Five Provocative Points about Bringing the Benefits of Information Technology to Health Care
A Discussion Paper

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Project Background

Gordon T. Moore, Harvard Pilgrim Healthcare Inc., received a grant from the Robert Wood Johnson Foundation's Pioneer Portfolio in July 2005 to examine the role of information technology, specifically electronic medical records, in the primary care setting. Moore's work included the development of a discussion paper, the convening of a small workgroup of information technology (IT) and practice systems experts, and a working paper that summarized the workgroup meeting, focusing on how IT can contribute to the basic functions of primary care.

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Dr. Moore is a Professor in the Department of Ambulatory Care and Prevention at Harvard Medical School. His academic work has been in health care policy, health system design, clinical process improvement, and designing and evaluating educational programs for medical students, residents, and other health professionals. Dr. Moore now directs Partnerships for Quality Education, a national initiative funded by The Robert Wood Johnson Foundation to train health professionals in the skills of managing care. In his non-academic work Dr. Moore has been a manager and leader in managed care, a strategic consultant to health insurers in the United States and Europe, and a teacher and consultant to clinical leaders in hospitals, medical schools, and integrated delivery systems settings.

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The Robert Wood Johnson Foundation focuses on the pressing health and health care issues facing our country. As the nation's largest philanthropy devoted exclusively to improving the health and health care of all Americans, the Foundation works with a diverse group of organizations and individuals to identify solutions and achieve comprehensive, meaningful and timely change.

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Abstract
Many leaders are calling for the widespread adoption of electronic medical records (EMR) in America. Opinions vary, however, about whether the EMR as commercially available can deliver sufficient benefits to practicing doctors to induce them to purchase and use it. In this paper, I argue that the current EMRs haven't gotten the product design right and are unlikely to be universally accepted by most practicing doctors, where the need for IT support is the greatest.

The design flaw, I argue, is that the commercial EMRs require the recording of doctors' medical notes. This information –especially the detailed history and progress notes-- is difficult to standardize and thus entering it into a rigid EMR format requires considerable training and high effort (and lost productivity) on the part of doctors. Moreover, these notes are of limited benefit to the work that doctors do and even to the handoffs and coverage of patients.

Requiring the doctor to do these functions digitally as part of the EMR has created a high barrier to moving doctors into an electronic environment. I posit that emphasizing order-entry rather than these archival record functions would be a less costly and more utilitarian way to get doctors into a digital environment and will more quickly deliver an improved health care system.

I then examine four areas in which IT could deliver major benefits to doctors and patients at low cost and effort. Each of these innovations can be implemented in practices using a current EMR but none requires that a doctor buy and implement a full EMR; an alternative inexpensive and easy to use order entry system could be the entry to an electronic environment that could deliver these benefits. These are:

- Delivering universal connectability on an electronic process flow IT skeleton;
- Replacing archival record functions with physician order-entry as the foundation of the IT System;
- Creating a logic architecture that can integrate, track, and pace the hundreds of transactions that constitute the process of care for an individual patient; and
- Constructing an IT-supported clinical database that measures real performance and can serve research and improve system performance.

Overview: The current problem
The vast majority of America's community doctors work today in an information and communication jungle. Patients and their workups and treatments are continuously handed off – to specialists, labs, radiology, drug stores – and returned. Data are exchanged intensively, especially at the most vulnerable periods when patients are especially sick. But the system regularly experiences blackouts, data losses, and broken communications, paradoxically at the most vulnerable times for patient care. Instead of critical patient information moving, as one advertisement put it, "at the speed of thought," data and information creeps, stutters, and stalls.

To create a better information environment, the President and the Secretary of HHS have advocated the nationwide adoption of an electronic medical record (EMR). In their statement, and the statement of numerous others, it is stated that the EMR could ameliorate the many problems of cost, reliability, and quality in American health care.

Recent reports have examined this proposition. There are studies and models that purport to demonstrate that an EMR can improve care and yield an attractive return on investment. However, there are other experts and reports that cast doubt on the notion that a universal EMR would be of sufficient benefit to warrant the investment it would take to assure its widespread use. A recent issue of *Health Affairs* raised many of these points-of-view (*Health Affairs*, September/October, 2005, entitled Health Information Technology. Can Electronic Medical Records Transform Care?)

