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Analysis of HEALTHCARE Interventions That Change Patient Trajectories

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Sponsored by Cerner Corporation, General Electric, Hewlett-Packard, Johnson & Johnson, and Xerox

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Summary

A *patient trajectory* is the sequence of events that involves the patient with the healthcare system. An intervention can affect trajectories by improving health, thereby reducing healthcare utilization or replacing a costly form of utilization (e.g., inpatient stays) with a more economical form of utilization (e.g., office visits to physicians or use of prescription medications). In this monograph, we examine the following selected interventions in the healthcare system that affect patient trajectories:[1]

- Implement Computerized Physician Order Entry (CPOE) as a means to reduce adverse drug events (ADEs) in both inpatient and ambulatory settings. ADE avoidance among inpatients reduces lengths of stay in the hospital. In an ambulatory setting, ADE avoidance may eliminate some hospital admissions and some office visits to physicians.
- Increase the provision of the following preventive services: influenza and pneumococcal vaccinations and screening for breast, cervical, and colorectal cancer. Vaccinations prevent some cases of influenza and pneumonia. Some people (mostly elderly) are hospitalized with these diseases. Screening identifies cancers earlier, improving survival and allowing less-extreme treatments to be employed.
- Enroll people with one of four chronic illnesses—asthma, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), or diabetes—in disease management programs. Disease management reduces exacerbations of a chronic condition that can put the patient in the hospital.
- Persuade people to adopt healthy lifestyles and estimate the health outcomes if everyone did so: controlled their weight, stopped smoking, ate a healthy diet, exercised, and controlled their blood pressure and cholesterol as necessary with medications. Lifestyle changes can reduce the incidences (and ultimately the

[1] Not all interventions affect patient trajectories. For example, an intervention might replace manual transcription of physician notes by computerized voice recognition. This intervention and many others that do not affect patient trajectories are discussed in Girosi, Meili, and Scoville (2005).

prevalences) of a number of conditions that require substantial amounts of healthcare.

Because this work was part of a larger study, "Using Information Technology to Create a New Future in Healthcare: The RAND Health Information Technology (HIT) Project," we chose interventions that should be facilitated by HIT. HIT operates through several mechanisms. First, HIT can help identify the consumers eligible for the intervention by scanning an electronic database—for example, of medical records or claims data. Second, HIT can help consumers and providers adhere to "improved care" guidelines—for example, by reminding providers and patients when particular services are due and by providing instruction. Third, HIT may increase efficiency (e.g., using automation to reduce the need for home monitoring of patients by a nurse). Finally, HIT makes it easier to record and analyze the performance of an intervention, so that it can be improved over time. For example, one can use data collected on today's medical practices to develop still-better care guidelines.

Information technology is an *enabler*: It makes possible new ways of working (Hammer and Champy, 1993). But it does not guarantee that an enterprise will adopt new work processes, not in healthcare (Scoville et al., 2005) and not in other sectors of the economy (Bower, 2005). We have defined our interventions in terms of changes in the way the healthcare system works. Our results are therefore estimates of what *could* be, not predictions of what *will* be.

Estimating Potential Effects of Interventions

We estimated the potential effects of each intervention on healthcare utilization (e.g., hospital stays, office visits, prescription drug use), healthcare expenditures, and population health outcomes (workdays or schooldays missed, days spent sick in bed, and mortality). By *potential* we mean the maximum effect that could be achieved, assuming that everybody eligible to participate did so as effectively as possible. Although we do not expect the entire potential to be achieved, it provides an upper bound.

For each intervention, we first established baseline values for utilization, expenditures, and population health. For most interventions, our baseline was a database of patient trajectories developed from several years of the Medical Expenditure Panel Survey (MEPS), the third in a series of national probability surveys conducted by the Agency for Healthcare Research and Quality (AHRQ) on the financing and utilization of medical care in the United States. We created a database of patient trajectories (the sequences of events that involve patients with the healthcare system) from several years of the MEPS.[2] In addition to detailed information on healthcare utiliza-

[2] Files and documentation for each year are available at http://www.meps.ahrq.gov.

tion and expenditures, our database also includes data from the MEPS files that describe the patient, such as age, sex, ethnicity, health insurance status, measures of health status (e.g., self-reported health, days sick in bed), and medical conditions.

The MEPS data are particularly appropriate for estimating the effects of the above interventions, because the data link healthcare utilization, healthcare expenditures, and health outcomes in a single source. The consumer is the unit of observation. Each consumer uses healthcare services and pays for them (or they are paid for on his or her behalf), and each consumer reports health status information. There are sources that examine utilization alone, or expenditures alone, or population health status alone; the MEPS is the only publicly available, nationally representative source of data that puts them all together. The other sources are often considered more accurate within their specialized domains. Therefore, we compare MEPS with other sources and devise adjustments to align our MEPS-based estimates with them.

