Microcomputer-Generated Reminders

Improving the Compliance of Primary Care Physicians With Mammography Screening Guidelines

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Recent studies have documented that physician compliance with recommended periodic health screening improves with reminders to physicians. These reminders, however, are often costly to maintain and modify. This study investigates the influence of a microcomputer tickler system on the ordering of mammograms. All women (N = 1262) aged 40 years and older who made visits to an outpatient office during a 6-month period were randomly assigned to one of two groups. For the experimental group, the date of the last mammogram ordered and recorded in the clinical database was printed on the encounter form generated for each patient visit. No information regarding previous mammograms was printed for patients in the control group. Women in the experimental group were more likely to have a mammogram ordered during the study period (19% compared with 12%, P = .001) and, as a result, were more likely to be in compliance with mammography guidelines at the study's completion (27% compared with 21%, P = .011). Microcomputerized data storage and retrieval systems may help increase physicians' attention to preventive health screening recommendations.

Primary care physicians are in a unique position to provide early detection and treatment of chronic diseases through routine screening activities. Studies have shown, however, that physician compliance with recommendations for periodic health screening is limited.[1,2] The major reasons for not performing recommended health screening tests cited by providers include provider forgetfulness, lack of time, inconvenience and logistical difficulties, and patient discomfort or refusal.[1] The relative importance of each of these factors is related to the specific intervention. Screening sigmoidoscopies, for example, are perceived by clinicians[3] as time-consuming procedures with a relatively low yield of positive findings and are poorly accepted by patients. Other interventions, however, including mammograms, breast examinations, immunizations, and the distribution of fecal occult blood testing cards, require much less time, and physicians report that their failure to comply with recommendations is primarily due to their oversight at the time of the visit.[1]

Reminders to physicians have significantly improved physician compliance with preventive medicine guidelines.[4–8] Screening flow sheets, which serve primarily as memory-prompting devices, have improved physician compliance with health-screening recommendations in several short-term studies.[4,6] It is time-consuming to search for health-screening information in previous clinical notes during a routine patient visit; therefore, the long-term usefulness of a flow sheet is dependent on its completion rate. Unfortunately, evidence suggests that handwritten flow sheets are not completed reliably, and most screening evaluations are documented only in the progress notes.[4,9]

Computer-stored medical records make retrieval of relevant clerical information more efficient.[10,11] Recent research has shown that physicians respond to computerized reminders to perform specific interventions.[8,12] McDonald et al developed a computer-stored medical records system that is able to analyze and respond to its own contents according to physician-authored reminder rules.[8] The performance of routine preventive care was at least twofold greater by physicians in their study group than by control group physicians. The authors acknowledged, however, that the VAX minicomputer system which generated the

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reminders would be too costly to maintain for most primary care practices. Whether similar changes in physician behavior can be effected using a relatively inexpensive microcomputerized office system, which would be more accessible to a majority of primary care physicians, has not been demonstrated.

The purpose of this study was to investigate the influence on mammogram ordering of a reminder bulletin or "tickler system" integrated with a microcomputerized system that links clinical encounter data and billing data and is routinely used in a family practice center. Because physician forgetfulness has been cited as an important factor in the underutilization of mammograms for cancer screening,[1] it was hypothesized that mammogram ordering would increase with the introduction of the reminder system.

METHODS

Study Site

This study was conducted in the clinical facility (Family Practice Center) of the Department of Family Medicine at Thomas Jefferson University, Philadelphia, between November 1, 1986, and April 30, 1987. In this practice, 12 full-time faculty and 18 residents provide continuing primary care to approximately 9000 patients, who make more than 25,000 visits to the practice each year.

Patient Encounter Form System

In 1984 the practice developed and implemented a microcomputerized patient registration system linked with a clinical encounter form system. In 1986 the system was coupled with billing information. An encounter form, which is generated for each patient just before a visit, is attached to the front of the patient chart and includes space for information regarding presenting symptoms, diagnoses, medications, and tests and procedures ordered (Figure 1). For new patients, all sections of the form are blank. For subsequent visits the diagnoses and medications from the previous visit are preprinted on the form; physicians need only update these items by writing in any changes. Updated information from the encounter form is entered into the database by the office receptionists when the patient leaves. When last assessed in 1987, the completion rate for this form was greater than 98%. The reliability of information recorded on the encounter form compares favorably with information contained elsewhere in the clinical record and contains fewer invalid diagnoses and medications than the handwritten problems list or medications sheet contained in the chart.[13] This success has been attributed to the ease with which physicians can use the encounter form.[13]

Randomization

Just before November 1, 1986, all female patients listed in the database who were 40 years of age or older were assigned, according to a computer-generated random number program, to experimental or control groups. All age-eligible new female patients seen during the study period were likewise randomized for subsequent visits.

