.1%)	73 (2.1%)	p = 0.7
Otolaryngology	57 (2%)	54 (1.9%)	55 (1.9%)	52 (1.8%)	56 (1.8%)	p = 0.01
Ophthalmology	60 (4.2%)	49 (4.1%)	56 (4.1%)	48 (4.1%)	64 (4.1%)	p = 0.07
<b>Medical Specialty</b>	<b>353 (27.3%)</b>	<b>396 (29%)</b>	<b>427 (27.3%)</b>	<b>339 (26.9%)</b>	<b>373 (26.9%)</b>	<b>p = 0.47</b>
Cardiovascular Diseases	68 (4%)	79 (4.4%)	77 (4.1%)	67 (4.7%)	85 (4.7%)	p = 0.77
Dermatology	50 (2.2%)	48 (2.4%)	52 (2.6%)	54 (2.5%)	43 (2.5%)	p = 0.8
Psychiatry	86 (5.7%)	82 (5.7%)	81 (5.9%)	69 (5.6%)	70 (5.6%)	p = 0.21
Neurology	73 (2%)	73 (2.1%)	86 (2.3%)	82 (2.2%)	71 (2.2%)	p = 0.87
Other Specialties	100 (18.1%)	94 (16.9%)	105 (16.8%)	85 (16%)	122 (16%)	p = 0.66

† Modified Test of Correlation (see Methods)

Covariate	n in sample (representing this % of US ambulatory based physicians)
<b>Region</b>	
NorthEast	237 (18.9%)
MidWest	311 (21.9%)
South	435 (35.2%)
West	308 (23.9%)
<b>Office Setting</b>	
Private solo or group practice	1064 (88.7%)
Community health center	142 (3.8%)
HMO or other prepaid practice	26 (2.2%)
Other	19 (1.9%)
<b>Solo Practice</b>	
Solo Practice	406 (34.3%)
<b>Practice Owner</b>	
Physician or Physician Group	972 (80.6%)
HMO	26 (2.1%)
Community health center	142 (4.2%)
Medical or Academic Center	29 (2.7%)
Other	122 (10.4%)
<b>MD or DO</b>	
MD	1187 (93.4%)
DO	104 (6.6%)
<b>More Than 50% Of Revenue From These Insurers</b>	
Private insurance	398 (34.9%)
Medicare	191 (15.1%)
Medicaid	98 (6.7%)
Other	24 (1%)
Non Responder	50 (3.7%)
<b>More Than 50% Of Revenue From These Payment Models</b>	
Fee for service	717 (57.5%)
Discounted fee for service	238 (18.5%)
Capitation	49 (4%)
Case rates	18 (1.2%)
Other	29 (1.6%)
Non Responder	108 (8.4%)

**Table 2**

Sample Size and Prevalence of Covariates Used in Adjusted Regression Analyses

**Table 3** Unadjusted Odds Ratios of EHR Adoption in 2009, by Specialty, Using four definitions of EHR adoption.

Model Statistics	Any EHR	Basic EHR	Full EHR	EHR Sophistication
Omnibus test (Specialty vs Null Model)	Rao-Scott p = 0.02	Rao-Scott p = 0.03	Rao-Scott p = 0.02	Wald F <sub>13,1277</sub> = 2.7; p = 0.001
Significance of Model	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Family Medicine / General Practice	0.7 [0.4, 1.21]	0.78 [0.42, 1.46]	1.16 [0.49, 2.75]	0.74 [0.43, 1.26]
Internal Medicine	<b>0.6 [0.37, 0.97]*</b>	0.74 [0.42, 1.3]	1.02 [0.46, 2.25]	0.64 [0.39, 1.04]
Pediatrics	1.05 [0.62, 1.79]	0.6 [0.3, 1.17]	0.78 [0.28, 2.19]	0.88 [0.56, 1.38]
Obstetrics and Gynecology	0.57 [0.31, 1.03]	0.57 [0.26, 1.24]	0.3 [0.06, 1.41]	<b>0.55 [0.31, 0.97]*</b>
General Surgery	0.9 [0.5, 1.63]	0.67 [0.34, 1.35]	<b>0.09 [0.01, 0.7]*</b>	0.78 [0.48, 1.27]
Orthopedic Surgery	0.75 [0.43, 1.31]	1.03 [0.55, 1.92]	0.41 [0.11, 1.47]	0.8 [0.46, 1.37]
Urology	0.88 [0.47, 1.64]	0.95 [0.46, 1.96]	<b>0.1 [0.01, 0.75]*</b>	0.85 [0.49, 1.47]
Otolaryngology	<b>0.54 [0.3, 0.96]*</b>	<b>0.33 [0.14, 0.74]**</b>	<b>0.12 [0.02, 0.95]*</b>	<b>0.48 [0.29, 0.79]**</b>
Ophthalmology	1.14 [0.66, 1.96]	0.92 [0.49, 1.73]	0.63 [0.23, 1.7]	1.02 [0.64, 1.63]
Cardiovascular Diseases	<b>0.39 [0.2, 0.78]**</b>	<b>0.27 [0.09, 0.84]*</b>	0.15 [0.02, 1.18]	<b>0.36 [0.19, 0.7]**</b>
Dermatology	<b>0.34 [0.19, 0.62]***</b>	<b>0.18 [0.06, 0.49]***</b>	<b>0.22 [0.05, 0.97]*</b>	<b>0.31 [0.18, 0.54]***</b>
Psychiatry	<b>0.52 [0.28, 0.97]*</b>	<b>0.45 [0.21, 0.94]*</b>	0.39 [0.12, 1.24]	<b>0.5 [0.29, 0.86]*</b>
Neurology	0.64 [0.4, 1.04]	0.61 [0.34, 1.1]	0.58 [0.24, 1.44]	<b>0.63 [0.4, 0.99]*</b>
Other Specialties				

