

Variation in Implementation and Use of Computerized Clinical Reminders in an Integrated Healthcare System

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Objectives: To identify patterns of use of computerized clinical reminders (CCRs) across an integrated healthcare system and describe institutional factors associated with their implementation.

Study Design: Cross-sectional study.

Methods: At a national electronic health record (EHR) meeting, we surveyed 261 participants from 104 Veterans Health Administration (VHA) healthcare facilities regarding the number and types of CCRs available at each facility. Potential explanatory measures included perceived utility and ease of use of CCRs, training and personnel support for computer use, EHR functionalities, and performance data feedback to providers at each facility.

Results: The number of conditions with CCRs in use at a facility ranged from 1 to 15; most reported implementation of reminders for 10 of the 15 conditions surveyed. The most commonly implemented CCRs, used in more than 85% of facilities, were for conditions with VHA national performance measures (eg, tobacco cessation, immunizations, diabetes mellitus). The least commonly implemented CCRs were for post-deployment health evaluation and management, medically unexplained symptoms, and erectile dysfunction. Facilities that had implemented greater numbers of clinical reminders had providers who reported greater ease of use and utility of the reminders ($P = .01$).

Conclusions: VHA facilities vary markedly in their implementation of CCRs. This effect may be partly explained by greater incorporation of clinical reminders for conditions with performance measures. Further study is needed to determine how to best implement clinical reminders and the institutional factors important in their use.

(*Am J Manag Care.* 2004;10(part 2):878-885)

Computerized clinical reminders (CCRs) have been widely publicized as potential tools for changing behavior¹ and improving quality of care.²⁻⁴ They have been particularly effective in improving adherence with preventive care and screening guidelines,^{2,5} monitoring diabetes,⁶ and treating hypertension.⁷ However, factors such as workload, time, and perceived reduction of the quality of the provider-patient interaction may be barriers to effective use of computerized reminders.⁸

The Veterans Health Administration (VHA), the United States' largest integrated healthcare delivery system, has invested heavily in the informatics infrastructure necessary to support CCRs. It has been on the forefront of developing these tools and incorporating them into the computerized patient record system

(CPRS), which is the VHA's electronic health record (EHR). The VHA developed CPRS, an application used throughout VHA facilities that enables clinicians to review and analyze patient data and supports clinical decision making.⁹

Computerized clinical reminders may be developed and distributed at the national, regional, or local level. Although VHA mandates use of a few clinical reminders such as assessing hepatitis C risk and possible sexual trauma during military service, most CCRs have been locally initiated.¹⁰ After reminders are created, they are tested and activated. Some reminders are applicable to all patients, while others apply to a particular group of patients. VHA facilities can generate clinical reminder reports, which provide information, for example, about the number of patients in a clinic with completed clinical reminders and the number of patients eligible for the reminder.

Although CCR technology is in widespread use in VHA, data regarding CCR patterns of use in VHA and institutional factors associated with their use have not been available. A description of the different types of reminders implemented in VHA may help other large organizations interested in promoting this technology. Identifying factors influencing widespread implementation of CCRs is a necessary step to promote their dissemination. Hence, our primary objective was to survey VHA facilities for variations in the numbers and types of CCRs used across VHA facilities nationally. Our secondary objective was to identify institutional fac-

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This study was supported by a Department of Veterans Affairs Health Services Research and Development Service Management Consultation Project and by Investigator Initiated Research (IIR) Merit Review grant CPI 01-141.

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tors associated with increased implementation of CCR technology.

METHODS

Study Population and Data

We assessed CCR use across the VHA by distributing a survey instrument to participants at the national Camp CPRS meeting that took place in Georgia in May 2003. This meeting focused on the VHA's EHR and in 2003, included 1304 representatives from 136 of the 142 VHA medical facilities participating in the VHA's External Peer Review Program (EPRP). The representatives, who are nominated by their facilities, may be clinical staff (eg, physician, nurses, others), administrative personnel (eg, chief of staff), or informatics experts. Many attendees are opinion leaders at their facility and have extensive experience with local CPRS capabilities, either as users or developers of clinical applications for the EHR and its decision support tools.

We received responses from 261 participants (20%) representing 104 VHA facilities (76%). Nonrespondents were not tracked because only those who volunteered were given the survey instrument. Sixty-five of the 104 facilities that responded to our survey had more than 1 respondent.