Next, we modified the baseline to reflect the presence of the intervention, basing our modifications on the published literature. We estimated the effects of the intervention to be the difference.

We performed a systematic review of both the peer-reviewed literature and the "gray" literature (i.e., HIT journals, conference proceedings, government reports, and healthcare trade journals) for studies that quantified the effects of our interventions. This review is described in Girosi, Meili, and Scoville (2005). We found a substantial number of articles that measured the effect of CPOE on adverse drug events and their costs. However, a handful of authors are responsible for the bulk of this research, so the data on effects are not nationally representative. Moreover, the ambulatory CPOE systems studied are mostly installed in hospital outpatient departments, not independent physicians' practices. Perforce, we extrapolated it to the national level anyway.

The data on preventive services come in two steps. First, there is a rich evidence base for the effects of preventive services on health. Second, there is much sparser literature on the effects of HIT on the performance of preventive services. Most of the latter articles report the effect of computer-generated reminders on the likelihood that physicians conform to guidelines, including guidelines related to preventive services.

We found many articles that estimated effects of disease management on healthcare costs and utilization, with a great deal of variation in the details of the interventions and the targeted population. HIT is generally considered to be an integral part of disease management, so there is no separate assessment of how much better disease management with HIT is than disease management without HIT.

We found quite a rich literature describing the effects of lifestyle changes on health. But we found few articles on the use of HIT to support lifestyle change. Our national efforts to influence lifestyles have mostly taken the form of public health campaigns, such as the campaigns to reduce tobacco use and to improve nutrition. In

the absence of data, we are forced to argue that it is plausible that HIT can play a role in lifestyle change.

The Evolution of Intervention Effects Over Time

We have estimated the effects our interventions would have in the healthcare system of the year 2000. In essence, we imagined that somebody changed the healthcare system back in, say, 1980, and that the data collected by MEPS in 1996–2000 (the data we used to construct our trajectory database) would have been different. It is this difference that we attempt to estimate.

In reality, of course, these interventions would be implemented in the present, and their effects would occur years in the future. We devised adjustments for future demographic changes to the year 2020, and we could, if we wished, adjust expenditure effects for assumed increases in healthcare costs. But these adjustments tell us nothing new about the interventions. For example, if we estimate that an intervention would reduce the expenditures captured in the 2000 MEPS data by 15 percent, our estimates adjusted for demography and inflation show a reduction little different from 15 percent.

We chose not to speculate about other possible changes to the healthcare system. For example, technological changes will flow from genomics, nanotechnology, and stem-cell research. Cultural attitudes may change—for example, about whether basic healthcare is a right and possibly about how much end-of-life care one is entitled to. And the healthcare system could respond to the changes wrought by our interventions in different ways (e.g., if hospital stays for today's reasons decline, either hospitals could be closed or the system could find other reasons to treat people in hospital). An investigation of these factors was far beyond the scope of the present project.

Potential Effects of the Interventions

Next, we describe how we estimated the potential effects of the interventions listed earlier. Recall that by *potential* we mean the maximum effect that could be achieved, assuming that everybody eligible to participate did so as effectively as possible. Although we do not expect the entire potential to be achieved, it provides an upper bound.

Preventing Adverse Drug Events in the Inpatient Setting

Evidence suggests that Computerized Physician Order Entry can be effective in both hospital and ambulatory environments. We examined the potential effects of using CPOE in both environments as a means of reducing adverse drug events.

To estimate the effects of inpatient CPOE for the nation as a whole, we took an overall rate of ADEs per patient-day from the literature, and we distributed it to hospital stays with diagnoses that a physician identified for us as being most likely to be associated with ADEs. Descriptions of hospital stays (including diagnoses and an identification of the hospital hosting the stay) came from the Nationwide Inpatient Sample (NIS), a public-use file available from AHRQ's Healthcare Cost and Utilization Project (HCUP).[3] Hospital characteristics came from the American Hospital Association (AHA) annual survey of the nation's hospitals.[4]

Figure S.1 shows the results of installing CPOE only in large hospitals, where we have varied the dividing line between large and small hospitals. We look at ADE avoided and at bed-days and dollars saved. Clearly, most of the effects can be realized by installing CPOE only in hospitals with at least, say, 100 beds. But it is not enough to install CPOE only in the really large hospitals.

These effects are not large. The total savings of $1 billion compares with total expenditures on hospital care of $413 billion in 2000.[5] A hospital with over 500 beds will save about $1 million per year, according to this analysis. Smaller hospitals save less, and, indeed, save somewhat less per bed.

