



Electronic health record use-diffusion patterns and eSharing of health information among US office-based physician practices[☆]



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ABSTRACT

Background: The use of some computerized capabilities (CCs) that support eligibility for meaningful use incentive has lagged despite an increase in Electronic Health Record adoption.

Purpose: This study described the use-pattern of CC among office-based physician practices by applying the Use-Diffusion model (UD); to identify CCs that support the Stage 1 core objectives for meaningful use, and to predict their effect on eSharing of health information.

Methods: Data from the United States 2013 National Ambulatory Medical Care Survey was used, and four use-patterns based on the variety and frequency of CC use were identified. Logistic regression was used to assess factors related to the use of a low variety of CC, and factors predictive of eSharing of health information.

Results: The unweighted sample of 2444 physician practices reported at least one computerized capability. The unweighted proportion of each UD group was 53%, 20%, 15% and 12% representing the intense, non-specialized, specialized, and limited groups respectively. Only 5.3% in the specialized and 8.9% in the limited UD groups reported the ability to provide electronic access to patients in 2013. Provision of email/internet patient consult and having an increasing number of CCs were predictive of eSharing of health information.

Conclusions: The use-diffusion model can describe office-based physician practices' use-pattern of EHR capabilities, and the characteristics that differentiate the groups. Solo and specialty practices may lag in their readiness to meet the Stage 1 meaningful use objectives, both in the variety of capabilities and the frequency of use to qualify for incentive payments.

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Introduction

The passage of the Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009 instituted by the United States government's support broad adoption and use of electronic health record (EHR). The HITECH Act provides payment incentives for physicians who implement and meet the EHR technology "meaningful use (MU) objectives." The objectives require that physicians demonstrate meaningful use of specific EHR capabilities determined to increase efficiency, patient engagement and quality care, such as reminders for patient follow-ups and preventive care, clinical decision support, computerized physician order, e-prescribing and clinical summary of care [1]. The impetus for the US Federal Government incentive for adoption and use of EHR in clinical practice is driven by the belief that EHR use will

improve the quality and safety of care while also reducing the cost of care [2]. The MU incentive program is implemented in three stages, each with specific objectives, measures, and standards that hospitals and eligible professionals must meet to qualify for incentive payments. MU Stage 1 objectives focus on the implementation and use of basic capabilities of EHR, while subsequent MU stages 2 and 3 focus on EHR use for advance clinical process, information exchange, decision support and their consequent effect on outcomes [3,4]. The Center for Medicare and Medicaid Services (CMS) revises and modifies the MU objectives and measures that eligible providers must attest to qualify for payment incentives periodically [5,6]. This can influence how providers use their EHR if they are inclined to use EHR capabilities that align with incentive payments. Since 2009, office-based physicians that reported basic EHR has increased steadily from 21.8% to 53.9% in 2015, and report of certified EHR has also increased [7]. This shows that a substantive number of office-based physicians have an EHR system with the requisite capabilities to help them meet the meaningful use criteria necessary to qualify for payment incentives [8]. However, previous research suggests that EHR adoption and use lag among

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small physician practices, older physicians, and non-primary care physicians [9].

Additionally, a 10% gap in EHR adoption rate between large physician practices and small ones has been reported [10]. EHR can improve care coordination and reduce fragmentation of care, facilitated by the timely sharing of health information among care providers [2,11]. Physician practices that lagged in their adoption and use of EHR may also lag in realizing these benefits.

MU Stage 1 objectives measured basic EHR capabilities and focused on providers capturing and sharing patient data. Understanding the patterns of use of EHR capabilities that align with MU Stage 1, will help to illustrate why certain practices lagged and indicate how they will perform on Stages 2 and 3. How clinical practices use EHR, specifically in terms of the types of capabilities and the frequency of use after its adoption is relevant to understanding the impact of EHR on care practices and outcomes. Physician practice that uses few and only the basic capabilities of an EHR may not demonstrate improvement on a quality score that measures advance EHR capabilities. Other factors that may influence how EHR capabilities are used include the level of technical skills, preferences, and the user's needs [11,12]. The objective of this research is to apply the use-diffusion model in describing the use-patterns of EHR capabilities that align with MU Stage 1 among office-based physician practices; determine factors predictive of use-patterns and assess their effects on eSharing of health information. We hypothesize that physician practices that used a high number of EHR capabilities frequently would be more likely to share health information electronically (eShare).

In this paper, we will highlight the methods employed, including an outline of the use-diffusion model to describe the use-pattern of computerized capabilities that support the core objectives for Meaningful Use Stage 1 among office-based physician practices. We then described the survey data and the statistical methods used. The results, discussion of the results, study limitations, and the conclusions are also presented in order.

Methods

In this section, we present the theoretical framework for the use-diffusion model, describe the survey data analyzed, and discuss the statistical methods used in the analyses.