\* p<0.05; \*\* p<0.01; \*\*\* p<0.001

**Table 4** Adjusted Odds Ratios of EHR Adoption in 2009, by Specialty, Using four definitions of EHR adoption

Model Statistics	Any EHR	Basic EHR	Full EHR	EHR Sophistication
Omnibus test (Specialty and Covariates <sup>†</sup> Model vs. Covariates <sup>†</sup> Only Model)	Rao-Scott	Rao-Scott	Rao-Scott	Wald
Significance of Model	p = 0.004	p = 0.008	p = 0.02	F <sub>13,1253</sub> = 3.2; p<0.001
Primary Care	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Family Medicine / General Practice	0.77 [0.43, 1.39]	0.81 [0.39, 1.67]	1.54 [0.5, 4.73]	0.86 [0.47, 1.55]
Internal Medicine	<b>0.42 [0.24, 0.72]**</b>	<b>0.52 [0.27, 0.98]*</b>	0.87 [0.34, 2.23]	<b>0.46 [0.27, 0.79]**</b>
Pediatrics	0.92 [0.52, 1.61]	<b>0.46 [0.22, 1]*</b>	0.69 [0.19, 2.42]	0.78 [0.48, 1.26]
Obstetrics and Gynecology	<b>0.52 [0.27, 0.98]*</b>	0.51 [0.22, 1.21]	0.29 [0.07, 1.2]	<b>0.54 [0.29, 0.99]*</b>
Surgical Speciality	0.79 [0.41, 1.54]	0.49 [0.23, 1.04]	<b>0.07 [0.01, 0.66]*</b>	0.66 [0.38, 1.15]
General Surgery	0.78 [0.41, 1.48]	1.07 [0.52, 2.21]	0.39 [0.07, 2.08]	0.85 [0.46, 1.57]
Orthopedic Surgery	0.72 [0.36, 1.42]	0.74 [0.32, 1.71]	<b>0.06 [0.01, 0.62]*</b>	0.68 [0.37, 1.25]
Urology	0.62 [0.32, 1.23]	<b>0.34 [0.14, 0.82]*</b>	0.1 [0.01, 0.74]*	0.56 [0.31, 1.01]
Ophthalmology	1.34 [0.72, 2.49]	1.05 [0.53, 2.07]	0.83 [0.26, 2.68]	1.24 [0.74, 2.09]
Medical Speciality	<b>0.32 [0.15, 0.67]**</b>	<b>0.2 [0.06, 0.63]**</b>	0.11 [0.01, 1.03]	<b>0.31 [0.16, 0.6]**</b>
Cardiovascular Diseases	<b>0.23 [0.12, 0.45]***</b>	<b>0.1 [0.03, 0.34]***</b>	0.24 [0.06, 1.06]	<b>0.22 [0.12, 0.41]***</b>
Dermatology	0.6 [0.3, 1.18]	0.56 [0.26, 1.2]	0.54 [0.15, 2.04]	0.62 [0.34, 1.11]
Psychiatry	0.67 [0.4, 1.13]	0.61 [0.32, 1.16]	0.64 [0.24, 1.74]	0.66 [0.41, 1.06]
Neurology				
Other Specialities				

\* p<0.05, \*\* p<0.01; \*\*\* p<0.001

<sup>†</sup> Covariates include: region, office setting, solo practice (vs not), practice ownership, MD vs DO, revenue source, payment model