The American Hospital Association database provided additional background information about VHA facilities. It provided information about geographic distribution of participating facilities, teaching status affiliation, and size of the facilities.

Questionnaire Development

After discussion with the VHA staff that oversee, develop, or perform research on clinical reminders, including members of the National Clinical Practice Guideline Council and members of its ad hoc Clinical Reminders Committee, we chose to evaluate facilities' use of 15 different types of CCRs. We selected reminders that represent a broad range of conditions clinicians might encounter in various clinic settings. Some reminders were for conditions that have VHA national performance measures (eg, addressing tobacco cessation), whereas others (eg, low back pain) were for conditions without VHA national performance measures.

The remainder of the 77 items in the survey instrument focused on institutional factors hypothesized from our ongoing studies to be important in implementation of clinical guidelines¹¹ or CCRs. The instrument assessed different forms of computer use (provider education, performance feedback, and clinical support such as the ability to retrieve radiological images), perceived utility and ease of use of CCRs, adequacy of computer

training and CCR training, organizational support, hospital culture/climate, and availability of feedback mechanisms for modifying CCRs. Responses for this portion of the survey instrument were either dichotomous (yes or no) or measured on a 5-point Likert-type scale. Respondents who answered "don't know" were recoded as "missing" or "no." The questionnaire is available, upon request, from Dr. Doebbeling.

The University of Iowa/Iowa City VA institutional review boards approved the study protocol. The data management plan underwent subsequent review and approval from the institutional review board of the VA Greater Los Angeles Healthcare System.

Outcome Measures

Outcome measures were obtained from questionnaire responses. For these measures, we aggregated individual responses at the facility level. Although 39 facilities (37.5%) had only a single respondent, the other facilities had multiple respondents, including 29 facilities with 2 respondents, 23 with 3 respondents, 6 with 4 respondents, 1 with 5 respondents, 3 with 6 respondents, and 3 with 10 or more respondents. When more than 1 response per facility was available, we used mean scores for questions that had Likert-like response scales. For dichotomous variables, we assumed that respondents from any given facility, while knowledgeable about their home facility, would be unlikely to report seeing or using a clinical reminder that they have never seen or used. In contrast, it is possible that they may not have seen or used a clinical reminder that was available at their facility, but a colleague at their facility may have reported seeing or using the clinical reminder. Because our goal was to determine whether a clinical reminder exists or not at a given facility, we weighted "yes" responses more than "no" responses. We reasoned that the union rather than intersection of positive responses would more accurately reflect, for example, the actual number of conditions with clinical reminders in place at a particular facility. Therefore, we treated any positive answer among respondents at the facility as a true-positive facility response. For example, if there were 3 responses and 2 stated that CPRS was used for requesting consults and 1 did not (or vice versa), the facility score was based on a "yes" answer. In a sensitivity analysis, we weighted negative responses more heavily than positive responses.

The first outcome measure represents which CCRs were available at the facility. The second outcome measure, a "facility clinical reminder score" (minimum possible score = 0, maximum possible score = 15), was created by summing "yes" responses to questions surveying whether a facility had at least 1 clinical reminder

for a particular health condition. This variable represented the level of implementation of CCR technology in VHA facilities. Although some conditions, such as diabetes, may have more than 1 clinical reminder (eg, glycosylated hemoglobin, microalbumin/creatinine ratio), we counted each condition only once in our facility clinical reminder score. We used *t* tests to determine whether responses to each question differed significantly for facilities with complete versus incomplete responses. There were 72 facilities with complete data and 32 facilities with incomplete data (missing data or “don’t know” response) for the questions used to construct the facility clinical reminder score. The mean facility clinical reminder score was 9.1 (95% confidence interval [CI]: 8.6, 9.7) for facilities with complete responses versus 7.4 (95% CI: 6.3, 8.5) for those with incomplete responses (a difference of 1.7; 95% CI: 0.7, 2.8). **Table 1** presents comparison data for VHA facilities that participated in Camp CPRS and had respondents to the survey versus VHA facilities that did not participate in Camp CPRS or did not have respondents to the survey. Facilities with complete and incomplete responses were similar with respect to number of acute-care beds, trainee and resident full-time equivalents, academic affiliation, and urban versus rural location (*P* > .05 for all comparisons).

