DOI: 10.1377/hlthaff.2011.0876
HEALTH AFFAIRS 31,
NO. 3 (2012): 488–496

By Danny McCormick, David H. Bor, Stephanie Woolhandler, and David U. Himmelstein

Giving Office-Based Physicians Electronic Access To Patients' Prior Imaging And Lab Results Did Not Deter Ordering Of Tests

Danny McCormick (DMccormick@challiance.org) is an assistant professor of medicine at Harvard Medical School, in Boston, and director of the Division of Social and Community Medicine, Department of Medicine, Cambridge Health Alliance, in Cambridge, Massachusetts.

David H. Bor is the chief of medicine at Cambridge Health Alliance.

Stephanie Woolhandler is a professor at the CUNY School of Public Health at Hunter College, in New York City.

David U. Himmelstein is a professor at the CUNY School of Public Health at Hunter College.

ABSTRACT **Policy-based incentives for health care providers to adopt health information technology are predicated on the assumption that, among other things, electronic access to patient test results and medical records will reduce diagnostic testing and save money. To test the generalizability of findings that support this assumption, we analyzed the records of 28,741 patient visits to a nationally representative sample of 1,187 office-based physicians in 2008. Physicians' access to computerized imaging results (sometimes, but not necessarily, through an electronic health record) was associated with a 40–70 percent greater likelihood of an imaging test being ordered. The electronic availability of lab test results was also associated with ordering of additional blood tests. The availability of an electronic health record in itself had no apparent impact on ordering; the electronic access to test results appears to have been the key. These findings raise the possibility that, as currently implemented, electronic access does not decrease test ordering in the office setting and may even increase it, possibly because of system features that are enticements to ordering. We conclude that use of these health information technologies, whatever their other benefits, remains unproven as an effective cost-control strategy with respect to reducing the ordering of unnecessary tests.**

Health policy experts, consultants, policy makers, and the Obama administration have argued that widespread adoption of health information technology will result in substantial cost savings.[1–6] In fact, support for passage of the Health Information Technology for Economic and Clinical Health (HITECH) provisions of the American Recovery and Reinvestment Act of 2009, which dramatically expanded federal expenditures for the adoption of health information technology, rested heavily on this argument.[7]

Reduced ordering of imaging and other diagnostic studies is often cited as a likely mechanism for cost savings related to health information technology. The use of imaging studies—particularly advanced imaging, or computerized tomography scans, positron emission tomography, and magnetic resonance imaging—has escalated dramatically.[8] In 2002 it accounted for more than 14 percent of Medicare Part B expenditures.[9]

Health information technology might be expected to decrease the use of diagnostic imaging in several ways. Providing physicians with electronic access to prior imaging test results might reduce redundant test ordering, especially for expensive advanced imaging. Even in the absence of prior imaging, the improved availability of data from previous physical examinations and diagnoses might reassure clinicians that a current abnormality is both long-standing and stable, and hence that it doesn't require further investigation.

Finally, electronic point-of-order decision support that provides real-time feedback on imaging test appropriateness might prompt physicians to order fewer tests that are not clinically indicated for a particular patient.

However, it is also plausible that more convenient access to results could encourage physicians to increase their test ordering. Studies in various settings have found that diagnostic tests are frequently duplicated.[10–13]

Researchers—mostly at a few flagship hospitals with cutting-edge academic computing groups that employ customized health information technology—have demonstrated that such technology can reduce total ordering of radiologic and other diagnostic tests by presenting ordering physicians with computerized results of prior tests,[14,15] costs of tests,[16] and feedback about the clinical utility of the test for a particular patient.[17,18] Yet no studies have examined whether these improvements are generalizable to current outpatient medical practice, where computer technology is commonly an "off-the-shelf" product rather than a customized one, or whether they apply specifically to the ordering of imaging tests.

We therefore analyzed data on a nationally representative sample of US office visits to determine whether the computerized availability of imaging results or image viewing, or the use of a full electronic health record, is associated with reductions in imaging test ordering. Computerized imaging results or viewing can be obtained either through limited computer systems designed specifically for that function or as part of a full electronic health record that contains comprehensive information on a patient's medical history, including such things as progress notes and lists of medical problems and medications.

To assess whether the relationship of the computerized availability of imaging results to image test ordering was generalizable to other test ordering, we also examined whether computerized access to laboratory results reduced the ordering of blood tests.