Intervention

For the experimental group, the date of the last mammogram ordered and entered into the database was displayed in the Comments section of the encounter form for each visit. This information was printed as "last mammogram: *date,*" or, if no mammogram was on record in the encounter form database (ie, none since 1984), the notation was listed as "last mammogram: ?" According to office routine, a physician ordered a mammogram by writing for one in the Tests Ordered section of the encounter form. For the experimental group, the entering of a physician-ordered mammogram into the database automatically updated the reminder in the Comments section for subsequent visits.

Patients randomized to the control group had no information provided regarding the date of the last mammogram. Mammograms ordered for these patients during the study period were entered into the database.

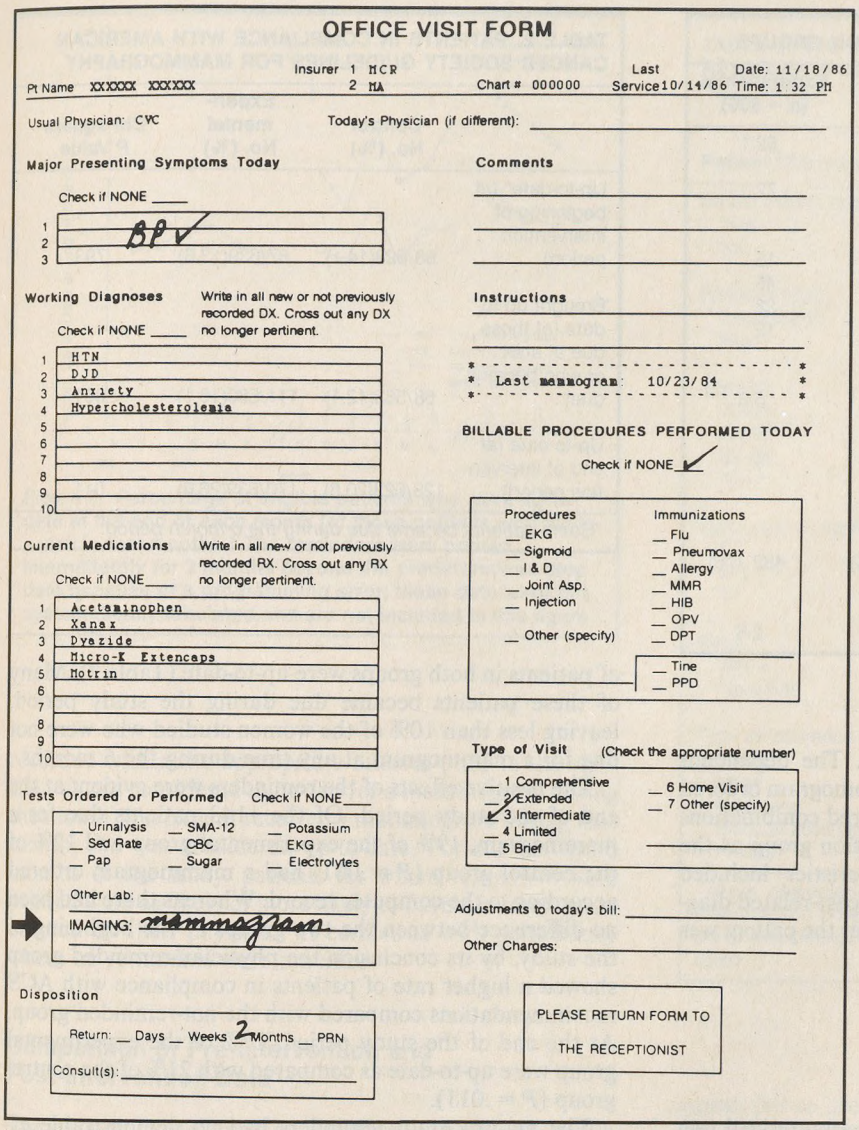
Exclusions

Established patients who made no visits during the 6 months were excluded from the analysis. If a new patient made only one visit during the 6 months, she was excluded from analysis, since the printed reminders did not begin until the visit following registration.

Patients of the two physician investigators (C.V.C., D.J.B.) for this study were also excluded from the analysis. All other physicians were uninformed as to the design of the study.