Potential Explanatory Measures

To identify potential explanatory variables, we developed scales from questionnaire items. The process of

developing scales also served as a method of data reduction. Existing literature and conceptual models, as well as factor analysis, guided development of the scales.^{12,13} We relied on a priori hypotheses developed from literature review, our conceptual framework, and clinical experience in the identification and labeling of a 5-factor solution. The resulting domains included:

1. *Computer training and personnel support*, measuring perceived adequacy of training and personnel support (8 items; alpha = .842).
2. *EHR functionality*, measuring the number of features available online to clinicians at the point of care and at the facility in general (12 items; alpha = .86).
3. *Clinical reminders utility and ease of use* (6 items; alpha = .75).
4. *Graphical data feedback*, measuring availability of graphical display of individual and clinic performance (2 items; alpha = .95).

For each scale, higher scores indicated greater perceived support, ease of use/utility, functionality, or availability (**Appendix**).

Statistical Analysis

To meet our primary objective, we used simple descriptive statistics to present data on the type and distribution of CCRs across VHA. For our secondary objective, bivariate relationships were tested and a multivariate linear regression model was estimated to determine which American Hospital Association facility characteristics and domains from our factor analysis were independent predictors of having a higher facility clinical reminder score. The number of facilities with complete responses for all variables included in the analysis (n = 62) limited the number of potential variables to no more than 6. Because there were more than 6 potential variables, only variables with a *P* value of ≤.25 in our bivariate analyses were considered for the multivariate analysis. Then, we used stepwise regression to build our multivariate model. We used an alpha of <.10 for inclusion in the final model (the level of significance that was used to

Table 1. Characteristics of VHA Medical Facilities Participating in the VHA’s External Peer Review Program, by Survey Response*

Characteristic	No. (%)		P
	Respondents	Nonrespondents [†]	
Number	93 (67)	45 (33)	
Region			.53
New England	7 (8)	2 (4)	
Atlantic	30 (32)	16 (36)	
Central	35 (38)	22 (49)	
Mountain/Pacific	20 (22)	5 (11)	
Other (Puerto Rico)	1 (1)	0 (0)	
Bed size (acute-care beds only)			.14
<100	13 (14)	8 (18)	
100-199	17 (18)	15 (33)	
200-399	32 (34)	13 (29)	
≥400	31 (33)	9 (20)	
Council of Teaching Hospitals	45 (48)	18 (40)	.35

*CPRS indicates computerized patient record system; VHA, Veterans Health Administration.
[†]Nonrespondents included facilities attending Camp CPRS (n = 39) and facilities not participating in Camp CPRS (n = 6). Four facilities did not have American Hospital Association data available and are not shown.

define the minimum acceptable F limit for adding or removing a variable in the model). All statistical testing was performed with SAS, version 8 (SAS Institute, Inc, Cary, NC).

RESULTS

Descriptive Results

Table 1 demonstrates that participating facilities were geographically distributed across the United States. Approximately one half (48%) of the hospitals were members of the Council of Teaching Hospitals. One third of the hospitals had fewer than 200 acute-care beds, one third had 200-399 acute-care beds, and one third had 400 or more acute-care beds. Participating facilities were similar to facilities that did not participate in the conference or respond to the survey in terms of geographic region ($P = .53$), teaching status ($P = .35$), and bed size ($P = .14$).

Table 2 summarizes the percent of respondents who were clinicians, information technologists, and clinical application coordinators. Clinical application coordinators, who are liaisons between informatics and clinical services, provide services such as implementing software packages and clinical support systems for VHA's EHR and customizing national-level VHA packages for local VHA healthcare facilities.

Figure 1 summarizes the number of conditions with CCRs across 104 facilities (the facility clinical reminder score). Of the 15 conditions surveyed, the number of conditions with reminders implemented across facilities ranged from 1 to 15, with a median of 9 (interquartile range 7, 10). In a sensitivity analysis, weighting negative responses more than positive responses, the median number of conditions with reminders implemented was 6 (interquartile range 4, 8), but variation across facilities remained unchanged. Figure 2 summarizes the types of clinical reminders reported at each facility. The most commonly implemented reminders across facilities were for conditions with VHA national performance measures, including tobacco cessation ($n = 99$), immunizations ($n = 97$), diabetes mellitus ($n = 95$), hypertension ($n = 91$), and dyslipidemia ($n = 88$). In contrast, conditions for which reminders were infrequently implemented included low back pain ($n = 14$), erectile dysfunction ($n = 8$), medically unexplained symptoms ($n = 7$), and post-deployment health evaluation and management ($n = 5$).