Despite national encouragement, the EMR is not spreading very fast. It is being taken up most readily in hospitals and large group practices. It is estimated that only 5-13% of American smaller practices use an EMR. And one of the major obstacles to its spread relates to the fact that while the health care system might well benefit from the widespread adoption of EMRs, it is the doctors and other health care professionals who are expected initially to foot the bill and put in the work. But regardless of who provides the upfront investment to initiate the EMR, this system will inevitably be paid for by those purchasers and patients who are already staggering under the costs of medical care. The EMR, thus, must prove itself capable of creating real efficiencies in health care in order to pay for its putative benefits or demonstrate overwhelming quality benefits such that the public is willing to pay even if it costs more. Such studies are not available.

Why is it proving so difficult to implement the EMR? The recent *Health Affairs* review of the EMR provided some insights, encouragement, and some solemn warnings about the EMR. It is expensive to implement. The *Health Affairs* issue concluded that implementing an EMR nationally would not occur without significant change in reimbursement and that, in turn, will require an active role of government in funding the change. Encouragingly, in a field study by Miller et al, 14 small practices in California were shown to achieve a good return on their investment in an EMR. Nevertheless, few of these early adopter practices actually used the EMR to enhance quality or true efficiency. Further, neither this nor other articles in the IT issue of *Health Affairs* answered the basic question: what is the actual cost and the return on investment in either better quality or in efficiency?

This paper will briefly examine the way public and private suppliers of the EMR have structured the product and ask whether we have got it right. My answer is "no." My basic proposition is that the EMR, as currently structured, overemphasizes archival record-keeping over process flow support. The current EMR is a relatively inefficient way to deliver the benefits of information technology to make patient care better or less expensive. By structuring the EMR along the lines of the traditional archival medical record, the current EMR companies are selling a product that is difficult for doctors to use, provides limited benefits to cover its costs, and thus increases the barriers to adoption. As a means to unleash the benefits of IT for patient care costs and quality, the full EMR is a high effort, low yield way to proceed.

Thus the EMR is being oversold and the obstacles to its adoption are under-estimated. It is highly likely that the current encouragement and weak incentives offered by the government is neither likely to overcome the skepticism and resistance of most practitioners, nor, even if it were to be accepted, to ameliorate problems we face in health care. As currently structured I believe the EMR is not a feasible method of improving health care cost and performance in the United States.

Moreover, the push to implement the EMR is distracting us from the real benefits that IT could deliver to improving health care. By focusing the discussion on the EMR, we divert attention and development towards issues of how we replace the old archival medical record functions rather than towards the design and improvement of the processes of medical care. It is in the latter that real opportunities for improvement lie. Later in the paper, I turn to physician order-entry as the core of electronic practice support development that could create real benefits for less cost and effort.

The Critique of the EMR as We Know It:

This paper is not intended as an exhaustive or methodologically robust critique of the EMR. Rather, I have tried to assess whether the reality in two settings supports my hunches about the limitations of the EMR, mainly as a starting point in thinking about how IT could support clinical practice. I tested the validity of my assumptions about the feasibility of the EMR in a non-rigorous way by examining its implementation in a small primary care practice in Philadelphia and through my personal use of an EMR over five years in a large, multispecialty group practice in Boston. However, by means of this examination, I was able to test the face validity of my assumptions in the field, examining the strengths and weaknesses of its implementation in two settings to assess if these experiences offer credible support of my claims about the EMR.

Site visit descriptions:

My personal experience with the EMR is with EPIC, which was installed in my own group practice more than five years ago. Record keeping has always been a chore for most of us practicing in primary care at the time of implementation. In the old days of the paper record, charting was often done as we conducted the work of doctoring. On the worst days, we finished the record after the patient had gone but usually during work. What we wrote depended on our own age and how we used our records. Many who were recently trained wrote extensive notes in a highly structured fashion. Those of us who were older realized that medical record notations were of most use as later reminders of what we had done, why we did it, and what we planned to do in the future. I came to recognize that my detailed notes were not highly regarded, or even necessary, when they were available to others covering our patients in the emergency setting or when we were communicating to the specialists with whom we consulted. They usually repeated my history or physical exam and ignored my progress notes. They were generally only interested in the basics – diagnosis, reason for referral, tests, and medications. In response, my notes became streamlined, so that more of the work of record keeping could be completed during the patient encounter. And each of us developed our own system of recording and accessing that fit best with how we worked. One of my colleagues, a pediatrician, kept his notes on 3X5 cards, which he carried with him everywhere in a shoebox.