Theoretical framework

The use diffusion (UD) model that guided this study differs from the adoption diffusion (AD) model because it focuses on the use of innovation while AD focuses on the rate of adoption [13]. UD measures the use of innovation in terms of the variety and frequency or rate of use. In various fields, the application of the UD model to determine the use-pattern of technologies post-adoption and subsequent impact is well established [14–18]. The UD model recognizes that users' positive or negative experience with technology, in general, can influence how they use a technological innovation [13]. Contrasting the UD framework with the Technology Acceptance Model (TAM) framework for understanding EHR adoption, the TAM focuses on factors impacting the acceptance and usage of technologies while the UD focuses on the evolving nature of use. Particularly, two factors have been proven to have a significant impact on the TAM: the perceived usefulness and perceived ease of use [19]. In a review of over 20 studies, Holden and Karsh (2009) stated the following to point out the need for new models: "TAM predicts a substantial portion of the use or acceptance of health IT, but that the theory may benefit from several additions and modifications to better understand the adoption and continuous

use after adoption." The UD framework, on the other hand, explains that rate and variety of technology usage are influenced by determinants, which can subsequently influence the outcomes of use. Consequently, UD is a suitable model for assessing EHR use in this study as the MU objectives, measures, and standards require providers to use varieties of EHR capabilities consistently to influence care outcomes.

The UD model has three components, the 'UD determinants,' 'UD patterns,' and the 'UD outcomes' (Fig. 1) [13]. The model also describes four dimensions of UD determinants: the social context which the user operates (e.g., competition for use where there are multiple users); the technological dimension (e.g. the sophistication of the technology and use of complementary technologies); the personal dimension (e.g., users' creative use of the technology and the level of satisfaction users derive) and lastly, the dimension of external factors that can influence use [13,20]. Specific for this study, the factors that related to these dimensions and included as UD determinants are characteristics of the practice, such as specialty and ownership; the sophistication of the practice in their use of complementary technologies; business needs and response to external demands. The UD patterns are presented as four typologies based on the 'variety of use,' which refers to the different ways the technology is used and the 'rate of use' that refers to how often it is used. The UD patterns are identified as four groups of users. The Intense user, Nonspecialized user, Specialized user, and Limited user (Fig. 1). We acknowledge that these patterns are temporal as the rate and variety of use are dynamic, and users can move across typologies. Nevertheless, the UD model is well suited to guide our understanding of how physician practices use EHR and its many capabilities following EHR adoption in this era of meaningful use.

Data

The data for this study was derived from the 2013 National Ambulatory Medical Care Survey (NAMCS), a US annual national survey of ambulatory care providers [21]. The Centers for Disease Control and Prevention's National Center for Health Statistics conducts an annual, nationally representative survey of office-based physicians, and collects information on physician and practice characteristics, including the adoption and use of EHR systems. The universe of NAMCS physicians comprises those classified as providing direct patient care in nonfederal office-based practices, as well as clinicians in community health centers excluding radiologists, anesthesiologists, and pathologists. The 2013 NAMCS used a two-stage probability design that involved probabilistic samples of physicians within targeted States/Census divisions, and patient visits within practices. The sample consisted of 11,212 physicians. Of the 6,999 eligible physicians, data was collected from 2,705 who participated in the study. The physician-level response was 39.1% (this represents the successful collection of data in the Physician Induction Interview). Physicians that provided data for at least one sampled visit was included in the public use data file and used for this current study, weighted for national representativeness.

Survey items related to (EHR) computerized capabilities were modified in 2013 to measure capabilities that align with MU Stage 1 objectives. New items were added, and some deleted [21]. Added items related to the meaningful use objectives include "Does your current system meet meaningful use criteria as defined by the Department of Health and Human Services?" "When did you first apply or when do you first intend to apply for Meaningful Use?" and "Can EHR provide patients the ability to view online, download, or transmit information from their medical record?" Information on twenty-four EHR computerized capabilities is presented in Table A1.

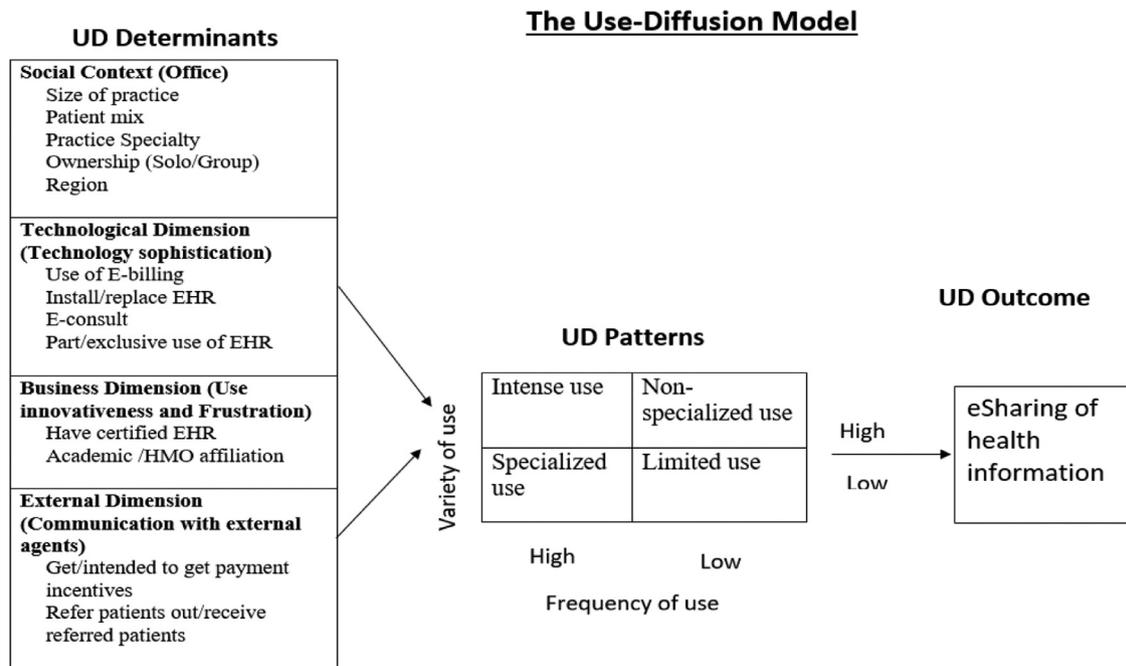


Fig. 1. The UD components and determinants of EHR use patterns among office-based physician practices in 2013.