Study Data And Methods

We analyzed data from the 2008 National Ambulatory Medical Care Survey, a survey of 28,741 patient visits to a nationally representative sample of the offices of 1,187 nonfederal physicians.[19] The survey excludes hospital outpatient departments and offices of radiologists, anesthesiologists, and pathologists. The National Center for Health Statistics conducts the survey with assistance from the Census Bureau. The center provided weights to allow extrapolation to the universe of office visits nationally.

The survey collects information about the practice setting, including detailed information about computerization, as well as about the characteristics of the patients seen and the tests ordered at each surveyed visit. For the roughly one-third of visits that lacked information on patients' race and ethnicity, the National Center for Health Statistics imputed these data.

To assess whether computerized access to imaging results reduced the ordering of imaging, we separately analyzed predictors of whether a patient received a computed tomography scan; magnetic resonance imaging; any advanced imaging procedure (computed tomography scan, magnetic resonance imaging, or positron emission tomography scan); or any image (an advanced image, X-ray, bone density measurement, ultrasound, or other image).

We examined two indicators of physicians' access to imaging results. The first was whether the practice had what the survey called "a computerized system for viewing imaging results"—that is, a system that presents a text report of a physician's interpretation of the imaging study, an actual visual electronic radiologic image, or both. The second was, for those practices with such a system, whether "electronic images [were] returned"—that is, whether in addition to or in place of a text report, the actual visual images were returned electronically.

In those few cases where physicians indicated that they had such a system but its capability was "turned off," we considered that they did not have access to imaging results.

STATISTICAL ANALYSIS We first analyzed the bivariate frequency of image test ordering according to patient, health insurance, and practice characteristics, including computerization. We then constructed multivariate logistic regression models. The outcome variables were the ordering of each type of imaging test (computed tomography, magnetic resonance imaging, any advanced imaging, and any imaging), and the predictor variable was the availability of computerized test results reporting.

Our initial set of models controlled only for patient characteristics and insurance type, as follows: age (less than 18 years, 18–45 years, 46–64 years, or more than 64 years); sex; race (black or nonblack); ethnicity (Hispanic or non-Hispanic); whether or not the patient resided in a ZIP code with a higher than median level of poverty; and whether or not the patient had been seen previously by the physician. The type of insurance was coded as private insurance, Medicare, Medicaid, none, or other.

We then constructed a second set of logistic regression models with the same outcome and predictor variables that included all of the patient and insurance characteristics above, as well as the following practice characteristics: urban location; physician's employment status (practice owner or employee/contractor); whether the practice was owned by a hospital; whether the physician was a solo practitioner; whether the physician's compensation was based, in part or whole, on "profiling" (that is, the use of epidemiologic methods to compare physician practice patterns across various quality-of-care and cost dimensions); whether the practice was predominantly prepaid (defined as a practice owned by or located within a health maintenance organization, or one receiving more than 50 percent of its revenue from capitation payments or from case rates); whether the practice had a computerized system for viewing actual images; and a few categorical variables for physician specialty and practice setting. The reference categories for the categorical variables were surgical specialty, private insurance, and private office, respectively.

To explore whether controlling for additional patient and physician characteristics would alter our findings, we carried out several sensitivity analyses. First, we substituted (alternately) a fourteen-level and a seven-level variable for physician specialty for the three-level specialty variable in the main models. Second, we added indicators of whether, at the time of the visit, the patient had cancer, cerebrovascular disease, congestive heart failure, ischemic heart disease, or diabetes.

Third, we explored whether the correlation between test ordering and electronic access to test results might reflect some physicians' nonspecific affinity for technology. In other words, were there "tech savvy" doctors who were more likely to both order more imaging and acquire and use a computer?

We therefore conducted supplemental analyses, in which we examined physicians' reported use of an electronic health record and computerized physician order entry. We began by analyzing these variables as independent predictors of test ordering, substituting them for the computerized test retrieval variables in the final logistic regression models described above. We then analyzed the variables as possible confounders by adding them to the final models, along with indicators of electronic access to test results.