Data Analysis

Data were entered by the office receptionists into a microcomputerized database system (Metafile),[14] and were analyzed using SYSTAT,[15] a microcomputer statistical package. For the purposes of this study, the American Cancer Society (ACS) guidelines (which recommend a



OFFICE VISIT FORM

Insurer 1 MCR
Pt Name XXXXXX XXXXXX 2 MA Chart # 000000 Last Service 10/14/86 Date: 11/18/86 Time: 1 32 PM

Usual Physician: CVC Today's Physician (if different):

Major Presenting Symptoms Today

Check if NONE ____

1 BP ✓
2
3

Comments

Working Diagnoses

Write in all new or not previously recorded DX. Cross out any DX no longer pertinent.

Check if NONE ____

1 HTN
2 DJD
3 Anxiety
4 Hypercholesterolemia
5
6
7
8
9
10

Instructions

* Last mammogram: 10/23/84 *

Current Medications

Write in all new or not previously recorded RX. Cross out any RX no longer pertinent.

Check if NONE____

1 Acetaminophen
2 Xanax
3 Dyazide
4 Micro-K Extencaps
5 Motrin
6
7
8
9
10

BILLABLE PROCEDURES PERFORMED TODAY

Check if NONE ✓

Procedures
__ EKG
__ Sigmoid
__ I & D
__ Joint Asp.
__ Injection
__ Other (specify)

Immunizations
__ Flu
__ Pneumovax
__ Allergy
__ MMR
__ HIB
__ OPV
__ DPT

__ Tine
__ PPD

Type of Visit (Check the appropriate number)

__ 1 Comprehensive
__ 2 Extended
✓ 3 Intermediate
__ 4 Limited
__ 5 Brief
__ 6 Home Visit
__ 7 Other (specify)

Tests Ordered or Performed Check if NONE____

__ Urinalysis __ SMA-12 __ Potassium
__ Sed Rate __ CBC __ EKG
__ Pap __ Sugar __ Electrolytes

Other Lab:

IMAGING: mammogram

Adjustments to today's bill:

Other Charges:

Disposition

Return: __ Days __ Weeks 2 Months __ PRN

Consult(s):

PLEASE RETURN FORM TO THE RECEPTIONIST

Figure 1. A sample encounter form (generated prior to each patient visit) showing the preprinted diagnoses and medications fields as well as a reminder in the comments and instructions field noting the date of the last recorded mammogram. The ordering of a mammogram (arrow) automatically updated the reminder for subsequent visits

mammogram at least every 2 years for women in their 40s, and an annual mammogram for women aged 50 years or older) were used to calculate the percentage of subjects who were considered up-to-date. The following calculations were made: (1) percentage up-to-date as of the beginning of the study period (November 1, 1986), (2) percentage already up-to-date through the end of study period (ie, did not need a mammogram at any time during the 6 months), (3) percentage up-to-date by the end of the study period, and (4) percentage brought up-to-date (ie, received a mammogram) for those who were due at some point during the study period. If a patient became due for a mammogram during the 6 months, but made visits to the practice only while up-to-date, the patient was not considered due for a mammogram during the study period. All women 40 years of age and older who were new to the practice after November 1, 1986, were considered to be due for a mammogram, as no prior mammography history was in the database. Chi-square tests were used to compare the percentage up-to-date for the two randomization groups.

The influence of certain patient characteristics on ordering of mammograms was examined with logistic regressions using the LOGIT[16] module of the SYSTAT statistical computing package. Patients not requiring a mammogram

TABLE 1. COMPARISON OF RANDOMIZATION GROUPS

Characteristic	Control (n = 623)	Experimental (n = 639)
Mean age (yrs)	61.9	62.1
Nonwhite (%)	69	72
Primary insurance (%)		
None	17	15
Medicare	45	45
Medicaid	27	28
Private	11	12
Mean number of recorded diagnoses	5.6	5.6
Presence of breast-related diagnosis in database (%)	7	7
Number with no record of mammogram in 2 years prior to November 1, 1986 (%)	461 (74)	482 (75)
Mean number of visits during study	2.8	2.8

TABLE 2. PATIENTS IN COMPLIANCE WITH AMERICAN CANCER SOCIETY GUIDELINES FOR MAMMOGRAPHY

	Control No. (%)	Experimental No. (%)	Chi-square *P* Value
Up-to-date* (at beginning of intervention period)	88/623(14.1)	87/639(13.6)	.793
Brought up-to-date (of those due at start or who became due)	68/563(12.1)	111/580(19.1)	.001
Up-to-date (at end of intervention period)	128/623(20.6)	170/639(26.6)	.011

**Some patients became due during the 6-month period.*

during the study period were excluded. The dependent variable was the proportion having a mammogram ordered during the 6 months. The models considered combinations of patient characteristics and randomization group as the independent variables. Patient characteristics included age, race, number of visits, presence of breast-related diagnosis, type of insurance, if any, and whether the patient was new to the practice.