Statistical analysis

Participants in the survey were asked to indicate whether the participating physician practice has the twenty-four computerized capabilities assessed in this study and how often they were used. The response options were ‘Yes, used routinely,’ ‘Yes, but NOT used routinely,’ ‘Yes, but turned off/not used,’ ‘No,’ and ‘Unknown.’ To determine the variety of the capabilities reported, we obtained the overall mean of the sums of computerized capabilities reported as ‘Yes’ by each participating practice. Physician practices with sum of reported computerized capabilities greater than or equal to the overall mean were classified as having high variety, otherwise low. Similarly, we obtained the overall mean of the sums of the scores for how frequent the capabilities reported were used (routine=1, non-routine=2, not used=3) to determine the frequency of use. Physician practices with the mean score less than or equal to the overall mean were categorized as high-frequency users, otherwise low. We identified four categories of users, also referred to as UD groups in this study. The groups are the “Intense users”, use of high variety of EHR capabilities at high frequency; “Nonspecialized users”, use of high variety of EHR capabilities at low frequency; “Specialized user”, use of low variety of EHR capabilities at high frequency; and “Limited user”, use of low variety of EHR capabilities at low frequency. The response to the survey question “Do you share any patient health information electronically (not fax) with other providers; including hospitals, ambulatory providers, or labs?” was used to assess eSharing of health information, which is the outcome measured in this study

We compared the characteristics of the four UD groups (intense users, nonspecialized users, specialized users, and limited users) using Chi-square tests. The analysis was conducted with the use of SAS software, version 9.4. Procedures that accounted for the complex survey design were used and analyses weighted to derive national estimates. We assessed the univariate and bivariate relationships in the data and used logistic regression to model the characteristics associated with the two dimensions, variety, and frequency of use. We modeled having a low variety of computerized capabilities, having a high variety of computerized capabilities was the reference.

Similarly, we modeled low-frequency use of reported computerized capabilities, with high-frequency use as the reference. We also modeled reported eSharing of health information as a UD outcome. In this model, we included the UD determinants and the UD patterns (Fig. 1) in the logistic regression model. We described EHR use-patterns that suggest the readiness of office-based practices to be eligible for the EHR incentive program for MU Stage 1. We also conducted a sensitivity analysis to check whether the use-diffusion patterns were consistent with groups obtained in cluster analysis. The Kappa test (0.366) indicated a fair agreement between the four UD groups and the four groups obtained in cluster analysis.

Results

The unweighted sample of physician practices was 2,705, of which 2,444 reported at least one computerized capability (CC) and were included in the analysis. Descriptive analyses showed that unweighted proportion of each use-diffusion group was 53%, 20%, 15% and 12% representing the intense use (high variety-high frequency); non-specialized use (high variety-low frequency); specialized use (low variety-high frequency); and limited, (low variety-low frequency) groups respectively (Table 1). Of the criteria to meet the meaningful use objectives for EHR incentive in 2013, the percentage of office-based practices that reported each computerized capability ranged between 89% and 100% for the intense UD group, 86% and 100% for the non-specialized UD group, 22.7% and 98.7% for the specialized UD group, and 22.3% and 96% for the limited UD group. Reporting of the capability to provide patients with an electronic copy of their health information was low across all groups relative to other capabilities. The proportion of limited and specialized UD groups that reported CCs required to meet the objectives for EHR incentive programs for Meaningful Use Stage 1 was lower for both Intense and Non-specialized UD groups. Only 5.3% of office practices in the specialized and 8.9% in the limited UD groups reported the ability to provide patients electronic access to their information in 2013.

Characteristics that differentiated the use-diffusion groups include practice structure, types of specialty and reported use of an EHR, and having EHR that meets the meaningful use criteria.

Table 1
The percentage of office-based practices in the US that reported computerized capabilities that meet the meaningful use objectives by use diffusion groups.