Figure S.1 also splits the benefits according to whether the patient is under 65 years of age or 65 and older, as an approximation of the Medicare population. Only about 13 percent of the population is 65 or older, but it accounts for more than its proportional share of hospital utilization (37 percent of hospital stays and 48 percent of hospital bed-days). But we calculated that about 62 percent of the benefits of inpatient CPOE would accrue to patients in the older group, because a higher fraction of patients 65 years and older have diagnoses associated with ADEs.

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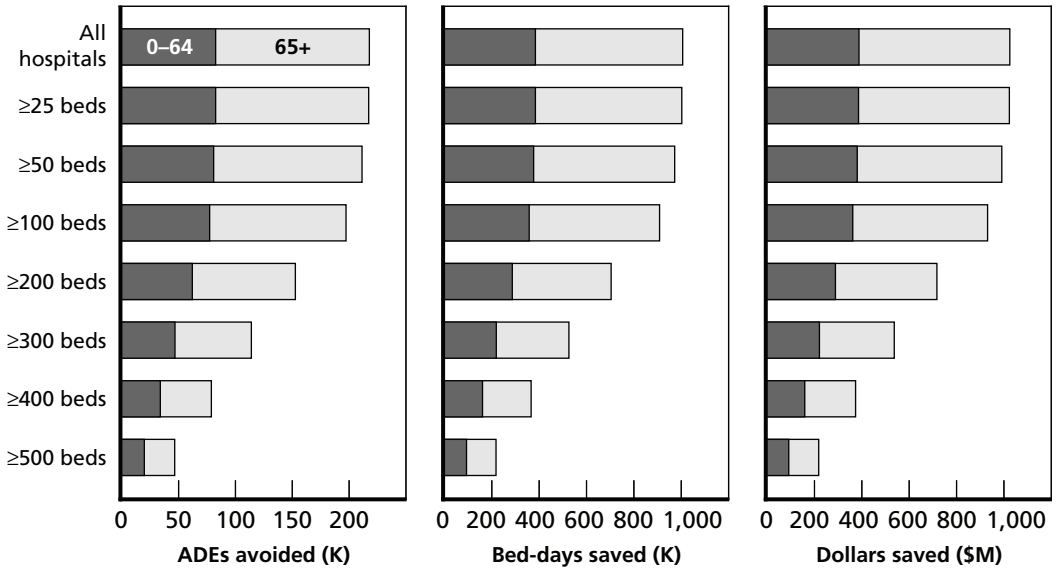
[3] Agency for Healthcare Research and Quality (AHRQ), Rockville, Md. Available at http://www.ahcpr.gov/data/hcup.

[4] The *AHA Annual Survey Database* may be purchased from the AHA at www.ahaonlinestore.com.

[5] National Health Expenditures are available at www.cms.hhs.gov/statistics/nhe. As of this writing, estimates are available for the years 1960 through 2002. Projected expenditures are available from 2003 through 2013.

Figure S.1
Annual National-Level Effects of Using CPOE to Avoid Inpatient ADEs, by Hospital Size



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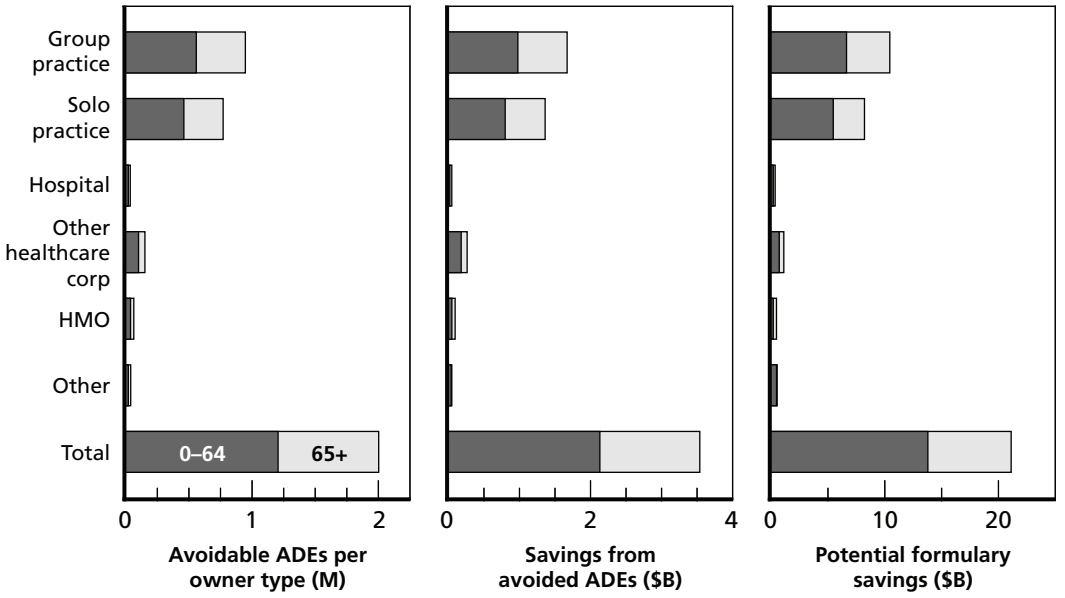
Preventing Adverse Drug Events in the Ambulatory Setting