Last, we explored the possibility that financial self-interest might explain physicians' ordering of imaging tests. Previous studies have suggested that physicians with a financial interest in imaging facilities, either in their own practice or an external facility, are more likely to order such tests, a practice known as "self-referral."[20–22] This association has been seen to persist after controlling for patient characteristics, illness severity, and physician specialty.[22]

Unfortunately, the survey data used in the present investigation do not include direct information on physicians' financial interests in imaging facilities. Thus, to explore this issue, we examined whether the association between electronic access to imaging results and test ordering persisted in multivariate models that added controls for a physician's likelihood of self-referral. For these models, we classified physicians as having a higher versus a lower likelihood of self-referral. We assumed that physicians practicing in a community health center or health maintenance organization were in the lower group because individual physicians in these settings would be very unlikely to have an financial stake in radiologic tests being performed. We added to that group those physicians in other practice settings who derived more than 50 percent of their revenue from capitation or case rates because physicians' financial incentives in these arrangements would, if anything, favor limiting the ordering of imaging tests.

Finally, in an additional sensitivity analysis, we ran again the full models for each outcome after excluding three physician specialties—orthopedics, neurology, and cardiology—that are associated with a large proportion of imaging self-referrals, according to a recent Medicare Payment Advisory Commission report.[23]

In supplemental analyses, we also examined whether computerized access to laboratory results reduced the ordering of blood tests, using the same modeling strategy as described for our principal analysis of image ordering. For blood tests, we examined another indicator in the survey: "Does your practice have a computerized system for viewing lab results?" The model examining predictors of blood test ordering also included a variable indicating the presence of an on-site laboratory.

All analyses were done using the Surveyfreq and Surveylogistic procedures in the statistical analysis software SAS, version 9.1. These procedures adjust confidence intervals for the complex sample design.

After review, the Institutional Review Board of Cambridge Health Alliance waived the requirement for approval for this study.

LIMITATIONS We did not have direct information on the extent to which physicians in this study self-referred. Therefore, we cannot exclude the possibility that confounding by self-referral fully explains our findings. However, our sensitivity analyses cast doubt on that explanation. When we excluded physician specialties most strongly associated with imaging self-referral (and when we added to our main models variables indicative of the likelihood of self-referral), the associations between image ordering and computerized access to image results or image viewing remained substantially the same.

In addition, we cannot dismiss the possibility that physicians predisposed to order tests for reasons other than self-referral are also more likely to purchase computerized image reporting and viewing systems. Our data source did not indicate whether a physician's computer system included online decision support or other features that might affect image ordering. Nor did it provide information about some physician characteristics, such as age, that might affect both test ordering and computerization. In addition to the lack of direct data on physician self-referral, these are important limitations of our analysis.

Yet, as detailed below, other indicators of office computerization—computerized physician order entry and the use of an electronic health record system—showed no association with test ordering. Hence, it appears that our results cannot be explained simply by the presence of doctors who use both more computers and more testing than their less "tech savvy" colleagues.

One additional important caveat applies to our findings. We could not assess whether the increased imaging associated with electronic access to results helped or harmed patients, an issue that warrants further study.

Study Results

IMAGING ANALYSES Using bivariate analyses, we found that access to electronic imaging results was strongly associated with greater imaging ordering. For example, physicians without such access ordered imaging in 12.9 percent of visits, whereas physicians with access ordered imaging in 18.0 percent of visits (Exhibit 1; for additional results, see Appendix Exhibit 1).[24]

Image ordering rates were much lower for children than for adults (Exhibit 1) and for return visits to the same practice, as compared to initial visits (Appendix Exhibit 1).[24] Women received more imaging studies overall than men—perhaps reflecting their use of mammograms and ultrasound studies— but not more advanced imaging (Exhibit 1).

In multivariate models adjusted only for patient characteristics (data not shown), the positive association between the availability of electronic results and imaging test ordering persisted, with odds ratios of 1.44 (95% confidence interval: 1.23, 1.69) for any image, 2.03 (95% confidence interval: 1.48, 2.76) for advanced images, 2.02 (95% confidence interval: 1.48, 2.76) for magnetic resonance imaging, and 1.98 (95% confidence interval: 1.40, 2.82) for computed tomography scans.

Similarly, physician access to the actual image remained strongly associated with image ordering, with odds ratios of 1.50 (95% confidence interval: 1.26, 1.79) for any image, 2.15 (95% confidence interval: 1.53, 3.02) for advanced images, 1.87 (95% confidence interval: 1.37, 2.57) for magnetic resonance imaging, and 2.36 (95% confidence interval: 1.54, 3.64) for computed tomography scans.