RESULTS

More than 4000 female patients in the computerized registration file and eligible for this study were randomized to the experimental and control groups. Of these, 1262 made at least one visit during the 6-month study period and were considered in the analyses (Table 1). The subjects in the experimental and control groups were similar in age, race, insurance coverage, and complexity of disease as estimated by the mean number of diagnoses recorded in the database. Seven percent of the women in each group had a diagnosis relating to the breast (eg, fibrocystic breast disease) listed among these diagnoses. One fourth of the subjects had a physician-ordered mammogram recorded in the database in the 2 years prior to the study period. The mean number of visits made by the patients in the two groups was similar.

At the beginning of the intervention, approximately 14% of patients in both groups were up-to-date (Table 2). Many of these patients became due during the study period, leaving less than 10% of the women studied who were not due for a mammogram at any time during the 6 months.

The positive effects of the reminders were evident at the end of the study period. Of the 1143 patients due for a mammogram, 19% of the experimental group and 12% of the control group ($P = .001$) had a mammogram ordered according to the computer record. Whereas there had been no difference between the two groups at the beginning of the study, by its conclusion the physician-reminded group showed a higher rate of patients in compliance with ACS recommendations compared with the not-reminded group. At the end of the study period, 27% of the experimental group were up-to-date as compared with 21% of the control group ($P = .011$).

The mammogram reminders had no demonstrable effects on the ordering of other health screening tests; there were no differences between the experimental and control patients before or after the intervention with regard to number of Papanicolaou tests performed or fecal occult blood tests distributed or performed.

Temporal Trend During Intervention Period

Potential temporal changes in the effects of the intervention were investigated by considering each month of the 6-month study period as if it were an individual study period, ie, only those women who made a visit during a given month were included. If a patient had a mammogram

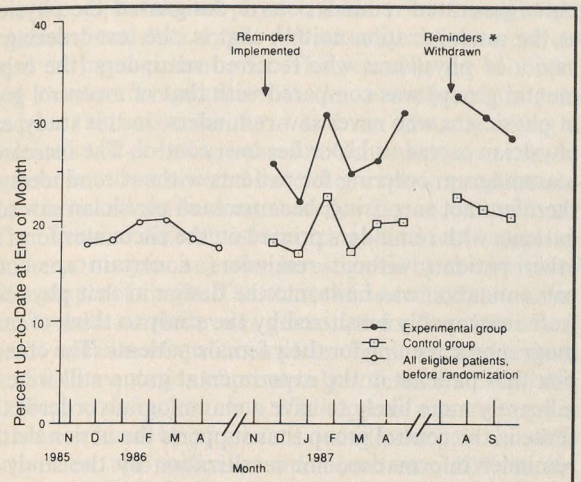


Figure 2. Percentage of eligible patients who were up-to-date at the end of each month (of those patients who made a visit in that month). * The reminders were printed intermittently for 2 months beyond the predetermined stop date because of a programming error; these data were not systematically tabulated and are not included in this figure

recorded within the appropriate interval prior to the visit, she was not considered to be due for a mammogram during the month. If a patient received a mammogram during that month, she was considered up-to-date. For each of the 6 months of the study, patients for whom reminders were printed were as likely or more likely to have a mammogram ordered by their physician as compared with patients for whom no reminders were provided.

Comparison of Pre-intervention and Post-intervention Data

The data from the study period were also compared with data on a similar population during a 6-month period exactly 1 year earlier (November 1, 1985, to April 30, 1986) and with the same population during a 3-month period soon after the tickler was removed (July 1, 1987, to September 30, 1987). These data are graphically represented in Figure 2. Before the intervention was implemented, the percentage of eligible patients who were up-to-date at the end of each month was consistently between 18% and 20%. During the intervention period there was an increase in the number of patients brought into compliance with mammography recommendations. Because of a programming error, however, complete cessation of reminders was delayed 2 months. After the reminders were stopped, the percentage of patients who were brought up-to-date each month fell to pre-intervention levels of approximately 4% per month for both the experimental group and control group. This trend is shown by the steady decline in the percentage of the experimental and control patients up-to-date at the end of each month during the post-intervention period.