Meaningful Use Stage 1 Objectives	Use Diffusion groups*			
	Intense (n = 1291)	Non-Specialized (n = 488)	Specialized (n = 339)	Limited (n = 261)
Eligible Professionals Meaningful use objectives for EHR Incentive Programs in 2013				
Use Computerized Physician Order Entry (COPE) for medication orders directly entered by any licensed healthcare professional who can enter orders into the medical record per state, local and professional guidelines	99.9	99.0	63.1	57.0
Implement drug-drug and drug-allergy interaction checks†	99.1	98.0	79.6	66.7
Maintain an up-to-date problem list of current and active diagnoses.	99.9	99.5	69.7	70.8
Generate and transmit permissible prescriptions electronically (eRx) †	99.0	97.4	89.7	93.1
Maintain active medication list and allergy list	100.0	99.7	98.7	96.0
Maintain active medication allergy list				
Record of patient history and demographics	100.0	100.0	82.1	70.2
Record and chart changes in vital signs	99.5	98.6	46.9	52.0
Record smoking status for patients 13 years old or older	99.5	99.8	55.8	47.5
Report ambulatory clinical quality measures to CMS, or in the case of Medicaid EPs, the States. (No longer core objective but still required)	94.7	91.8	27.3	22.3
Implement one clinical decision support (CDS) rule relevant to specialty or high clinical priority along with the ability to track compliance with that rule	92.6	92.4	30.6	25.8
Provide patients with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, medication allergies) upon request	89.0	86.7	22.7	27.8
Provide clinical summaries for patients for each office visit	97.6	93.8	36.4	35.4
Protect Patient Health Information (Protect electronic created or maintained by the certified EHR through appropriate technical capabilities)	NA‡	NA‡	NA‡	NA‡
Health Information Exchange (Provide summary of care record)	NA‡	NA‡	NA‡	NA‡
Patient Specific Education (Identify educational resources)	91.4	84.8	25.4	33.1
Medication Reconciliation (Reconcile patients' medications)	99.3	98.4	50.1	49.2
Patient Electronic Access (Patient's ability to view online and download their health information)	63.4	65.6	5.3	8.9
Public Health Reporting (Submit electronic data to immunization, syndromic surveillance data to registries)	77.7	70.1	12.8	11.4

* Intense, reported high variety-high frequency use of computerized capabilities (CC); Non-specialized, reported high variety-low frequency use; Specialized use, reported low variety-high frequency use; Limited, low variety-low frequency use.

† The estimates for these objectives are based on a subset of office practices that reported CPOE.

‡ These objectives were not evaluated in this study.

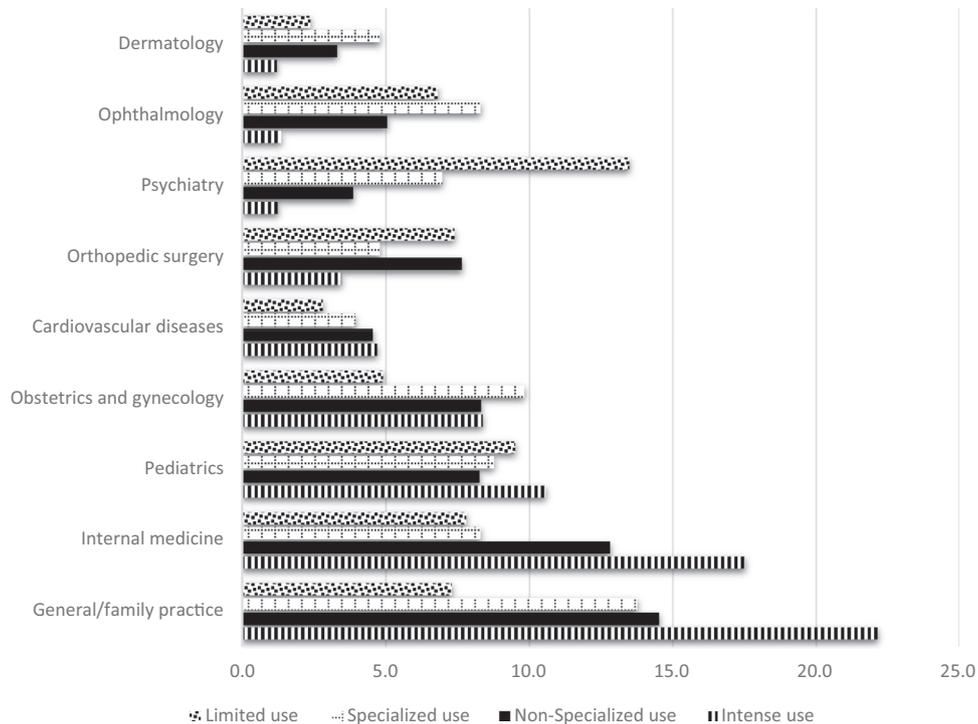


Fig. 2. Distribution of physician specialties by use-diffusion groups.

There were more solo practices in the limited use group (52.8%) than in the intense use group (21.4%). Reported exclusive use of EHR is highest in the intense use group (90.9%) and lowest in the limited use group (20.4%). Office-based practices in the intense use group applied for the meaningful use incentives early, 32.7% compared to 9.1% in the limited use group (Table A2).

The analysis that assessed the distribution of office practice specialties by use-diffusion groups showed that psychiatry, pediatrics, ophthalmology, and orthopedic practices are more common in the limited use group while general family and internal medicine practices are more common in the intense use group (Fig. 2).

Table 2
Factors associated with reported and use of a low variety of computerized capabilities.