For all of our analyses, odds ratios can be interpreted as a ratio of the odds of an event occurring in an exposed group to the odds of the same event occurring in a control group. For example, an odds ratio of 0.87 means that in one group the outcome is about 13 percent (1 – 0.87) less likely than in the comparison group. An odds ratio of 1.40 means that in one group the outcome is about 40 percent more likely than in the comparison group.

In this case, an odds ratio of greater than 1 indicates a higher probability, and an odds ratio of less than 1 indicates a lower probability, of image ordering occurring at an office visit, given the predictor controlled for. Thus, if the odds ratio for image ordering given the availability of electronic results is 1.4, this represents a 40 percent increase in the likelihood of image ordering when such results are available.

Further adjustment for practice characteristics modestly reduced the positive associations between computerized access to imaging results and the likelihood of ordering an imaging test. Exhibit 2 displays the results of the full multivariate models for predictors of ordering any imaging test (see Appendix Exhibit 2[24] for 95% confidence intervals for all variables). Exhibit 3 displays the full models for ordering of advanced imaging (see Appendix Exhibit 3 for 95% confidence intervals for all variables).[24] The full multivariate models for magnetic resonance imaging and computed tomography scans separately yielded similar results. However, the positive association between electronic image viewing and ordering magnetic resonance imaging was of borderline significance (data not shown).

SENSITIVITY ANALYSES In sensitivity analyses that included patient and practice characteristics, but not indicators of electronic access to test results, neither having an electronic health record system nor using computerized physician order entry was associated with the likelihood of image ordering. When we added computerized

EXHIBIT 1

Frequency Of Physicians' Image Test Ordering During Office Visits, By Patient And Practice Characteristics (Weighted)

Patient/practice characteristic	Percent of visits in which physician ordered: Any image	Any advanced image	Magnetic resonance imaging	Computed tomography scan
SEX				
Female ($n = 16,751$)	16.9****	3.3	1.6	1.6
Male ($n = 11,990$)	13.0	3.4	1.7	1.6
AGE (YEARS)				
< 18 ($n = 5,180$)	5.8****	0.6 ****	0.4****	0.2****
18–45 ($n = 7,945$)	14.9	3.0	1.7	1.2
46–64 ($n = 8,405$)	20.1	4.8	2.4	2.3
> 64 ($n = 7,211$)	17.8	3.9	1.5	2.2
RACE				
Black ($n = 3,384$)	14.1	3.7	1.9	1.7
Nonblack ($n = 25,357$)	15.5	3.3	1.6	1.6
TYPE OF INSURANCE				
Private ($n = 14,507$)	15.5****	3.2****	1.7****	1.4***
Medicare ($n = 6,689$)	17.4	4.1	1.5	2.3
Medicaid ($n = 3,617$)	9.5	1.9	1.0	0.9
Other ($n = 1,057$)	23.7	5.9	3.9	2.0
None ($n = 1,697$)	10.1	2.5	1.2	1.3
PHYSICIAN SPECIALTY				
Primary care ($n = 14,701$)	13.4****	2.2****	1.1****	1.1****
Surgical specialty ($n = 6,996$)	20.7	5.1	2.6	2.4
Medical specialty ($n = 7,044$)	15.6	5.0	2.3	2.4
PRACTICE SETTING				
Private office ($n = 23,669$)	15.6	3.3	1.6	1.6
Community health center ($n = 3,355$)	10.8	2.6	1.3	1.3
Health maintenance organization ($n = 645$)	12.6	4.5	2.7	1.8
Free-standing clinic ($n = 842$)	10.3	2.0	1.6	0.4
Other office ($n = 240$)	21.5	7.4	5.9	1.5
PHYSICIAN OWNS PRACTICE				
Yes ($n = 17,921$)	15.0	3.2	1.6	1.5
No ($n = 10,697$)	16.1	3.7	1.8	1.7
PHYSICIAN HAS COMPUTERIZED SYSTEM FOR:				
Accessing imaging results				
Yes ($n = 13,401$)	18.0****	4.5****	2.2****	2.2****
No ($n = 14,848$)	12.9	2.5	1.1	1.1
Viewing actual images				
Yes ($n = 6,458$)	18.9****	5.1****	2.3****	2.6****
No ($n = 18,543$)	13.4	2.4	1.2	1.1

SOURCE Authors' analysis of data from the 2008 National Ambulatory Medical Care Survey. **NOTES** Of the 28,741 physician visits in the study, 4,335 resulted in an order for any imaging; 1,117 in an order for any advanced imaging; 612 in an order for magnetic resonance imaging; and 496 in an order for a computed tomography scan. Some office visits had missing information on variables in this table. Thus, for some variables, the sum does not equal the total number of visits analyzed in the study. ***$p < 0.01$ ****$p < 0.001$

physician order entry or an electronic health record system to the models that included indicators of electronic access to test results, those additions had virtually no impact on the odds ratios of these indicators.