Most facilities had implemented basic components of an EHR: entering patient notes ($n = 100$), requesting consultations ($n = 101$), order-

ing radiological procedures ($n = 101$), ordering laboratory tests ($n = 102$), and prescribing medications ($n = 104$). Many facilities also provided customization of the reminders ($n = 96$) or formats tailored to specific patient populations ($n = 97$). Respondents considered clinical reminders generally useful, with an overall mean response of 4.0 on a scale 1 to 5 (1 = not at all and 5 = very great).

Bivariate and Multivariate Analyses

Table 3 summarizes the institutional structure and process variables associated at a bivariate level with the facility clinical reminder score. Multivariable regression (Table 4) found 2 hospital-level variables associated with implementation of clinical reminders; these were "perceived utility and ease of use" and "number of full-time equivalent trainees and residents" (F statistic = 5.78; $P = .005$). Each 5-point increase on the "ease of use and utility" scale was associated with a 1-unit increase in the number of CCRs at the facility (parameter estimate of 0.21; $P = .01$). Conversely, an increase in the number of residents and trainees had a borderline association with a decrease in CCR implementation (parameter estimate of -0.00711; $P = .069$), meaning our model predicts that facilities will have 1 less CCR for every 150 full-time equivalent trainees and residents gained.

DISCUSSION

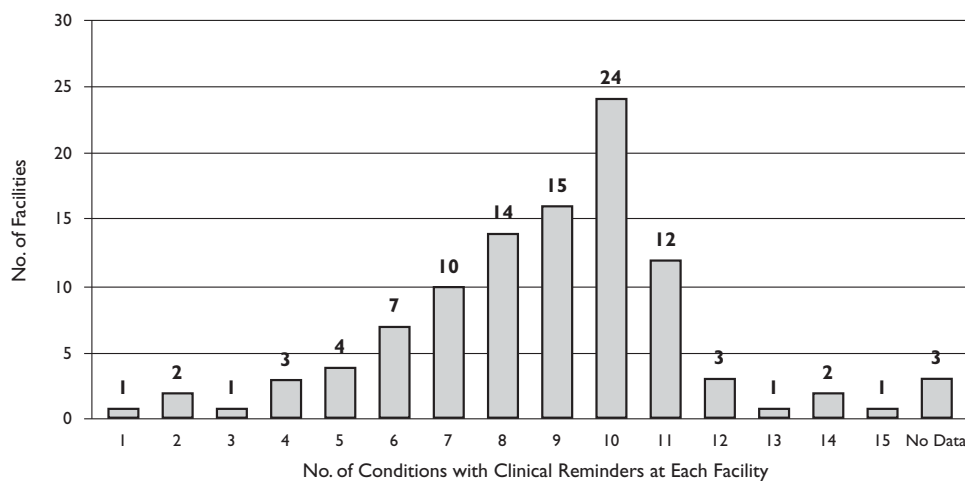
We found wide variation across VHA facilities nationally in the types and number of conditions with CCRs. We observed this variation even though VHA

Table 2. Professional Training and Experience of Respondents (n = 261)*

Variable	Survey Result
Categorical (professional training)	No. (%)
Registered nurse	90 (34.5)
Physician	81 (31.0)
Clinical application coordinator	36 (13.8)
Nurse practitioner and physician assistant	30 (11.5)
Pharmacist	16 (6.1)
Information technologist	10 (3.8)
Other	31 (11.8)
Continuous (experience)	Mean (SD)
Length of time employed in VHA	14 y (7.1 y)
Length of time employed at current VHA facility	11.3 y (6.7 y)

*Participants can be in more than 1 occupational category. VHA indicates Veterans Health Administration.

Figure 1. Distribution of the Total Number of Conditions with Computerized Clinical Reminders Being Used per Facility (n = 104)*



*Facilities were categorized as having "no data" when respondents answered "don't know" to all of the questions used to construct the facility clinical reminder score variable.

facilities are part of a single-payer system and nearly all facilities have common information technology infrastructure, including a basic EHR that is similar across facilities, to develop CCRs. Our study also sought to identify factors associated with greater implementation of clinical reminders. We found that facilities with higher perceived utility and ease of use of clinical reminders were more likely to have implemented a larger number of CCRs at each facility.