Category	Odds Ratios	95% Confidence Limits		P-value
Practice use EHR*				
Yes, part paper, part electronic	4.53	3.00	6.83	<0.0001
No	13.71	5.47	34.41	<0.0001
Unknown	0.86	0.16	4.56	0.86
Specialty†				
Surgical care specialty	2.36	1.58	3.51	<0.0001
Medical care specialty	3.08	1.93	4.92	<0.0001
Practice type‡				
Solo	1.22	0.83	1.78	0.32
Current EHR system meets the meaningful use criteria‡				
No	3.07	1.50	6.28	0.00
Unknown	4.51	2.26	9.02	<0.0001
Receive electronic medical reports on patients referred to practice‡				
No	2.27	1.52	3.39	<0.0001
Unknown	2.30	0.39	13.62	0.36
To install new or replace old EHR‡				
No	0.56	0.33	0.93	0.03
Maybe	0.74	0.30	1.78	0.50
Unknown	0.45	0.15	1.39	0.16
To apply for incentive payments§				
Yes, we intend to apply	2.78	1.75	4.40	<0.0001
Uncertain if we will apply	3.06	1.87	5.00	<0.0001
No, will not apply	6.30	3.70	10.71	<0.0001
Unknown	2.15	0.82	5.64	0.12
Submit claims electronically ‡				
No	1.48	0.75	2.93	0.26
Unknown	1.69	0.65	4.38	0.28
Email/internet patient consult ‡				
No	2.03	1.22	3.39	0.01
Unknown	1.56	0.59	4.10	0.37
Revenue from Case rate§				
26%–50%	0.54	0.06	4.81	0.58
51%–75%	0.19	0.03	1.09	0.06
76%–100%	2.54	0.76	8.55	0.13
Unknown	0.67	0.44	1.04	0.07

Reference Category:

* Yes, only electronic

† Primary care

‡ Non-solo

‡ Yes

§ Yes, have applied

§ 0%–25%.

The UD outcome assessed in this study was eSharing of health information. Of the 2,444 office practices that reported at least one computerized capability, 2,438 provided response to the eSharing survey question, 47% reported eSharing, while 53% did not. Office-based practices that reported eSharing also tend to report a high variety of computerized capabilities. The overall mean number of computerized capabilities was 16.2, (95% Confidence Intervals (CI) for Mean 15.8–16.6), the mean for practices that reported eSharing of patient's health information was 21.1, (95% CI 20.8–21.4) compared to 12.6, (95% CI 12.0–13.2) for practices that did not.

Adjusted analyses evaluated the factors that were associated with the report of low variety and non-routine use of reported computerized capabilities. Reported no use of EHR (Odds Ratio (OR) 13.71, Confidence Interval (CI) 5.47–34.41) and non-exclusive use of EHR (OR 4.53; CI 3.00–6.83) were associated with reporting a low variety of reported computerized capabilities. Medical care specialty practice compared to primary care practice have higher odds of having reported low variety of computerized capabilities (OR 3.08; CI 1.93–4.92); and non-routine use of the capabilities (OR 2.30; CI 1.68–3.15). Other associated factors were solo practice and not receiving electronic medical reports on referred patients (Table 2).

Adjusted analysis that assessed the factors that were associated with eSharing of health information showed that increasing

number of reported capabilities (OR 1.18; CI 1.10–1.27) was associated with eSharing of patients' health information with other care providers. Other factors included providing email/internet patient consult (OR 1.55; CI 1.05–2.28), medical/ academic or health plan owned practices, receiving eReport for referred patients, and being in the West geographic region compared to the South (Table 3). There was no statistically significant difference between the UD groups with regards to eSharing of health information.

Discussion

The discussion will focus on three areas, the hypothesis for the study, the dimensions of UD determinants- the UD groups, and the use-pattern of EHR capabilities that support Meaningful use (MU) Stage 1 objectives. This study adds to the current literature on how computerized capabilities are used among office-based physician practices in the "meaningful use" era in the US [8]. It applied the use-diffusion model to explain the use-patterns of computerized capabilities that support Stage 1 MU objectives after adoption and their relationship with eSharing of health information. Our hypothesis that practices that used high numbers of EHR capabilities routinely will be more likely to eShare health information was not supported by the results. The eSharing of health information was not significantly different in the Intense UD group from the Limited UD group. In this study, activities for patient referral were predictors of eSharing. This may explain why the hypothesis was not supported as specialty practices are represented in higher proportions in the Limited UD group than the Intense UD group. Specialty practices like orthopedic, dermatologic, and psychiatric depend on patient referrals for their patient volume and have seen a significant increase in referral rates in recent years [22]. The use of EHR capabilities for referral related activities was comparable for both the Intense and Limited UD groups (See Table A2). Moreover, specialty practices may be influenced to use the computerized capabilities that align with those used by their patient referral sources to facilitate a smooth transition. Hence, making their use of eSharing of health information similar to the referral sources, which often are primary care practices.

This study identified four use-patterns of computerized capabilities among physician practices based on a variety of use (high and low) and frequency of use (high and low). The intense use and limited use are on the extremes. The specialized and non-specialized use groups are more nuanced. Intense use group comprised mostly of general practices while limited use group comprised of specialty practices (psychiatry, orthopedic, and pediatrics). The UD determinants that differentiated the UD groups include practice ownership, providing consult with patients via email, and exclusive use of EHR (no additional use of a paper-based system increased the variety and frequency of use). In addition, having a plan to apply for meaningful use incentives, receiving and sending eReport of patient's information, and in particular, the reported use of an EHR. Reported EHR use was 20% in the Limited UD group compared to 91% in the Intense UD group. This finding is consistent with prior studies' suggestion that small practices' adoption rates of EHR are lower [7,10,12]. The challenge for small practices to fund the initial purchase costs of an EHR, the operational costs of implementation, and having the requisite skills to use the EHR capabilities may explain why solo practices used few varieties of computerized capabilities, and non-routinely [23–25].