For instance, the odds ratios for association between electronic image viewing and ordering an advanced image increased only slightly, from 1.78 in the original model to 1.93 in a model that included indicators for the presence of both a full electronic health record and computerized physician order entry. Similarly, including these two variables increased the odds ratio for the association between ordering any advanced image and the availability of electronic access to imaging results from 1.71 to 1.86. In all models, the odds ratios for the presence of an electronic health record and for computerized order entry were not significant (data not shown).

As noted above, excluding physician specialties most strongly associated with imaging self-referral did not have a major effect on the associations between image ordering and computerized access to either image results or image viewing.

SUPPLEMENTAL ANALYSES In bivariate analyses, computerized access to laboratory test results was associated with a greater likelihood of ordering a blood test (data not shown), a finding that persisted in multivariate analyses adjusted for patient characteristics (odds ratio 1.54; 95% confidence interval: 1.24, 1.99). In the full model including practice characteristics, however, this association was of borderline significance (Appendix Exhibit 4).[24]

Discussion And Conclusion

We found no evidence that office-based physicians with electronic access to imaging or blood test results order fewer imaging tests or blood tests, respectively. Indeed, at least for imaging, the reverse may be true: Facilitating physicians' access to test results through computerization may increase diagnostic image ordering.

One possible explanation for our findings is that ready access to imaging results, or to the images themselves, reduces the time and effort required to review study results. The effect may be to provide subtle encouragement to physicians to order more imaging studies. In borderline situations, substituting a few keystrokes for the sometimes time-consuming task of tracking down results from an imaging facility may tip the balance in favor of ordering a test. This "convenience" effect of computerized access might cancel out the potential decreases in ordering due to reductions in duplicate or unnecessary testing.

There are, however, other possible explanations for the associations we observed, and it may be that more than one explanation is correct. Perhaps physicians who order more imaging studies, for whatever reason, are more likely to acquire health information technology that facilitates the retrieval of imaging results or images.

For example, as mentioned above, physicians who have a financial stake in imaging are more likely to order imaging tests. If these physicians are also more likely to purchase health information technology systems with image results capability, then self-referral—rather than electronic access by itself—might explain our results.

OTHER STUDIES Our findings are not consistent with the widespread expectation that computerization will reduce excessive image ordering and perhaps other types of duplicative testing,[2,4,6,13,25] an expectation shared by President Obama[3] and the previous national coordinator for health information technology.[26]

This assumption was incorporated in two widely cited estimates of the likely savings from computerization. One projected annual savings of up to $77.8 billion,[6] including $8.3 billion on imaging and $8.1 billion on lab testing. The other foresaw more than $81 billion in savings,[2] including $1.3–5.3 billion annually on outpatient radiology and lab testing. In contrast, systematic reviews have found evidence for cost and quality benefits of health information technology at only a few institutions, with few data to support claims of more widespread benefits.[27,28]

Two randomized trials and one using historical controls at academic hospitals have shown that electronic health records that present recent

EXHIBIT 2

Adjusted Odds Of Ordering Any Imaging Test, By Patient And Practice Characteristics

Patient/practice characteristic	Odds ratios, results model[a]	Odds ratios, images model[b]
Female	1.44****	1.42****
Age (years)		
< 18 (reference)	1.00	1.00
18–45	2.69****	2.89****
46–64	3.82****	4.20****
> 64	3.13****	3.24****
Black race	0.87	0.86
Hispanic ethnicity	0.89	0.88
Lives in ZIP code > median poverty	0.94	0.93
Lives in urban location	1.07	1.07
Seen previously by physician	0.53****	0.55****
Type of insurance		
Private (reference)	1.00	1.00
Medicare	0.99	0.98
Medicaid	0.86	0.87
Other	1.56***	1.71****
None	0.69**	0.62***
Physician specialty		
Surgical specialty (reference)	1.00	1.00
Primary care	0.77**	0.80
Medical specialty	0.73	0.70
Practice setting		
Private office (reference)	1.00	1.00
Community health center	0.64***	0.67**
Health maintenance organization	0.38****	0.39**
Free-standing clinic	0.54	0.80
Other office	1.36	0.82
Solo practitioner	0.63****	0.62****
Physician owns practice	0.86	0.85
Practice mostly prepaid[c]	0.99	0.98
Hospital-owned practice	0.93	1.01
Physician compensation based on cost profiling	1.03	1.09
Computerized system for accessing imaging results	1.40****	—[d]
Computerized system for viewing actual images	—[d]	1.45****