When I transitioned to the EPIC electronic record, my primary care colleagues and I struggled to take our clinical information and translate it into the rigid formats that the EMR required. Histories, physical exam results, and progress notes are inherently messy. Even after learning how to use the system, we concluded that structuring these data to fit with the EMR format had added about an hour to our day just to interact with the EMR and enter and retrieve data in its complicated, structured format. We all agreed that there were advantages to the EMR, but we also knew that we paid the price so that others could benefit.

My own conclusion, and that of most of my close colleagues, was that the effort to put medical information into the required format was too close to a wasted effort. While there were indisputable benefits, most of these were not directly experienced by us as the clinicians who had to make the record "work." There was universal sentiment that the record was, in personal business terms, probably not worth the cost and effort, at least for the primary care doctors who dealt with the most unstructured problems of patients.

Background of practice:

The second step in this process was to make an investigative site visit to a Philadelphia four-person primary care internal medicine practice that had recently converted to an EMR. This visit allowed me to test my assumptions about the utility of EMRs in a small practice setting.

The practice services a mixed income neighborhood in urban Philadelphia. The four doctors include two principles that have practiced there for many years and two associates, both of whom have been with the practice for several years at minimum. The practice operates extended days and is accessible on weekends. It is located in a renovated former greenhouse, which has been converted to a quite serviceable clinic, with capacity for two exam rooms each during each doctor's practice sessions. The clinic formerly used a traditional paper record.

One year prior to our visit, the practice had implemented an EMR. They chose Logician, a GE product. Their experience is related in some detail in a recent publication (Annals of Internal Medicine, August, 2005). Their summary of this article is included here.

> *We recently implemented a full-featured Electronic Health Record in our independent four-internist community based practice of general internal medicine. We encountered a number of challenges, some unexpected, in moving from paper to computer. We describe here the impact on our finances, our workflow and our office environment: financial impact is not clearly positive, workflows were substantially disrupted and there was significant deterioration initially in the office environment for staff, doctors and patients. That being said, none of us would go back to paper, and all of us find the technology helps us do better at meeting patient expectations and expedites a number of tedious work processes (such as prescription writing and creation of chart notes) even as it creates new capacities for population health improvement in our practice. Five broad issues need to be addressed to promote successful implementation in offices like ours: financing; interoperability/standardization/connectivity of clinical information systems; help with workflow re-design; technical support/training; and help with change management. We hope sharing our experience can better prepare others who plan EHR implementation and inform policy makers on strategies necessary for success in the small practice environment.*

The site visit confirmed the conclusions of their paper, but, a year on, there are some important caveats not revealed in the article. The additional details garnered from seeing the practice in action are important, and are summarized as follows:

- ♦ More than a year after implementing the EMR, two of the four doctors mournfully described doing their records late at night from home. All said it had added time to their work, although the most sophisticated user – the director of the practice – clearly was more efficient in his use of the EMR than the other doctors.
- ♦ Running costs continue to be an issue, with costs not covered by efficiencies from the record's use; cost is a high barrier to implementing an EMR in an independent small practice.
- ♦ Hidden costs are real. The input of clinical information such as the history and physical exam into the EMR format takes time and is cumbersome. The extra time is uncompensated, and generally occurs in non-productive (that is, not generating revenue), personal time of the doctors.
- ♦ The record, like all others except those used in a fully integrated, closed multidisciplinary practice system, increases rather than reduces the logistics, effort, and expense of referrals out and back;
- ♦ The electronic environment, (though not requiring the full EMR), has facilitated laboratory testing and prescription writing. This has not extended to other information such as imaging and consult results;
- ♦ The record is relatively inflexible and local adaptation and improvement is poorly supported by the vendor. Local support is needed, but there is low input from

company and the practice has had to hire its own IT consultants to provide it. The record is very difficult to change.

- The four practitioners would not change back, however. They like the record but wish it could be made better.

The visit lent credence to my hypothesis that the greatest effort and lost productivity is with recording the history, PE, and progress notes, which are probably of the least value to their practice partners inside the practice and to the outside users such as the ER, hospital, and consulting specialists.

<u>Four IT Innovations in Practice Support that Could Create Real Benefits for Less Cost and Effort than the EMR</u>

In this section, I will present some ideas about the use of IT to reduce costs and improve care. These ideas are not a comprehensive compilation of steps to create an integrated system, although they do build on each other. Rather, these are some suggestions to stimulate discussion about components of a new IT system that might quickly be developed and used to create new uses and stimulate new development in both the public and the private sector. All of these ideas are ones that I believe could be built now; the technology exists to bring these elements to life. On the other hand, how to accomplish this is uncertain and will certainly stimulate discussion about feasibility and implementation, as well as criticism and brainstorming at the meeting to be held to discuss this paper.