We used a similar process to estimate the implications of ambulatory CPOE for the nation. Again, we took from the literature an overall rate for ADEs per visit to a physician's office, and we distributed them to visits where problem drugs (i.e., the drugs most likely to be involved in ADEs) were prescribed. Descriptions of office visits came from the National Ambulatory Medical Care Survey (NAMCS) (National Center for Health Statistics, multiple years).

Figure S.2 shows the results of installing CPOE, by practice size and ownership, which one might view as a proxy for financial strength. National savings from avoiding outpatient ADEs are around $3.5 billion. Savings from substituting generic drugs for brand-name drugs (typically accomplished by urging physicians to choose drugs from a formulary) exceed $20 billion per year.

Unlike with hospital-based CPOE, one should not ignore the small players when considering physicians' offices. About 37 percent of the potential savings comes from solo practitioners. The question is, Can single practitioners afford ambulatory CPOE? Also, some group practices will have only two or three physicians, and they, too, may have trouble affording ambulatory CPOE.

Figure S.2
Annual National-Level Effects of Implementing Ambulatory CPOE in Physicians' Offices



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Patients 65 years and older account for about 40 percent of ADEs, but for only 35 percent of the savings that comes from prescribing cheaper drugs. An office visit by a person 65 or older is more likely to be associated with an ADE than is a visit by a person under 65, probably because the elderly take more drugs on average.

Not shown in the figure are potential savings of $6.4 billion per year by eliminating duplicate laboratory tests and diagnostic radiological procedures. These savings will accrue to practices only if they are associated with capitated patients.[6] Otherwise, the savings accrue to the payer and (one hopes) will eventually be passed along to society as a whole in the form of lower health insurance premiums.

Vaccination and Disease Screening

Reminders provided by Electronic Medical Record Systems have been shown to increase the likelihood that patients receive influenza and pneumococcal vaccinations, and screening for breast cancer, cervical cancer, and colorectal cancer.

To estimate the effects of these preventive interventions, for each condition to be prevented, we selected the population from our MEPS analysis file that the United States Preventive Services Task Force (USPSTF) recommends should receive the intervention. For example, the USPSTF recommends that everybody 65 and over

[6] Under a capitation arrangement, a physicians' group agrees to provide all necessary care for a fixed payment per covered person. A more usual arrangement, called fee for service, pays the physician for each service rendered.

should receive an influenza vaccination each year. Therefore, to model flu vaccination, we selected all MEPS respondents of age 65 or older.[7] We combined these data with information from the published literature on the fraction of people that currently receives the service, and costs and benefits per instance of the service.

Table S.1 shows our estimates of some of the effects of these five preventive services. These estimates assume that the services are rendered to 100 percent of people not currently complying with the USPSTF recommendation. We made optimistic assumptions regarding the health benefit estimates as well. We concluded

Table S.1
Summary Results for Five Preventive Services (assumes 100-percent participation)

	Influenza Vaccination	Pneumococcal Vaccination	Screening for Breast Cancer	Screening for Cervical Cancer	Screening for Colorectal Cancer
			Program Description		
Target Population	65 and older	65 and older	Women 40 and older	Women 18–64	50 and older
Frequency	1/yr	1/lifetime	0.5–1/yr	0.33–1/yr	0.1–0.2/yr
Population Not Currently Compliant	13.2 M	17.4 M backlog; 2.1 M new persons/yr	18.9 M	13 M	52 M
			Financial Impacts		
Program Cost (with 100% compliance)	$134 M to $327 M/yr	$90 M/yr	$1,000 M to $3,000 M/yr	$152 M to $456 M/yr	$1,700 M to $7,200 M/yr
Financial Benefits	$32 M to $72 M/yr	$500 M to $1,000 M/yr	$0 to $643 M/yr	$52 M to $160 M/yr	$1,160 M to $1,770 M/yr
			Health Benefits		
Reduced Workdays Missed	180,000 to 325,000/yr	100,000 to 200,000/yr			
Reduced Days Abed	1.0 M to 1.8 M/yr	1.5 M to 3.0 M/yr			
Deaths Avoided	5,200 to 11,700/yr	15,000 to 27,000/yr	2,200 to 6,600/yr	533/yr	17,000 to 38,000/yr
Years of Life Gained				13,000/yr	138,000/yr

[7] The USPSTF recommends vaccination for persons in certain high-risk groups as well, but we do not attempt to identify those persons in the MEPS database.

that all these measures provide health benefits, and all except pneumococcal vaccination increase healthcare utilization and expenditures. Pneumococcal vaccination is an exception, because only one dose is needed after age 65, and it continues to provide protection for life.