The results shows that the use -patterns of computerized capabilities that support MU Stage 1 shows that the intense UD group (mainly primary care physicians) in comparison to the limited and specialized UD groups (mainly specialty and small/solo practices) give them an advantage in qualifying for meaningful use financial

Table 3

Factors associated with eSharing of patients' information among office-based physician practices.

Categories	Odds Ratios	95% Confidence Limits		P-value
Use-diffusion groups*				
Intense users	1.26	0.47	3.37	0.6461
Non-specialized users	1.25	0.50	3.18	0.633
Specialized users	1.13	0.50	2.57	0.7698
Routine use of EHR capabilities†	0.54	0.23	1.25	0.1506
Number of reported computerized capabilities	1.18	1.10	1.27	<0.0001
Received medical reports on patients referred to practice±	1.24	0.88	1.76	0.2182
Received eReport on patients referred to practice±	1.70	1.18	2.46	0.0044
Referred patients to provider outside practice±	0.53	0.30	0.96	0.0356
Received eReport on patients referred out of practice±	2.36	1.70	3.27	<0.0001
Provide email/internet patient consult±	1.55	1.05	2.28	0.026
Submit claims electronically±	0.82	0.41	1.63	0.563
Ordered lab test electronically±	1.38	0.95	1.99	0.0907
Reminders for guideline-based interventions or screening tests±	1.01	0.67	1.52	0.9566
Electronic reporting to immunization registries±	0.75	0.54	1.04	0.0879
Warnings of drug interactions or contraindications provided when ordering prescriptions±	0.38	0.22	0.66	0.0006
Practice have EHR±				
Yes, all electronic	1.60	1.05	2.45	0.0296
Yes, part paper, part electronic	1.14	0.50	2.58	0.7534
Plan to apply for incentive payments±				
Yes, have applied	1.842	0.53	6.405	0.3365
Yes, we intend to apply	1.475	0.397	5.483	0.562
Uncertain if we will apply	2.678	1.372	5.225	0.0039
Ownership type‡				
Medical/Academic health center and CHC	3.08	1.84	5.14	<0.0001
Insurance company, health plan, or HMO	2.71	1.85	3.98	<0.0001
Geographic Region§				
Midwest	1.28	0.92	1.79	0.1405
Northeast	1.17	0.82	1.68	0.3831
West	1.59	1.09	2.31	0.0165
Year first applied or intend to apply for payment incentives§				
2011	0.93	0.33	2.58	0.882
2012	0.78	0.28	2.16	0.6341
2013	0.76	0.28	2.05	0.5817
Patient care revenue comes from managed care contracts**				
26%–50%	0.87	0.63	1.20	0.397
51%–75%	1.03	0.68	1.57	0.8921
76%–100%	0.90	0.34	2.34	0.8222
Percent of patient care revenue comes from Medicare**				
26%–50%	1.75	0.49	6.25	0.386
51%–75%	0.05	0.01	0.41	0.0059
76%–100%	0.19	0.04	0.87	0.0326
Percent of patient care revenue comes from Capitation **				
26%–50%	1.07	0.55	2.11	0.8371
51%–75%	0.90	0.27	3.02	0.8634
76%–100%	0.24	0.09	0.67	0.0062

Reference Category:

* Limited user

† 1=routine use, 3= no-use

± No

‡ Physician or physician group

§ South

§ 2014 or later

** 0%–25%

incentives [26]. This study observed a potential lag in the readiness of the limited and specialized UD groups to qualify for MU Stage 1 payment incentives, especially in the use of capabilities for reporting to external agencies and providing patients access to their records. This suggests that practices in these groups may not be realizing the full benefits EHR offers, importantly, in the opportunity to involve patients more in their care [27]. This also suggests that these small office practices may have other challenges that may impact how they deliver care to their patients [28].

Limitations

The variables used in this study were limited to what was available in the NAMCS public use data file. The inclusion of other potential UD variables, such as the use of complementary technologies (e.g., eScheduling, online check-in, etc.), user experience, and level of satisfaction with use could influence not only the UD pat-

terns but also the characteristics of the groups that emerged. Business use of technologies often aligns with the specific business and compliance requirements with external agencies [13].

Another important limitation is that the policy assessed and the data analyzed in this study are US-based, and the findings mostly apply to US providers and policymakers, and may not be generalized to other countries. However, the results can inform researchers and policymakers globally on the pattern of use of new technologies

We did not assess this context in this study and could not determine whether the variety and frequency of computerized capabilities used are affected by the specific business requirements of the practice. For instance, practices in urban areas that serve predominantly technologically-savvy patients may be more inclined to invest in a comprehensive EHR system with higher varieties of computerized capabilities or use them more frequently in their operations.