TABLE 3. CHARACTERISTICS ASSOCIATED WITH RESPONSE TO COMPUTER-GENERATED REMINDERS

Patient Characteristics	Number	Percent Brought Up-to-Date	
		Control	Experimental
Breast-related diagnosis*			
Yes	77	23.1	29.0
No	1066	11.3	18.5
Patient status			
Established	1058	11.9	18.8
New	85	14.0	23.8
Age (yr)			
40–49	226	12.4	16.8
50–59	259	11.1	15.0
60–69	322	13.0	21.4
70+	335	11.8	21.7
Visits over 6 months*			
1	320	8.6	15.6
2–3	506	14.6	18.0
4+	312	11.3	24.7
Race			
White	317	12.0	16.7
Nonwhite	750	12.9	19.4
Type of insurance (primary)			
None	182	10.4	15.1
Medicare	520	13.7	22.6
Medical assistance	306	11.4	16.6
Private	135	9.5	16.7

**These characteristics were significant predictors ($\alpha = .10$) of mammogram ordering in logistic regression models containing the characteristics and randomization group as independent variables.*

Patient Characteristics Associated With Levels of Response

The effect of the reminders in the presence of specific patient characteristics was analyzed, and the data are presented in Table 3. For all subgroups examined, a higher percentage of patients randomized to the experimental group had mammograms ordered than of patients random-

ized to the control group. Factors other than randomization that appeared to influence the ordering of mammograms included the presence of a breast-related diagnosis, the number of visits made during the 6-month study period, patient age and primary insurance coverage, and the residency background of the patient's physician.

Patients with a breast-related diagnosis in the clinical database were more likely to receive a mammogram than patients without such a diagnosis regardless of randomization; however, the reminders had a similar effect regardless of whether a breast-related diagnosis was listed. Patients who made four or more visits benefited more from the reminder (25% compared with 11%) than those who made two or three visits (18% compared with 15%). Those making only one visit were least likely to have a mammogram ordered in either group.

The reminders increased the ordering of mammograms more for women aged 60 years and older than for those aged 40 to 59 years. When patients were grouped by their primary insurance coverage, women with Medicare, again an older part of the study population, benefited most from randomization to the reminded group. Uninsured patients had the smallest difference between groups (15% compared with 10%).

The effect of the reminder remained statistically significant in the presence of all other factors using multiple logistic regression models. Patient factors evaluated were randomization group, age, race, number of visits made during the study period, presence of breast-related diagnosis in database, insurance status, type of insurance, and whether the patient was new to the practice. In a model containing all of these variables, three factors were statistically significant determinants of whether a mammogram was ordered (at $\alpha = .10$): breast-related diagnosis ($P = .002$) was the most important determinant, followed by the reminder (randomization group ($P = .037$) and number of visits made ($P = .099$).

DISCUSSION

This study shows that a microcomputerized reminder system can be used to increase physicians' compliance with preventive health screening recommendations. Computer reminder messages incorporated into an ongoing encounter form system had a significant and persistent effect on physician behavior resulting in an increase in mammogram ordering in the experimental group. Consistent with the assumption that a major reason for failure to comply with accepted standards for health screening is provider forgetfulness, there was a decline in mammogram ordering in the 3 months following removal of the reminder.

Previous studies designed to measure the effects of computer-generated reminders have designated the physician as the randomization unit[8,12]; that is, the test-ordering behavior of physicians who received reminders (the experimental group) was compared with that of a control group of physicians who never saw reminders. In this study, each physician served as his or her own control. The increase in mammogram ordering for patients without reminders was therefore not surprising; because each physician saw some patients with reminders printed on the encounter form and other patients without reminders, a certain amount of contamination was built into the design in that physicians were inescapably sensitized by the study to think of mammography screening for their female patients. The observation that patients in the experimental group still were significantly more likely to have a mammogram ordered than those in the control group thus supports the notion that the reminder information, not sensitization by the study (ie, the Hawthorne effect), is responsible for the results.

An alternative explanation for the increase in mammogram ordering, that physicians felt obliged to order a test they would not otherwise have recommended, seems unlikely. Physicians resist suggestions to order tests they think are inappropriate.[8] Moreover, the printed messages did not mandate a correct interval for mammogram screening; the date of the last study ordered and recorded in the database was provided, and the clinician decided whether a repeat study was indicated.