Facilities have incentives to implement clinical reminders for conditions that have VHA national performance measures. The VHA's performance measures are similar to Health Plan Employer Data and Information Set (HEDIS®) measures, which were developed from evidence-based practice guidelines.^{14,15} The VHA's EPRP gathers information on the quality of care delivered for conditions such as tobacco cessation, immunizations, and diabetes care, and feeds back facility-level data on adherence to performance measures for these conditions to administrators. Clinical reminders also have been shown to increase adherence to these types of measures.^{2,5-7} Post-deployment health evaluation and management, medically unexplained symptoms, erectile dysfunction, and low back pain did not have associated performance measures. In our study, clinical reminders for many of the EPRP target conditions were more commonly implemented than clinical reminders for non-EPRP target conditions. This pattern suggests that the audit and feedback of performance data may be a strong force for adopting and implementing clinical reminders.

The extent of clinical reminder implementation at the facility level was independently related to perceived utility and ease of use of clinical reminders. These results are consistent with prior studies. Clinicians surveyed in a study by Schellhase et al also reported that lack of ease of use was a possible explanation for the observed under-use of automated health maintenance reminders.¹⁶ In a recent study of human-factor barriers to the effective use of HIV

clinical reminders in VHA, inapplicability to the specific clinical situation was identified as 1 of multiple barriers to their regular use.⁸ Our results suggest that greater attention to utility and ease of use of the reminders, perhaps through qualitative or formative studies of their use, may be important for healthcare systems trying to promote the adoption of clinical reminder technology.

Prior studies have identified organizational factors such as hospital size and location (urban vs rural) as influences on the diffusion of healthcare information technology.^{13,17-19} These organizational factors did not predict the extent of CCR implementation in the VHA facilities that participated in our survey. However, other factors identified in the literature that we were unable to test may be contributing to the observed variation in the number of conditions with CCRs. Centralized development and mandated adoption may lead to more uniform adoption of CCRs across a system.¹² This uniformity may be desirable to large healthcare systems, especially as more studies show the benefits of CCRs and how to optimally implement them. In contrast, decentralized development and optional adoption of reminders may lead to slower uptake by some facilities and, thus, variation in the number of CCRs across different facilities.¹² Decentralized development and local modification, however, may be advantageous for a system, because these factors may improve the chances that only those facilities with adequate clinical and technological capability to effectively support clinical reminders will push adoption and implementation. Furthermore, the input of local providers in adapting reminders may improve accept-

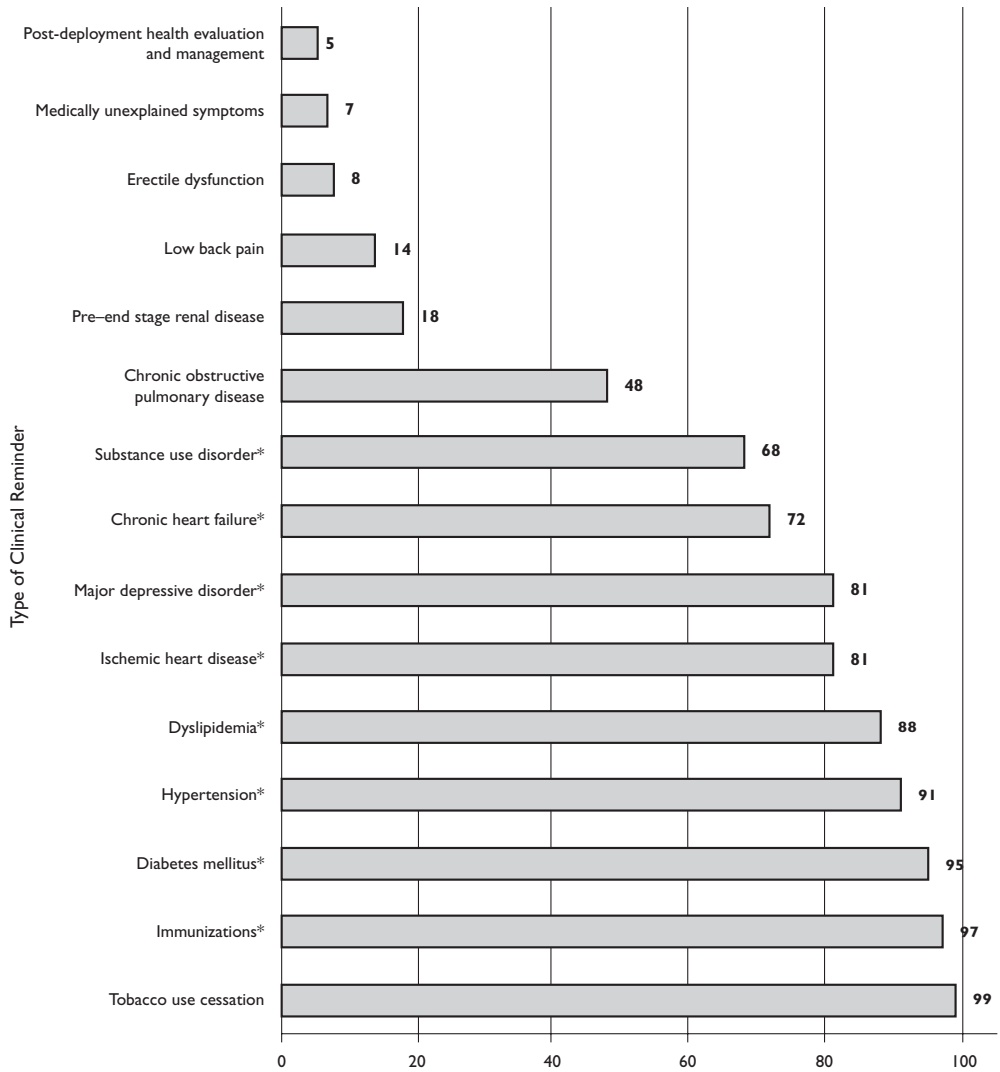
ance by providers and, perhaps, usability. Central development and testing of highly selected reminders with dissemination and local adaptation, a model that VHA has recently adopted, may strike the optimal balance between well-designed, evidence-based clinical reminders that serve a patient population and the needs of local facilities.