Conclusion

Despite the limitations, this study provides significant practical and policy implications. In terms of policy implications, successful implementation of the MU incentive strategy by the providers depends on their use of an EHR and related computerized activities. Therefore, our results presented for the Stage 1 MU sheds light on the use of computerized capabilities that supports Stage 2 MU. In addition, the results of this study show a substantial opportunity to further evaluate the reasons behind different use-patterns, especially the low use of EHR capabilities in specialty practices and eSharing across all types of physician practices. A better understanding of the reasons associated with low usage of EHR capabilities implies practical solutions that would improve EHR usage and hence improvements in quality and safety of care, with related reductions in the cost of care. For example, the low usage of EHR capabilities in specialty practices may be inherent in the implementation process and lack of need for such capabilities to effectively manage patient care. Our method of determining the use-patterns of computerized capabilities by applying the use-diffusion model also provides a useful way to analyze the adoption

of EHR, and its subsequent effects on the care process. Lastly, this study provides the basis for further evaluation of EHR use in solo/small practices and specialty practices by policymakers and health officials. It also suggests a need for policies that facilitate effective integration of EHR into the workflow of medical facilities, especially for small and specialty practices in the US.

Author statements

Funding

None.

Competing interests

None declared.

Ethical approval

Not required.

Appendix

Table A1

Survey questions on computerized capabilities assessed in the 2013 national ambulatory medical care survey- physician induction interview.

Recording patient history and demographic information?
If Yes, ask – (1) Does this include a patient problem list?
Recording and charting vital signs?
Recording patient smoking status?
Recording clinical notes?
If Yes, ask – (1) Do the notes include a list of the patient's medications and allergies?
Reconciling lists of patient medications to identify the most accurate list?
Ordering prescriptions?
If Yes, ask – (1) Are prescriptions sent electronically to the pharmacy?
If Yes, ask – (2) Are warnings of drug interactions or contraindications provided?
Providing reminders for guideline-based interventions or screening tests?
Ordering lab tests?
If Yes, ask – (1) Are orders sent electronically?
Viewing lab results?
If Yes, ask – (1) Can the EHR/EMR automatically graph a specific patient's lab results over time?
Viewing imaging results?
Identifying educational resources for patients' specific conditions?
Reporting clinical quality measures to federal or state agencies (such as CMS or Medicaid)?
Generating lists of patients with particular health conditions?
Electronic reporting to immunization registries?
Providing patients with clinical summaries for each visit?
Exchanging secure messages with patients?
Providing patients with an electronic copy of their health information?
Providing patients, the ability to view online, download, or transmit information from their medical record?

Table A2

Characteristics of office-based physician practices by use-diffusion groups.

Category	Intense use (n = 1291)			Non-Specialized use (n = 488)			Specialized use (n = 339)			Limited use (n = 261)		
	Freq	Weighted Freq*	%	Freq	Weighted Freq*	%	Freq	Weighted Freq*	%	Freq	Weighted Freq*	%
Solo practice	252	34,353	21.4	164	23,392	36.8	144	20,116	42.5	131	20,951	52.8
Non-solo practice	1,040	126,430	78.6	324	40,199	63.2	235	27,116	57.3	153	18,729	47.2
Specialty												
Primary care	643	92,754	57.7	177	27,070	42.6	119	18,545	39.2	76	10,971	27.6
Surgical care	254	21,821	13.6	156	15,987	25.1	129	13,046	27.6	90	11,724	29.5
Medical care	395	46,208	28.7	155	20,534	32.3	132	15,757	33.3	118	16,985	42.8
Ownership type												
Physician or physician group	832	103,826	64.6	383	49,664	78.1	291	36,921	78.0	225	30,999	78.1
Medical/academic health center;	146	16,918	10.5	38	4,125	6.5	30	3,555	7.5	18	3,461	8.7
Community health center; other												
hospital												
Insurance company, health plan, or	272	34,291	21.3	47	6,901	10.9	36	3,719	7.9	27	3,134	7.9
HMO; other health corporation; other												
Unknown	42	5,748	3.6	20	2,901	4.6	23	3,152	6.7	14	2,087	5.3
Metropolitan statistical area status												
MSA (Metropolitan Statistical Area)	1,159	149,288	92.9	444	60,057	94.4	341	44,020	93.0	261	36,851	92.9
Non-MSA	133	11,495	7.1	44	3,534	5.6	39	3,327	7.0	23	2,829	7.1

(continued on next page)

Table A2 (continued)