Chronic Disease Management

Effective disease management requires that the provider maintain a patient registry, and that enrolled patients have the means to receive advice and support from the provider and to send current symptoms and questions to the provider, all in real-time. These functions are best performed by information technology.

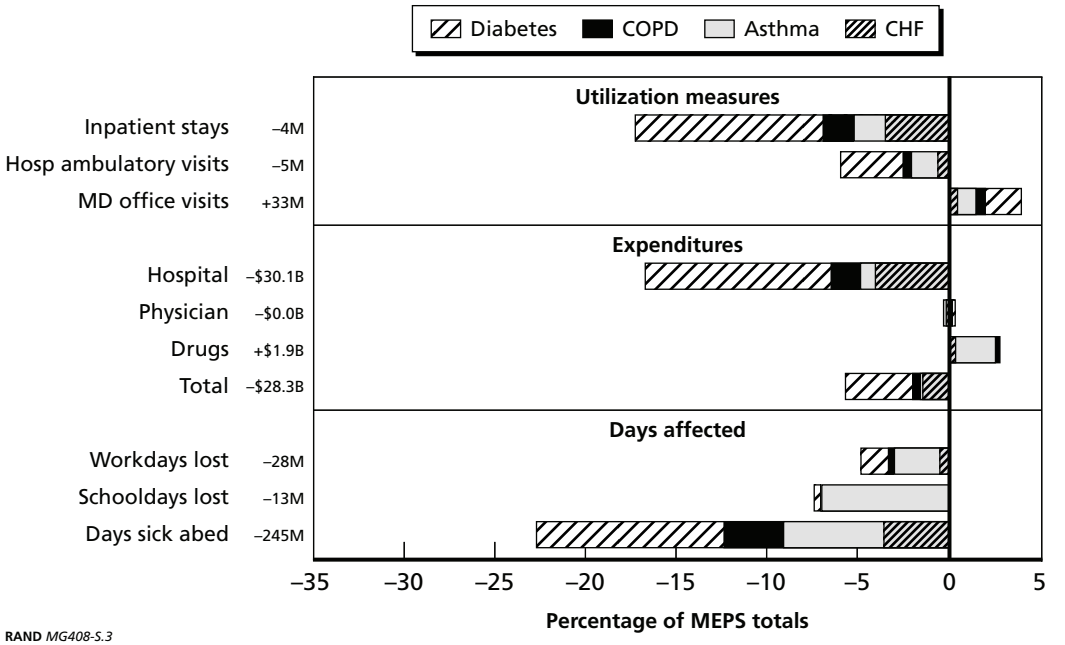
To estimate the costs and benefits of enrolling people with chronic illnesses in disease management programs, we examined management programs for four conditions: asthma, chronic obstructive pulmonary disease, diabetes, and congestive heart failure. For each condition, a disease management program seeks to avoid costly hospitalizations and visits to the hospital emergency department. For these encounters with the healthcare system, the program substitutes regular contacts with a provider (sometimes telephone calls with a nurse case manager, sometimes group or individual visits with a physician). Often, patients in a disease management program use more medications than those not in such a program. All of these changes occur in the short term—i.e., within a year or so of the patient enrolling in the program.

Figure S.3 shows the results we obtained, assuming that 100 percent of the people eligible for each disease management program participated. We also assumed that, in the analysis database (our baseline), nobody participated in programs to manage these diseases. On both counts, our results are optimistic. These programs reduce hospital utilization substantially, at the cost of increased office visits to physicians and an increase in the use of prescription drugs. However, there is a potential net savings of several tens of billions of dollars. Keeping people out of the hospital is, of course, a health benefit, but we also expect reductions in days lost from school and work, and days spent sick in bed. The reductions in days shown in the figure are optimistic, because some days lost or sick will be for reasons unrelated to the condition being managed.