## Rereference

1. National Ambulatory Medical Care Survey, 2005 Codebook. Ann Arbor, Michigan: Inter-University Consortium for Political and Social Research 2005.
2. National Ambulatory Medical Care Survey, 2006 User Guide. Ann Arbor, Michigan: Inter-University Consortium for Political and Social Research 2006.
3. National Ambulatory Medical Care Survey, 2007 User Guide. Ann Arbor, Michigan: Inter-University Consortium for Political and Social Research 2007.
4. National Ambulatory Medical Care Survey, 2008 User Guide. Ann Arbor, Michigan: Inter-University Consortium for Political and Social Research 2008.
5. Health Information Technology for Economic and Clinical Health Act. [waysandmeans.house.gov/media/pdf/111/hitech.pdf](http://waysandmeans.house.gov/media/pdf/111/hitech.pdf) (19 April 2012).
6. National Ambulatory Medical Care Survey, 2009 User Guide. Ann Arbor, Michigan: Inter-University Consortium for Political and Social Research 2009.
7. Inter-University Consortium for Political and Social Research. [www.icpsr.umich.edu/](http://www.icpsr.umich.edu/) (21 April 2012).
8. The Official Web Site for the Medicare and Medicaid Electronic Health Records (EHR) Incentive Programs. [www.cms.gov/ehrincentiveprograms/](http://www.cms.gov/ehrincentiveprograms/) (19 April 2012).
9. Blumenthal D. Stimulating the adoption of health information technology. *The New England journal of medicine* 2009; 15: 1477-1479. doi: 10.1056/NEJMp0901592.
10. Blumenthal D, Tavenner M. The "meaningful use" regulation for electronic health records. *N Engl J Med* 2010; 6: 501-504. doi: 10.1056/NEJMp1006114.
11. Bramble JD, Galt KA, Siracuse MV, Abbott AA, Drincic A, Paschal KA, Fuji KT. The relationship between physician practice characteristics and physician adoption of electronic health records. *Health Care Manage Rev* 2010; 1: 55-64. doi: 10.1097/HMR.0b013e3181c3f9ad.
12. Burt CW, Sisk JE. Which physicians and practices are using electronic medical records? *Health Aff (Millwood)* 2005; 5: 1334-1343. doi: 10.1377/hlthaff.24.5.1334.
13. Chiang MF, Boland MV, Margolis JW, Lum F, Abramoff MD, Hildebrand PL. Adoption and perceptions of electronic health record systems by ophthalmologists: an American Academy of Ophthalmology survey. *Ophthalmology* 2008; 9: 1591-1597; quiz 7 e1-5. doi: 10.1016/j.ophtha.2008.03.024.
14. Damico A. Transitioning to R: Replicating SAS, Stata, and SUDAAN Analysis Techniques in Health Policy Data. *The R Journal* 2009; 2.
15. DesRoches CM, Campbell EG, Rao SR, Donelan K, Ferris TG, Jha A, Kaushal R, Levy DE, Rosenbaum S, Shields AE, Blumenthal D. Electronic health records in ambulatory care--a national survey of physicians. *N Engl J Med* 2008; 1: 50-60. doi: 10.1056/NEJMs0802005.
16. Esper GJ, Drogan O, Henderson WS, Becker A, Avitzur O, Hier DB. Health information technology and electronic health records in neurologic practice. *Neurol Clin* 2010; 2: 411-427. doi: 10.1016/j.ncl.2009.11.014.
17. Ferrante JM, Balasubramanian BA, Hudson SV, Crabtree BF. Principles of the patient-centered medical home and preventive services delivery. *Annals of family medicine* 2010; 2: 108-116. doi: 10.1370/afm.1080.
18. Fox J, Weisberg S. *An R Companion to Applied Regression*, Second Edition. Thousand Oaks, CA: Sage 2011.
19. Grosshandler JA, Tulbert B, Kaufmann MD, Bhatia A, Brodell RT. The electronic medical record in dermatology. *Arch Dermatol* 2010; 9: 1031-1036. doi: 10.1001/archdermatol.2010.229.
20. Holroyd-Leduc JM, Lorenzetti D, Straus SE, Sykes L, Quan H. The impact of the electronic medical record on structure, process, and outcomes within primary care: a systematic review of the evidence. *J Am Med Inform Assoc* 2011; 6: 732-737. doi: 10.1136/amiajnl-2010-000019.
21. Hsiao C, Hing E, Socey T, Cai W. Electronic Health Record Systems and Intent to Apply for Meaningful Use Incentives Among Office-based Physician Practices: United States, 2001-2011. NCHS Data Brief, no 79. National Center for Health Statistics 2011.
22. Kaliyadan F, Venkitakrishnan S, Manoj J, Dharmaratnam AD. Electronic medical records in dermatology: practical implications. *Indian J Dermatol Venereol Leprol* 2009; 2: 157-161.
23. Kemper AR, Uren RL, Clark SJ. Adoption of electronic health records in primary care pediatric practices. *Pediatrics* 2006; 1: e20-e24. doi: 10.1542/peds.2005-3000.
24. Kern LM, Malhotra S, Barron Y, Quaresimo J, Dhopeswarkar R, Pichardo M, Edwards AM, Kaushal R. Accuracy of electronically reported "meaningful use" clinical quality measures: a cross-sectional study. *Annals of internal medicine* 2013; 2: 77-83. doi: 10.7326/0003-4819-158-2-201301150-00001.
25. Kootte RS, Stuijver DJ, Dekkers OM, van Zaane B, Fliers E, Cannegieter SC, Gerdes VE. The incidence of venous thromboembolism in patients with overt hyperthyroidism. A retrospective multicentre cohort study. *Thrombosis and haemostasis* 2012; 3. doi: 10.1160/TH11-10-0691.