Previous research has shown that physicians are more apt to attend to the health maintenance needs of certain patient types. Patients new to a practice are more likely to receive health screening than either established patients[17] or patients with chronic diseases.[18] Similarly, though mammography screening has one of the lowest rates of compliance among health screening recommendations,[1,5] more mammograms are ordered for women who are at high risk[1] or who have a previous diagnosis of fibrocystic breast disease.[19] These patient characteristics were associated with an increased likelihood that a mammogram would be ordered in this study as well. The reminders also had a significant effect on physician behavior for established patients without a breast-related diagnosis in the database. These relatively lower risk patients, without a clinical history to flag the physician's attention, may be the group most likely to benefit from reminders to their physicians.

There are potential limitations of this study related to the inherent properties of a computer-generated reminder system and to the choice of mammography screening as to the physician behavior selected for the study. First, data in the computer record could be incomplete and inaccurate. There was no attempt to collect and enter data from any patient's preregistration history. Some patients saw other physicians within the medical center or elsewhere for part of their medical care and could have had mammograms performed that were not entered in the database. Further-

more, the difference in physician behavior found in the encounter form data might not actually reflect what occurred during a patient visit. Theoretically, the reminder could increase compliance with the recording of tests ordered on the encounter form and not actually affect a physician's test-ordering behavior. Conversely, more mammograms could be ordered for either experimental or control patients and not be documented on the encounter form.

The effects of differential reporting (bias) and completeness of reporting (noise) were investigated by the review of a 10% sample of charts. The charts reviewed indicated that an inaccurate reminder was generated for less than 1% of patients because of an incomplete computer record from lack of documentation of previously ordered studies within the office, and for less than 3% because a mammogram had been ordered by physicians outside the practice. The chart review also indicated that more than 80% of the mammograms ordered, as abstracted from the chart, were also noted on the encounter form. There was no difference between chart documentation for experimental and control patients. Because the primary dependent variable of interest was physician behavior, no attempt was made to assess systematically whether patients followed through with scheduled appointments for mammography or whether mammogram reports were filed in the office charts.

While the large number of patients in this study would provide sufficient power to detect even a small effect from the intervention, the clinical importance of a 50% increase in physicians' attention to screening mammography should not be minimized. Nonetheless, the impact of this intervention is not so large as desired. First, the potential benefits of office-based reminder systems are limited to patients who make visits to their physicians. Only about 30% of all the eligible patients listed in the database made an office visit during the study period. Furthermore, although patients randomized to receive the printed reminders benefited from the intervention, 73% were still not up-to-date with accepted guidelines for mammography at the end of the 6-month period. This study did not address the issue of why mammograms were not ordered in seemingly appropriate situations. Administrative interventions, such as reminders to physicians, may not be sufficient to overcome other barriers to compliance with published recommendations.

In a survey of a large group of physicians in a hospital-based ambulatory practice, the frequency for screening mammograms recommended by clinicians was every 3.9 years for women aged 51 to 60 years and every 4.8 years for women older than 60 years.[2] Only 11% of physicians claim to follow or exceed ACS guidelines for all female patients.[3] Clearly, a patient's insurance category may influence compliance with recommendations for mammography screening. Patient factors other than cost, including fear of radiation and discomfort, may also explain in part the small number of mammograms ordered.[1,3] Higher response rates to reminders have been found when the interventions suggested are more widely accepted by physicians and patients than mammography.[8]

The introduction of flow sheets into patient charts has improved physician compliance with health screening recommendations in several previous short-term studies; however, most screening evaluations are documented only in the progress notes.[4,9] The flow sheets themselves are reliably completed in only 17% to 29% of patients' charts.[4,9] Since the long-term usefulness of a flow sheet is dependent upon its completion rate, and it is time-consuming to find health screening information in previous clinical notes during a routine patient visit, the value of the flow sheet as a data-storage device is limited. Given the ease with which physicians can update the health screening information fed back to them from the ongoing computerized database used in this study, periodic computer-generated reminders may represent a more efficient and effective system for data retrieval.

Previous research has shown that physicians respond to reminders generated by a VAX minicomputer system.[8] Because of its modest cost to implement and maintain, the microcomputerized tickler system described in this study is potentially applicable to a broader range of clinical practices. This system is designed for maximum convenience in collecting the appropriate and necessary clinical information, is linked to a billing module, and allows reminder messages based on practice preferences to be easily introduced and modified. It can be a valuable assistant, therefore, in improving the compliance of primary care physicians with intended screening practices.

Acknowledgments

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