Category	Intense use (n = 1291)			Non-Specialized use (n = 488)			Specialized use (n = 339)			Limited use (n = 261)		
	Freq	Weighted Freq*	%	Freq	Weighted Freq*	%	Freq	Weighted Freq*	%	Freq	Weighted Freq*	%
Practice use EHR												
Yes, all electronic	1,195	147,732	91.9	385	47,353	74.5	138	15,617	33.0	65	8,082	20.4
Use part paper, part electronic	85	10,231	6.4	89	13,371	21.0	72	9,533	20.1	61	9,198	23.2
No	8	1,199	0.7	14	2,867	4.5	164	21,565	45.5	157	22,310	56.2
Unknown	4	1,622	1.0	0	0	0.0	6	633	1.3	1	91	0.2
Submit claims electronically												
Yes	1,236	152,358	94.8	463	59,060	92.9	317	37,725	79.7	238	32,121	80.9
No	39	6,038	3.8	19	3,473	5.5	48	7,477	15.8	40	6,937	17.5
Unknown	17	2,387	1.5	6	1,057	1.7	15	2,145	4.5	6	622	1.6
Plan to install new or replace old EHR												
Yes	117	14,041	8.7	45	6,322	9.9	110	12,861	27.2	87	11,248	28.3
No	1,110	136,200	84.7	415	53,885	84.7	211	26,596	56.2	151	21,429	54.0
Maybe	23	3,506	2.2	12	1,652	2.6	37	4,700	9.9	32	5,529	13.9
Unknown	42	7,037	4.4	16	1,732	2.7	22	3,190	6.7	14	1,474	3.7
Plan to apply for incentive payments												
Yes, we already applied	1,027	125,583	78.1	343	44,616	70.2	113	12,730	26.9	68	9,255	23.3
Yes, we intend to apply	84	11,208	7.0	64	8,181	12.9	71	8,334	17.6	66	9,593	24.2
Uncertain if we will apply	97	11,709	7.3	39	5,134	8.1	78	10,791	22.8	45	5,709	14.4
No, will not apply	60	8,764	5.5	40	5,515	8.7	109	14,584	30.8	101	14,884	37.5
Unknown	24	3,520	2.2	2	145	0.2	9	908	1.9	4	240	0.6
Current EHR system meets the meaningful use criteria												
Yes	1,229	152,961	95.1	437	56,860	89.4	156	17,446	36.8	86	11,744	29.6
No	32	4,516	2.8	42	5,932	9.3	199	26,444	55.9	179	24,656	62.1
Unknown	31	3,306	2.1	9	799	1.3	25	3,458	7.3	19	3,280	8.3
Year first applied or intend to apply for payment incentives												
2011	425	52,647	32.7	145	19,052	30.0	35	4,219	8.9	31	3,600	9.1
2012	389	47,290	29.4	133	16,421	25.8	50	5,774	12.2	22	3,668	9.2
2013	119	14,814	9.2	86	12,362	19.4	53	5,835	12.3	43	6,334	16.0
2014 or later	27	3,689	2.3	13	1,348	2.1	20	2,390	5.0	22	2,874	7.2
Have not applied and uncertain	175	21,870	13.6	32	3,759	5.9	35	3,756	7.9	20	2,613	6.6
Unknown	157	20,472	12.7	79	10,649	16.7	187	25,375	53.6	146	20,592	51.9
Provide email/internet patient consult												
No	992	121,432	75.5	425	55,122	86.7	348	43,495	91.9	248	33,606	84.7
Yes	247	33,031	20.5	54	7,597	11.9	22	3,131	6.6	35	5,925	14.9
Unknown	53	6,321	3.9	9	871	1.4	10	722	1.5	1	149	0.4
Geographic Region												
Northeast	174	30,516	19.0	71	12,940	20.3	63	11,256	23.8	64	11,963	30.1
Midwest	375	34,755	21.6	153	15,192	23.9	106	9,418	19.9	70	5,581	14.1
South	450	55,619	34.6	165	20,946	32.9	141	16,798	35.5	89	10,424	26.3
West	293	39,893	24.8	99	14,513	22.8	70	9,875	20.9	61	11,712	29.5
See referred patients												
Yes	1,060	130,782	81.3	427	55,714	87.6	325	39,981	84.4	255	36,176	91.2
No	224	29,211	18.2	61	7,877	12.4	55	7,367	15.6	28	3,446	8.7
Unknown	8	791	0.5	0	0	0.0	0	0	0.0	1	58	0.1
Receive medical reports on referred patients												
Yes	1,014	125,101	77.8	404	51,990	81.8	300	36,628	77.4	240	34,480	86.9
No	269	34,783	21.6	84	11,601	18.2	79	10,626	22.4	43	5,142	13.0
Unknown	9	899	0.6	0	0	0.0	1	94	0.2	1	58	0.1
Receive electronic medical reports on referred patients												
Yes	503	59,312	36.9	126	13,522	21.3	49	5,007	10.6	28	4,981	12.6
No	779	100,372	62.4	362	50,069	78.7	329	42,125	89.0	255	34,641	87.3
Unknown	10	1,099	0.7	0	0	0.0	2	216	0.5	1	58	0.1
Refer patients to provider outside the practice												
Yes	1,210	151,313	94.1	462	60,691	95.4	347	43,502	91.9	264	36,573	92.2
No	76	9,120	5.7	25	2,825	4.4	32	3,728	7.9	20	3,107	7.8
Unknown	6	351	0.2	1	74	0.1	1	118	0.2	0	0	0.0
Receive medical reports on patients referred out												
Yes	1,194	148,403	92.3	457	59,628	93.8	333	41,839	88.4	260	36,207	91.2
No	92	12,029	7.5	30	3,889	6.1	46	5,391	11.4	24	3,474	8.8
Unknown	6	351	0.2	1	74	0.1	1	118	0.2	0	0	0.0
Receive electronic medical reports on patients referred out												
Yes	592	71,072	44.2	138	15,469	24.3	63	6,358	13.4	35	5,956	15.0
No	692	89,205	55.5	349	48,048	75.6	315	40,778	86.1	248	33,674	84.9
Unknown	8	506	0.3	1	74	0.1	2	212	0.4	1	50	0.1

* Weighted to the U.S. office-based Physician Practices Population

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