The strength of our study is its national scope. Many studies of clinical reminders are unable to obtain the national sampling we achieved in this study, because few healthcare systems with an EHR and CCR system have the geographic reach achieved by VHA. Similarly, this report provides previously unavailable data regarding the implementation and dissemination of clinical reminders throughout a national healthcare system with an already-implemented EHR.

The chief limitation of this study is that we relied on a convenience sample. Thus, the responses may not be representative of all hospitals within the VHA system. Nevertheless, we aggregated individual responses within facilities to better reflect experiences at the facility level. Although we excluded facilities with incomplete responses, we noted that facilities with incomplete scores and complete scores differed minimally in their mean reminder scores and that overall they had similar organizational characteristics in terms of acute-care beds, trainees, academic affiliation, and location. Facilities with respondents were similar to VHA facilities without respondents in terms of hospital size and teaching status

(membership in Council of Teaching Hospitals). Although verification of the survey answers through direct contact with each facility was beyond the scope of the current study, we included participants who had been selected to attend a conference on the VHA's EHR and, thus, were likely to be reliable informants about their home systems. Furthermore, this study design enabled us to survey the number of conditions with clinical reminders that are clinically relevant. Nevertheless, measurement of all possible types of reminders at each facility may be informative in future studies. Other locally important clinical reminders may have been inadvertently omitted from our questionnaire, thereby underestimating the number of clinical reminders used at

Figure 2. Types of Computerized Clinical Reminders Across Facilities (n = 104)



*External Peer Review Program target condition.

Table 3. Bivariate Analyses of Structure and Process Variables Associated with the Number of Conditions That Have Computerized Clinical Reminders in Use at the Facility*

Variable	Beta (SE)	95% CI	P
Ease of use and usefulness of clinical reminders	0.18 (0.08) [†]	(0.03, 0.34)	.03
Resident and trainee FTEs	-0.01 (0.00) [†]	(-0.02, 0.00)	.02
Rural location	1.34 (0.90)	(-0.43, 3.11)	.14
Functionality of electronic medical record (CPRS)	0.04 (0.03)	(-0.02, 0.11)	.17
Number of acute-care beds (log)	-0.37 (0.27)	(-0.89, 0.15)	.17
Training and personnel support computer use	0.06 (0.04)	(-0.03, 0.14)	.18
Graphical data feedback	0.06 (0.05)	(-0.03, 0.16)	.20
Physician FTEs per 1000 outpatient visits	-3.96 (3.24)	(-10.31, 2.39)	.23
Council of Teaching Hospitals	0.18 (0.57)	(-0.93, 1.28)	.76

*CI indicates confidence interval; CPRS, computerized patient record system; FTE, full-time equivalent.
[†]Significant at the alpha = .05 level.