Effects of Lifestyle Change

A program of lifestyle change would have huge benefits if everybody controlled their weight, stopped smoking, ate a healthy diet, exercised, and controlled their blood pressure and cholesterol as necessary with medications. In the long run, the population would be much healthier, and it would use substantially less healthcare. But for these outcomes to happen, consumers must come to see themselves as their own front-line caregivers. They need the information, the skills, and the confidence

Figure S.3
Annual Effects of Four Disease Management Programs (assumes 100-percent participation)



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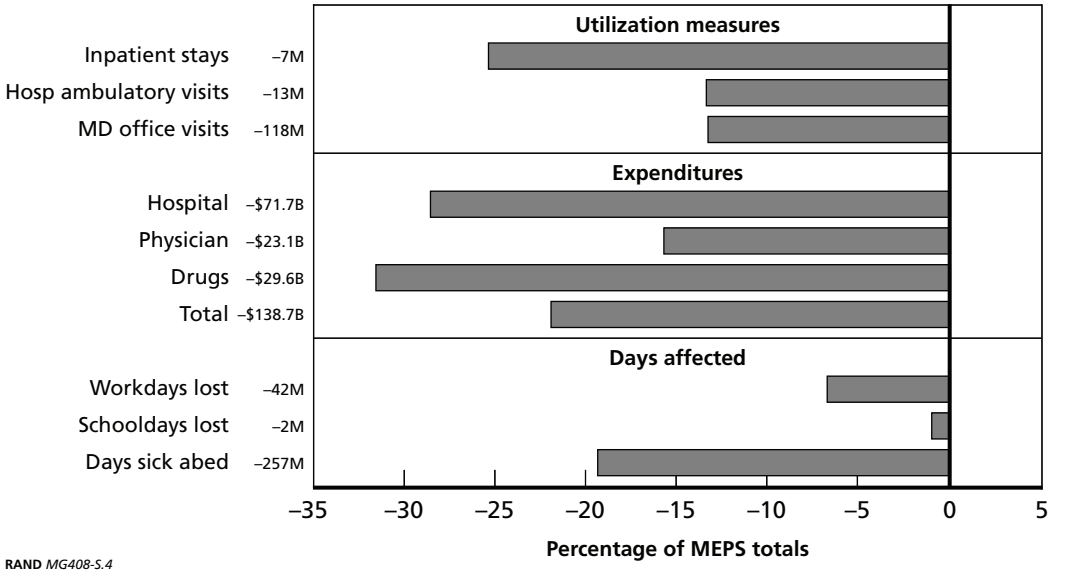
to keep themselves healthy to the degree that they can, and to seek help when events slip out of their control. By itself, information technology will not bring about this transformation. But we argue that the transformation cannot happen without information technology.

We modeled the effects of a program of lifestyle change by changing the incidence of selected chronic medical conditions. Smoking cessation can reduce the incidence of COPD and smoking-related cancers. Combinations of diet, exercise, weight control, and medications can control hypertension and hyperlipidemia, which are risk factors for more serious cardiovascular conditions. Weight control can reduce the incidence of diabetes and its complications. For our example, we assumed that lifestyle changes can reduce the incidence of each condition to 40 percent of its current level. Over the long term, this reduction in incidence will result in a reduction in *prevalence*—the number of cases in the population at a point in time.

Figure S.4 shows the results. Again, we assumed that 100 percent of the population participates in the program. But if, by some wizardry, that participation could be achieved, there would be huge benefits. The total expenditures captured in the MEPS file declined by over 20 percent.

Figure S.4
Annual Effects of Lifestyle Changes (assumes 100-percent participation)



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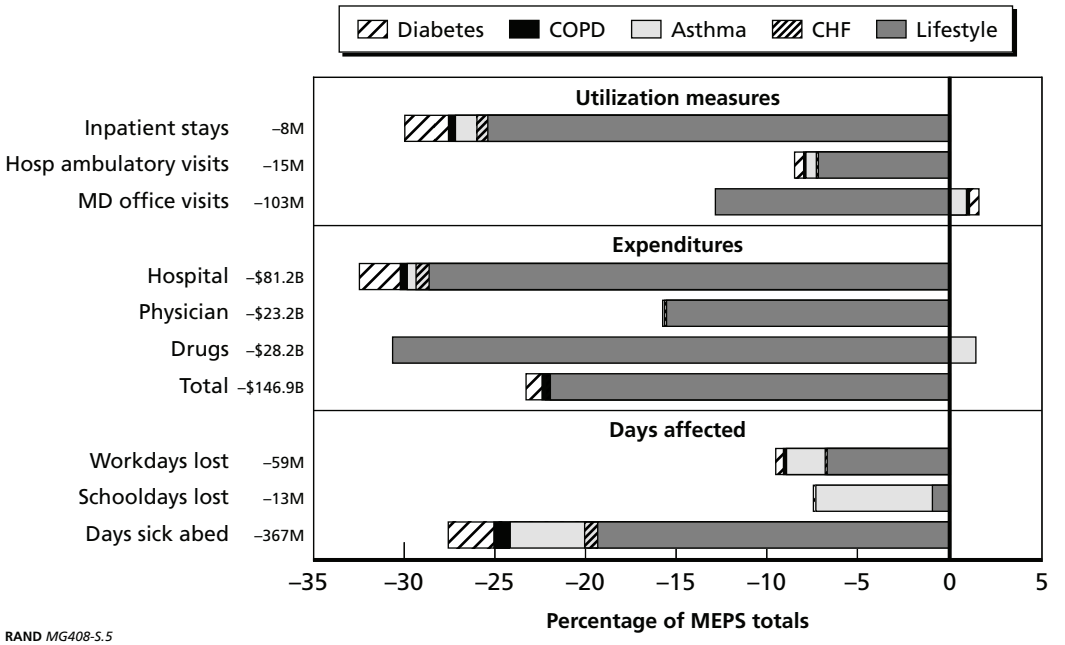
Combining Disease-Management and Lifestyle-Change Effects