SOURCE Authors' analysis of data from the 2008 National Ambulatory Medical Care Survey. [a]Multivariate logistic model for availability of imaging results. [b]Multivariate logistic model for availability of actual images. [c]Office setting or practice ownership designated as health maintenance organization, or > 50 percent of patient care revenues from capitation or case rates. [d]Not applicable. $^{**}p < 0.05$ $^{***}p < 0.01$ $^{****}p < 0.001$

EXHIBIT 3

Adjusted Odds Of Ordering Any Advanced Imaging Test, By Patient And Practice Characteristics

Patient/practice characteristic	Odds ratio, results model[a]	Odds ratio, images model[b]
Female	0.97	0.95
Age (years)		
< 18 (reference)	1.00	1.00
18–45	4.10****	3.83****
46–64	6.34****	6.44****
> 64	5.28****	5.21****
Black race	1.11	1.04
Hispanic ethnicity	0.81	0.82
Lives in ZIP code > median poverty	0.97	1.04
Lives in urban location	1.05	1.02
Seen previously by physician	0.55****	0.56****
Type of insurance		
Private (reference)	1.00	1.00
Medicare	1.07	1.03
Medicaid	1.15	1.13
Other	1.66**	2.03***
None	1.00	1.02
Physician specialty		
Surgical specialty (reference)	1.00	1.00
Primary care	0.63***	0.61**
Medical specialty	1.01	0.97
Practice setting		
Private office (reference)	1.00	1.00
Community health center	1.27	1.34
Health maintenance organization	1.56	1.23
Free-standing clinic	0.73	0.87
Other office	1.81	0.41
Solo practitioner	0.60****	0.61***
Physician owns practice	1.44**	1.46**
Practice mostly prepaid[c]	0.86	1.00
Hospital-owned practice	2.49***	2.75***
Physician compensation based on cost profiling	1.24	1.30
Computerized system for accessing imaging results	1.71****	—[d]
Computerized system for viewing actual images	—[d]	1.78***

SOURCE Authors' analysis of data from the 2008 National Ambulatory Medical Care Survey. [a]Multivariate logistic model for availability of imaging results. [b]Multivariate logistic model for availability of actual images. [c]Office setting or practice ownership designated as health maintenance organization, or > 50 percent of patient care revenues from capitation or case rates. [d]Not applicable. $^{**}p < 0.05$ $^{***}p < 0.01$ $^{****}p < 0.001$

results[29,30] or advise providers on appropriate test ordering, including imaging,[31] can reduce testing. However, the decision support features in these studies are not in widespread use. One recent analysis noted that patients transferred between two hospitals with electronic health records frequently underwent duplicate tests, perhaps because the two computer systems were not interoperable.[10]

Limited data are available on computerization's impact on imaging costs in ambulatory settings. At the Regenstrief Institute, in Indiana, computer programs that presented the ordering physician with previous results,[15] test cost data,[16] or the probability of a normal result[17] reduced test ordering. An earlier study at the same institution found that providing emergency department physicians with computer-generated paper summaries of patients' medical records resulted in decreased image ordering.[14]

A more recent study of a single integrated health care system (Virginia Mason Medical Center) demonstrated a decline in image ordering following the implementation—and mandatory use—of a clinical decision support system for advanced imaging.[18] Some studies have noted increased efficiency in radiology departments through computerization,[32] but they have not documented overall testing costs.

Perhaps office computerization has not yet reduced imaging use because current systems are cumbersome, insufficiently interoperable,[33] or lack effective decision support software. If so, savings on imaging may emerge in the future. However, our finding that there were particularly high rates of testing in hospital-owned practices, where current levels of interoperability and decision support are probably highest, argues against this view.

POLICY IMPLICATIONS Our findings may have several policy implications. The results suggest that the federal government's ongoing, multibillion-dollar effort to promote the adoption of health information technology may not yield anticipated cost savings from reductions in duplicative diagnostic testing.[5,7] Indeed, it is possible that computerization will drive costs in this area up, not down.