1. **Delivering Universal Interconnectibility On A Clinical Communication Electronic Backbone**

The Problem:

Modern IT is used hardly at all to facilitate clinical data exchange in small community practices. Current EMR systems do not support inter-connectibility between the many doctors, labs, and radiologists with whom they network. The exception is the very large, multidisciplinary group practices, such as Kaiser Permanente, which work within a single integrated system that can be wired across all sites. Without inter-connectibility, data and decision-making cannot move with the patient, and the doctor and the doctor's practice must connect with their "suppliers" using less efficient methods.

The problem is not insurmountable technically. With the advent of the Web, any practice or hospital could, with appropriate security, send and access patient data. The National Health Service (NHS) in England is trying to do just that by standardizing the IT environment so that it is interoperable across the entire NHS.

The key to making data ubiquitously available and easily accessed by community practitioners is to overcome three barriers. These are: lack of standardization of communication protocols; variation in the form in which clinical data are entered and stored, and; the high cost of accessing such a system through the EMR even if such an electronically connected system were available.

First, there is a lack of standardization that could make electronic information interoperable. Each EMRs' communication protocols are unique, and they don't speak to each other.

Second, in addition to incompatible communication protocols, the information is uniquely structured in different EMRs, so decoding them on the receiving end is a problem. Lacking common language and syntax, different EMR systems cannot speak with each other. By contrast, core descriptive data such as diagnosis, lab test, imaging, procedure, and prescription are relatively simple and highly codified. While national efforts by CMS and AHRQ are underway to develop standards to facilitate interoperability, we are years away from having a common platform.

Third, the opportunity cost of ubiquitous electronic data transfer today is that of buying and using an EMR. Most practices, reluctant to take on the EMR, do not regularly use the Web for clinical workflow alone. And without crossing the threshold of use, few will make an effort to learn to use the Web.

What is needed is an electronic interface that is cheap and easy to use. This makes it possible to exceed a functionality threshold and achieve “scale” within a practice, by which I mean enough functions to make it worth a doctor's while to be on the IT-based system. Once enough practices are communicating on such a system, others will join, creating a virtuous cycle. These features interact.

The EMR has a high financial barrier to use. It is expensive to acquire and its running costs are high. So, the idea here is to make it much less expensive to initiate a new system. Newer versions of the EMR may reduce its acquisition costs but will largely leave the running costs where they are now – an expense that reduces net income to the practice. The solution to the puzzle of reducing acquisition expense is to create a less complex product, make it easier to install, and provide a quick financial or reduced work effort return to the purchasing doctor.

Enough utility must be available to the implementing doctors to surmount a threshold of use such that making the effort to change their behaviors is attractive. I mean that the user interface must provide multiple functional applications to each user. When drug order entry has been tried, use has been low because it has been introduced as a stand-alone. When there is a portfolio of uses, the return on the investment of adopting a new system is enhanced.

While certain functions have shown their worth (billing, prescription order entry), the doctor needs to see the immediate ways that the EMR will quickly return his investment of money, effort, and time. These benefits need to be experienced by the physician in his or her core business; not in functionalities added elsewhere in the system that do not directly benefit the practice (such as legible records when used by others or ubiquitous availability of information).

Similarly, the new system must be easy to use. The system must be simple. Training should be minimal and its use should fit easily into routine practice flow. To the degree possible, the system should reduce the steps that clinicians undertake in the course of their work.

A Proposed Solution:
To create an inexpensive, utilitarian system, I propose that the data needed to “mail” clinical information be radically simplified. To do so, the communication elements should be separated from the content. The “mailing” of the information should be based upon a universal data set so simple that it is easily codified and, thus, universally compatible.

First, consider the data that are needed for transmission and reception of an envelope by U.S. mail. All that is needed are name and address of recipient and sender, a stamp, information about whether it is expedited or routine delivery, and other information that represents default specifications (return to sender if recipient is not there, add more postage if it is too little). This “packaging” is designed so that standards can be easily developed and the envelope can be opened and manipulated and re-transmitted without difficulty. This is a minimum set that is needed to move it from a sender to the recipient, track it, or know how long it will take to get there.

The equivalent would not be difficult to achieve for “mailing” medical information. The only additional specifications would be an identifier of the patient and a security code. These are all sufficiently simple and standardized that agreement would not be difficult to achieve and a common format easy to build on web-based access and architecture.