To combine effects of disease management with those of lifestyle change, we cannot simply add the two estimates. In the long term, lifestyle change reduces the number of people with chronic diseases. Thus, fewer people are eligible for disease management programs. Figure S.5 shows the results. As expected, the combined results are smaller than the sum of the individual results. The sum of expenditure reductions from Figures S.3 and S.4 is $167.0 billion; the combined reduction is "only" $146.9 billion.

Realistic Participation Rates

To obtain the results in Figures S.3, S.4, and S.5, we made the unrealistic assumption that 100 percent of those eligible participated in each intervention. To obtain a more realistic estimate, we scale participation down to 50-percent participation in our four disease-management programs and 20-percent participation in a program to foster healthier lifestyles. Experience shows that patients comply with medication regimes about 50 percent of the time on average, although there is a great deal of variation from one study to another. Studies show that patients comply with

Figure S.5
Combined Effects of Disease Management Plus Lifestyle Change (assumes 100-percent participation)



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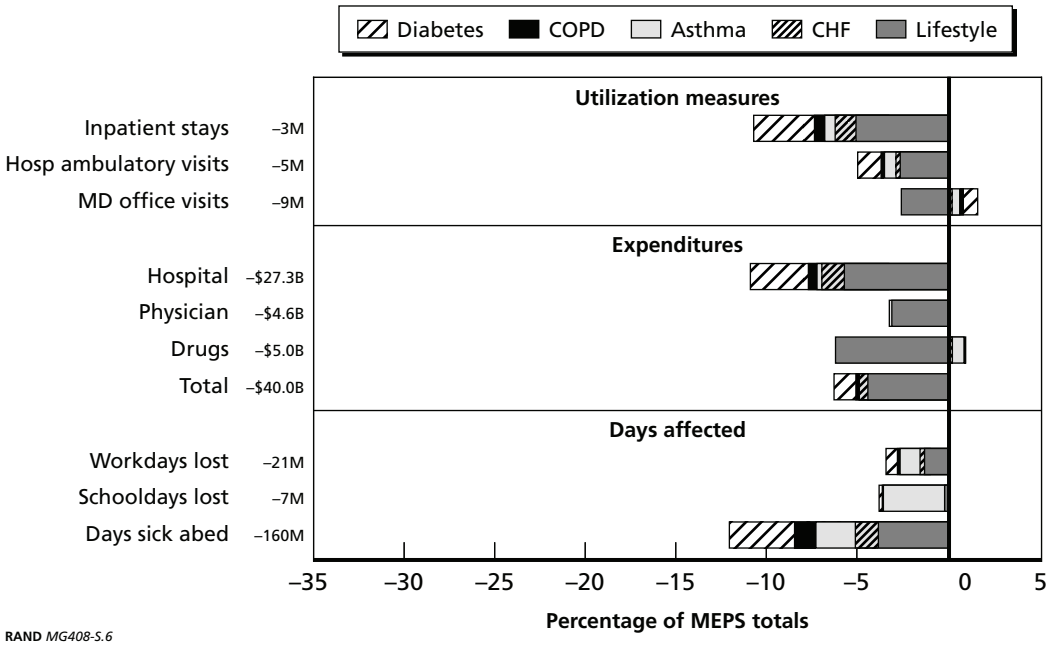
their physicians' lifestyle recommendations only about 10 percent of the time (Roter et al., 1998; Haynes, McDonald, and Garg, 2002). Optimistically, we double that figure.

Figure S.6 shows the benefits realized if we apply these participation rates. Our estimate of total monetary savings is only about 30 percent that of the 100-percent-participation case, and other benefits drop by similar proportions. Clearly, there are large potential benefits that will not be realized by a "business as usual" approach to healthcare.

Increasing Consumer Participation

What may be the most profound aspect of the HIT-mediated transformation of healthcare is requiring much more from the patient (or consumer, since a person does not have to be sick to receive health care) than traditional health care does. Through disease management and lifestyle changes, healthcare ceases to be a commodity that healthcare providers deliver to passively accepting patients. Instead, it becomes an activity in which consumers and providers engage jointly and cooperatively. Think of the analogy of a coach and a player. The coach provides technical knowledge, advice, support, and encouragement to the player. But,

Figure S.6
Combined Effects of Disease Management and Lifestyle Change
(assumes 50-percent disease management and 20-percent lifestyle participation)



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ultimately, the player is the one who scores the points. Similarly, the healthcare provider has the technical knowledge. But especially for chronic care and lifestyle change, if the patient doesn't do it, it doesn't get done.