26. Li C. Use of health information technology by office-based physicians: comparison of two contemporaneous public-use physician surveys. *Perspect Health Inf Manag* 2011; 1f.
27. Linney B. Cardiology practice proves that electronic medical records do raise revenue. *Physician Exec* 2003; 3: 34-36.
28. Lumley T. Analysis of complex survey samples. *Journal of Statistical Software* 2004; 1: 1-19.
29. Lumley T. *Complex Surveys: A Guide to Analysis Using R* Hoboken, NJ: John Wiley & Sons, Inc. 2010.
30. Lumley T. survey: analysis of complex survey samples. R package version 3.28-2. 2012.
31. Menachemi N, Brooks RG. EHR and other IT adoption among physicians: results of a large-scale state-wide analysis. *J Healthc Inf Manag* 2006; 3: 79-87.
32. Menachemi N, Powers T, Au DW, Brooks RG. Predictors of physician satisfaction among electronic health record system users. *J Healthc Qual* 2010; 1: 35-41.
33. Menachemi N, Powers TL, Brooks RG. Physician and practice characteristics associated with longitudinal increases in electronic health records adoption. *J Healthc Manag* 2011; 3: 183-197; discussion 97-98.
34. Patil M, Puri L, Gonzalez CM. Productivity and cost implications of implementing electronic medical records into an ambulatory surgical subspecialty clinic. *Urology* 2008; 2: 173-177. doi: 10.1016/j.urolgy.2007.09.024.
35. Peterson D, Wickeham D. New challenge for academic psychiatry: the electronic health record. *Acad Psychiatry* 2011; 2: 76-80. doi: 10.1176/appi.ap.35.2.76.
36. Pham HH, O'Malley AS, Bach PB, Saiontz-Martinez C, Schrag D. Primary care physicians' links to other physicians through Medicare patients: the scope of care coordination. *Annals of internal medicine* 2009; 4: 236-242.
37. AAP Division of Pediatric Practice. AAP Engaging Regional Extension Centers to Support Members in Adoption of EHRs. *AAP News* 2011; 12.
38. Rao JNK, Scott AJ. The Analysis of Categorical Data From Complex Sample Surveys: Chi-Squared Tests for Goodness of Fit and Independence in Two Way Tables. *Journal of the American Statistical Association* 1981; 374: 9.
39. Robinson JC, Casalino LP, Gillies RR, Rittenhouse DR, Shortell SS, Fernandes-Taylor S. Financial incentives, quality improvement programs, and the adoption of clinical information technology. *Med Care* 2009; 4: 411-417. doi: 10.1097/MLR.0b013e31818d7746.
40. Rogers EM. *Diffusion of Innovations*. New York, NY: Free Press 2003.
41. Salomon RM, Blackford JU, Rosenbloom ST, Seidel S, Clayton EW, Dilts DM, Finder SG. Openness of patients' reporting with use of electronic records: psychiatric clinicians' views. *J Am Med Inform Assoc* 2010; 1: 54-60. doi: 10.1197/jamia.M3341.
42. Simon SR, McCarthy ML, Kaushal R, Jenter CA, Volk LA, Poon EG, Yee KC, Orav EJ, Williams DH, Bates DW. Electronic health records: which practices have them and how are clinicians using them? *AMIA Annu Symp Proc* 2006: 1097.
43. Spooner SA. Special requirements of electronic health record systems in pediatrics. *Pediatrics* 2007; 3: 631-637. doi: 10.1542/peds.2006-3527.
44. Starr JC. Integrating digital image management software for improved patient care and optimal practice management. *Dermatol Surg* 2006; 6: 834-840. doi: 10.1111/j.1524-4725.2006.32169.x.
45. R Development Core Team. *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing 2011.