“Inside” the envelope is further detailed information that sender and receiver need to communicate. Even here, however, some critically useful information can be hard-wired and sent automatically by separating the remaining information into that for which widely accepted, standardized coding already exists and that for which there is no acceptable code or method. For practical purposes, standardized coding includes billing information, diagnoses, tests, and treatments (including drugs). Coding of these data is already far advanced because most of them are part of the orders that doctors routinely write and the bills they submit – lab tests, imaging, treatments, drug prescriptions, referrals, and procedures.

Because it is standardized already, such data could be attached to the identifying envelope, creating a kind of structured, simple, easily standardized format that contains these data. This core of information would greatly enhance the management of a patient in different settings by different providers. In most cases, no further information would be needed to manage the consult or referral adequately.

The inputting of the above data by doctors could be made easy. The electronic backbone would need to be accessed in an easily portable graphic user interface (such as a palm or laptop) that could be carried into the exam room. Entry of data would be mostly automatic if it could be generated in the course of routine ordering writing, most of which is already done using some type of structured order form. By taking orders through this electronic interface and standardizing the form (as we already do for billing forms), one can create a simple GUI with point and click functionality, making real-time order entry very easy. Access to the system on both ends would require using provider identification, a security code, and a patient identifier. None of these functions is complex. Once orders are placed in this fashion, the data needed for the "mail" is already available, having been entered by the doctor in an easier method than the predominantly paper forms that most use now.

The remaining information mostly comprises the history, physical findings, and progress notes containing the assessment, and plan.

These data are often of more use to the initiating doctor than to the referral doctor. Doctors use this aspect of the record to remind themselves of what they did and of their reasoning about diagnosis and treatment. This information, while not devoid of utility, is not critical in most actions taken by others – covering doctors, emergency rooms, or referral specialists – if there is available basic data such as presumed diagnosis, tests, and treatments. Most of these doctors will elicit the history and repeat the necessary physical examination regardless of the available historical information.

In the proposed system, the archival history and physical and the running notes would be recorded by each practitioner in whatever format they prefer to use – handwritten, dictated, typed, pictorial – and scanned and converted to a PDF file if they are considered useful to other doctors. This information would be transmitted "attached" to the envelope and can be printed out at either end of a transaction.

2. Replacing Archival Record Functions with Physician Order-entry as the Foundation of the IT System

The Problem:

Clinicians are constantly confronted with making decisions about patients but have little real-time support to help them. What decision information is easily available is limited to that which the doctor can remember. Memory can be supplemented by looking things up, but this is rarely easy to do without interfering with productivity. Almost all interventions to vet or support decision-making do not occur at the point of care but usually later, removed from the flow of the doctor's work and the patient's experience.

What is needed is a way to connect relevant medical information in real time to decisions as they are being made at the point of care. Decision support needs to be immediately and conveniently available just after the assessment of the patient's problem and before the ordering of tests, treatments, and referrals. This is when the doctor is most in need of guidance and support.

When initiating orders today, most doctors operate with little or no support. Looking up something about medical management takes precious time, whether by computer or paper or phone call.   Understanding whether an order will be covered by the patient's insurance is critical but usually not easily available. Duplicating tests that have already been performed is a common problem in specialty care but the doctor does not know this at the time of ordering the new set. Moreover, the bulk of ordering is done by most doctors today in a paper form environment even though many of the tests and treatments are digitally supported.

What are the conditions that would need to be met in order to intervene at the time decisions are made and orders written? First, the doctor must be in a digital environment; paper or other media will not work efficiently. Second, the graphic user interface must be immediately available and part of the process flow of the doctor's work. Third, the demographic information about the patient and a specification of their probable diagnosis must be available so that the system can flag up appropriate advice and determine the appropriateness of the doctor's orders that follow.   Fourth, there must be a portfolio of support activities that make it worth the doctor's while to use the system (Table 1). Use generates more use and improves productivity.   If these conditions can be met, the support to the doctor could be greatly enhanced

Table 1:

Decision support portfolio
• Expert, evidence-based information about optimal decision pathways and guidelines for workup and treatment
• Relevant literature
• Beyes' theorem calculation on the benefits and risks of ordered tests[1]
• Preferred lists of tests, based on cost-effectiveness
• Structured referral notes to facilitate handoffs
• Reminders about "to do's" for the patient
• Flags about test duplications or unexamined data from prior visits
• Insurance information about coverage and billing criteria
• Preferred consultants for that patient and their insurer to facilitate triaging
• Appropriate drugs and coverage
• Schedule availability for referral specialists and return visits

Once the doctor is interacting in real time, and using an electronic system to order tests, initiate procedures, refer patients, and prescribe drugs and treatments, just-in-time information will not only support and improve those processes but also document these transactions at the same time. In such an IT environment, virtually all the important information about patient care are available to support research and clinical process analytics based on primary data collected by doctors and reliable enough to serve as the foundation of true measurement of clinical processes and doctors' work rather than unreliable claims data from insurance companies.