Insurers and health care providers should also be wary of claims that computerization alone will lead to a more parsimonious practice style. Our results emphasize the salience of other approaches to reducing imaging costs, such as curtailing self-referral.

The contrast between our negative findings and the positive experience at a few flagship institutions also raises important policy questions. The organizational model behind these successes—highly customized systems developed by on-site academic experts who were closely integrated with the clinical staff—differs markedly from the model employed elsewhere. Off-the-shelf commercial systems, often chosen because of billing concerns and more closely allied with the needs of administrators than those of clinicians, are the norm.

This dominant model may not produce optimal results. Certainly, computer system vendors should prioritize refinements in their systems to discourage redundant and clinically inappropriate imaging, improvements that have the potential to reduce needless imaging.

CONCLUSION Whatever the explanation for our findings, they emphasize the importance of establishing the benefits of computerization rather than estimating them in the absence of data, or generalizing from small studies at a few atypical institutions. History urges caution in assuming that advances in medical technology will result in cost savings. In fact, the opposite is more often the case. ■

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24 To access the Appendix, click on the Appendix link in the box to the right of the article online.

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ABOUT THE AUTHORS: DANNY MCCORMICK, DAVID H. BOR, STEPHANIE WOOLHANDLER & DAVID U. HIMMELSTEIN

Danny McCormick is an assistant professor of medicine at Harvard Medical School.

In this issue of *Health Affairs*, Danny McCormick and coauthors focus on the widely held assumption that use of health information technology will result in less diagnostic testing and reduced health care costs. In fact, in their analysis of patient visits to a nationally representative sample of office-based physicians in 2008, the authors found that physicians without computerized access to imaging results ordered imaging tests in 12.9 percent of visits, whereas physicians with such access ordered imaging in 18.0 percent of visits. Similar results played out with respect to blood test reports and repeat blood testing. The authors conclude that health information technologies, whatever their other benefits, remain unproven as an effective cost-control strategy in themselves with respect to reducing the ordering of unnecessary tests.

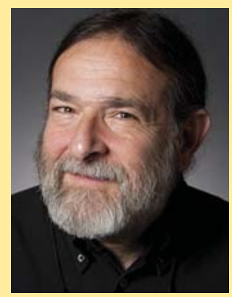
McCormick, who joined the faculty of Harvard Medical School in 1999, has been an assistant professor of medicine there since 2006. He also serves as director of the Division of Social and Community Medicine in the Department of Medicine at the Cambridge Health Alliance, and he is codirector of the Harvard Medical School Fellowship in General Medicine and Primary Care. A primary care physician, McCormick served as a staff member on the Senate Committee on Health, Education, Labor, and Pensions under Sen. Edward M. Kennedy. He holds a master's degree in public health with a concentration in clinical effectiveness from the Harvard School of Public Health and earned his medical degree from Tufts Medical School.

David H. Bor is the chief of medicine at Cambridge Health Alliance.

David Bor, the chief of medicine at the Cambridge Health Alliance, joined the staff at Cambridge Hospital as a primary care physician and infectious disease specialist in 1981. He is also the Charles S. Davidson Associate Professor of Medicine at Harvard Medical School, and he serves as chair of the Cambridge Health Alliance's Academic Council, which oversees all of the alliance's scholarly research and training activities. Bor received his medical degree from Harvard Medical School.

Stephanie Woolhandler is a professor at the CUNY School of Public Health at Hunter College.

Stephanie Woolhandler is a professor at the CUNY School of Public Health at Hunter College. A full-time faculty member at Harvard Medical School and the Cambridge Health Alliance from 1986 until 2010, she continues her affiliation with Harvard Medical School in the role of visiting professor. She holds a medical degree from the Louisiana State University Medical School, and she earned her master's degree in public health from the University of California, Berkeley.



David U. Himmelstein is a professor at the CUNY School of Public Health at Hunter College.

David Himmelstein has served as a professor at the CUNY School of Public Health at Hunter College since 2010, when he also assumed the role of visiting professor at Harvard Medical School. Prior to those appointments, he was on the Harvard Medical School faculty and practiced primary care internal medicine with the Cambridge Health Alliance for twenty-six years. Himmelstein received his medical degree from the Columbia University College of Physicians and Surgeons.