There can be no coaching without communication. Similarly, to help consumers become effective self-caregivers, they must be connected to the people who will coach them. They must have access to the appropriate knowledge, and they must have opportunities to learn needed skills. They must have a number to call when they need advice or encouragement. In short, consumers, information sources, and providers must all be connected via a community network.

Connecting the community is necessary but not sufficient. Much needs to be learned about how to increase consumers' participation in their own care. The quality and quantity of participation need to be measured routinely and subjected to systematic improvement efforts. Nonparticipants need to be identified and ways found to overcome individual barriers to participation and to promote convenient and pleasant ways to maintain and improve everyone's health.

We do not have evidence to tell us how well such a process can work, or how long it may take. But there is evidence that people adopt healthier behaviors when they understand the reasons and they have the incentive. For example, the anti-smoking campaign has reduced the fraction of people over 18 that smokes from 42 percent in 1965 to 23 percent in 2001 (National Center for Health Statistics,

2003)—a 45-percent reduction. It has done so, in part, by making smoking more expensive and, in part, by making it less acceptable. Twenty years ago, almost nobody objected to smokers lighting up in their homes or offices. Today, almost nobody—in California, at least—would fail to object.

Realizing the Potential

We estimated the *potential* benefits of our interventions, meaning the maximum effect that could be achieved, assuming that everything goes as well as it possibly could. But the benefits actually realized will generally be less than the potential benefits we have estimated—and, perhaps, much less. A major reason is that our interventions require that the healthcare system undergo some change. Change is disruptive, and people resist it. But unless providers, payers, and consumers do change, the benefits will not be realized.

Most existing HIT applications operate within a single provider organization, and they require changes of only the staff of that organization. Even within a single organization, those changes are not made easily; the staff must experiment to learn how to take advantage of HIT. Among our interventions, this is true of inpatient CPOE, and of ambulatory CPOE, which is installed in a hospital outpatient department, and which has access to ancillary services (e.g., pharmacy, laboratory, and radiology) provided by the hospital.

But some interventions require coordination among providers in different organizations. An Electronic Medical Record (EMR) installed in a physician's office has much greater potential value if it connects to other providers and, for that matter, to the consumer. If it connects to the pharmacy, for example, much the same opportunities to intercept medication errors and ADEs are enabled that an inpatient EMR offers. If it connects to the consumer, both physician and consumer can be reminded when preventive services are due.

Our remaining interventions require that the consumer be made into an expert provider of his or her own care, rather than a passive recipient. This is the change discussed in Chapter Eight. There, we point out that the consumer is already an active participant, but that the healthcare system rarely helps the consumer to participate expertly. Disease management requires both coordination of multiple providers and expert participation by the patient. But the chronically ill patient has an immediate incentive to learn how to manage his or her symptoms. Patients do not, after all, go to the emergency room (ER) for the pleasure and excitement it affords. Lifestyle change requires expert participation by the patient, but without the obvious immediate incentive.

Our interventions, their potential benefits, and the relative risk of realizing that potential are summarized in Table S.2. The relative risk is our own subjective

assessment of how difficult it is likely to be to realize a large fraction of the potential benefit. It is based partly on the strength of the evidence and the amount of experience, and partly on the amount of change our interventions require of the healthcare system.

For each of our interventions, there is some risk that the potential benefits will not be fully realized, and, as we move down the rows of Table S.2, the risk becomes greater. But we need not leave the matter entirely to chance. Taylor et al. (2005) discuss policies that we think could speed up adoption of HIT; facilitate the development of the networks needed to connect and coordinate payers, providers, and consumers; and promote efforts to monitor compliance with prevention and disease management guidelines; and to measure and improve healthcare quality. Monitoring and measurement are important for all our interventions, but especially for programs to promote lifestyle change. Because we know least about how to promote such changes, the greatest amount of experimentation will be required to get this aspect right.

Table S.2
Summary Potential Net Benefits of Interventions

Class of Intervention	Monetary Net Benefits (billion)	Relative Health Benefits	Relative Risk
CPOE, inpatient	$1.1	Modest	Low
USPSTF-recommended preventive services	Break-even or small net cost	Modest	Medium
CPOE, ambulatory	$31.2	Modest	Medium
Disease management with 100% participation (diabetes, CHF, asthma, and COPD)	$28.3	Large	High
Lifestyle change with 100% participation	$138.7	Very large	Very High