Table 4. Multivariate Model of Structure and Process Variables Associated with the Number of Conditions That Have Computerized Clinical Reminders in Use at the Facility (n = 62)*

Independent Variable	Beta (SE)	95% CI	P
Ease of use and usefulness of clinical reminders	0.20 (0.08)	(0.03, 0.37)	.02
Resident and trainee FTEs	-0.01 (0.00)	(-0.01, 0.00)	.07
Intercept	4.47 (1.88)	—	—

*CI indicates confidence interval; FTE, full-time equivalent.

a particular facility. However, although this may have changed the overall number per facility, it is unlikely to have lessened the variation noted. Another limitation involves our sample size. Because of a limited sample size and the descriptive nature of this investigation, we used results from our bivariate analyses and stepwise variable selection for our multivariate analysis. Finally, in our regression model, we did not adjust for clustering at the hospital level, which may affect our results.

CONCLUSION

This study found many CCRs in widespread use across VHA and suggested that considerable variation exists in the number of conditions with reminders. Facilities where more CCRs have been implemented have greater provider support for their utility and ease of use. Other large healthcare systems interested in adopting CCRs into regular practice should consider the association we demonstrated between ease of use/utility and adoption of CCRs. Future studies should explore human and systems factors that facilitate increased

adoption and routine use of CCRs in clinical care.

Acknowledgments

We appreciate the contributions of Drs. Toni Tripp-Reimer, PHD, RN, Ashley Hedeem, MD, Robert Smith, MD, Bonnie BootsMiller, PHD, and Valerie Forman-Hoffman to the design of the instrument.

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Appendix. Composite Variables From the Survey of Clinicians Attending Camp CPRS Training in the Veterans Health Administration, May 2003*

Variable	Mean	SD
(1) Training and personnel support computer use^a	27.0	6.0
Personnel assigned to help providers learn basic functionality of system	3.6	0.8
Have you been trained in using clinical reminders?	3.5	1.1
Personnel assigned to help providers input patient data into system	3.4	0.8
Helps you learn new clinical reminders: administrative support/involvement	3.3	1.0
Helps you learn new clinical reminders: facility culture	3.3	0.9
Helps you learn new clinical reminders: performance feedback	3.2	0.9
Personnel assigned to help providers learn full functionality of system	3.1	0.9
Personnel assigned to help providers extract patient data for counseling in exam room	3.1	0.9
(2) Functionality of electronic medical record^b	47.2	9.2
Exam room: all lab test results	4.7	0.6
Available: Internet access	4.6	0.6
Exam room: patient medication history	4.6	0.6
Exam room: history of adverse drug reactions	4.4	0.6
Exam room: medication dosing information	4.4	0.7
Exam room: potential adverse drug interactions	4.4	0.7
Exam room: clinical problem lists	4.4	0.7
Available: drug-drug interaction warnings	4.3	0.6
Available: remote access to CPRS	3.5	0.9
Available: input validation checks	3.5	1.0
Available: images from radiology	3.4	1.5
Available: drug-disease interaction warnings	3.4	1.1
(3) Ease of use and utility of clinical reminders^c	23.0	3.4
Are enough workstations available in each exam room?	4.3	0.6
Are enough workstations available in patient interview rooms?	4.0	0.7
Do you feel clinical reminders are useful?	4.0	0.7
Reminder formats easy to use	3.7	0.8
Reminder formats tailored to specific patient populations	3.6	0.8
Available: specialty customization	3.6	0.8
(4) Graphical data feedback^d	8.5	5.7
Available: graphical display of individual provider data	2.8	1.1
Available: graphical display of clinic performance	2.7	1.1

*CPRS indicates computerized patient record system.

^aSummary score of 8 items, ranging from 1 = "not at all" to 5 = "very great"; minimum = 10, maximum = 40.

^bSummary score of 12 items, ranging from 1 = "not at all" to 5 = "very great"; minimum = 15, maximum = 60.

^cSummary score of 6 items, ranging from 1 = "not at all" to 5 = "very great"; minimum = 14.5, maximum = 30.

^dNote: summary score of 2 items, ranging from 1 = "not at all" to 5 = "very great"; minimum = 2, maximum = 10.