[1] Medical decision-making is a complex process. The core of decision-making follows a process called hypothetico-deductive reasoning. In this process, a pattern of symptoms, initial signs, and development lead to the generation of a list of potential diagnoses that might explain the pattern. Successive bits of information are gathered (tests, physical examination findings, diagnostic procedures such as biopsies, and even treatments) in an effort to confirm or disconfirm those diagnoses on the list. Most clinicians do this in a relatively crude fashion, looking for a single piece of data that will rule in or rule out a possible diagnosis, or for a distinctive pattern or complex of data that is the fingerprint for the diagnosis under consideration.

However, a more sophisticated approach underlies this rather crude process in general use. That is the application of Bayesian statistics to the diagnostic sorting out of possible causes. Bayesian reasoning and its use in clinical reasoning has been amply described. In summary, every possible diagnosis has a probability or likelihood at any point in a workup. With a high enough probability, a single diagnosis can become the leading, or final, candidate to explain what is going on. Every bit of data collected on the patient makes a contribution to that probability estimate. Before the collection of a further datum, the diagnosis has an associated likelihood, or what is called a prior probability. Depending on the performance characteristics (sensitivity and specificity) of the test, the additional results may increase or decrease the probability that the diagnosis is, in fact, the disease process that is causing the patient's illness. The available tests are always increasing and research data constantly modify the estimates of sensitivity and specificity. Further, epidemiologic data are regularly refining the estimates of prior probability in any individual patient.

The problem with applying Bayesian reasoning to clinical decision-making is its complexity. Most doctors simply cannot handle the quantitative challenge of estimating prior probability, applying the sensitivity and specificity, and calculating the posterior odds of the diagnosis. Even knowing the estimates of prevalence and the test characteristics is daunting. These steps are made even more difficult by the changing research data and evidence that needs to be applied.

The Proposed Solution:
The key to providing just-in-time decision support is to inject it into the doctor's workflow without decreasing (and perhaps even increasing) their productivity. Ordering electronically is the way to accomplish this. Replacing paper forms with an electronic point and click order entry would not take a great deal of learning and could increase office productivity by streamlining order entry and reducing labor intensive duplication, forwarding, integration, and posting of orders and results.

Studies have shown that billing and collections could be enhanced by electronic order entry (Miller et al, The Value of Electronic Health Records in Solo or Small Group Practices. 24:1127-1137 *Health Affairs*). The key to creating a bill is entering the diagnosis at an appropriate prompt; by entering the diagnosis electronically and activating a link to each patient's insurance data, an automatic electronic bill could be created and instantly submitted for payment. Pop ups could warn of services that were not covered by insurance, thus triggering cash collection. This makes the use of an IT interface very attractive, especially if the EMR is not needed to do so.

Third, the presumptive or final diagnosis can easily call up relevant literature or guidelines in pop ups. Once tests and treatments are added, algorithms can determine which are appropriate when linked to the putative diagnosis and flags can warn when there are incompatibilities that might be injurious to the patient. Further, reminders can be programmed based on actions that might be recommended to rule in or out the presumptive diagnosis. Preventive measures that are due could be flagged at this moment of ordering.

In order for this to happen, we need to make the process of data recording and decision-making happen in real time in an electronic environment. At first this may seem impossible. But imagine that the doctor (or the patient) enters their symptoms and physical findings and an algorithm creates a differential diagnosis (Dxplain or the problem knowledge coupler are already established technologies that can do so in an electronic environment). A doctor could sort through that list and assign a probability that would be reflected in a rank order of what is most likely and needs to be ruled in or out first. A list of questions, physical findings, tests or procedures could be offered in a popup based on their sensitivity and specificity in that patient with that putative diagnosis. These could be backed up by hotlinks to relevant expert opinion or other literature, such as up to date.

A further benefit for both the doctor and the health care system is the possibility of introducing Bayesian reasoning into the decision process as described above. Once a doctor has taken the step of using a computer and the web, Bayesian calculations and support are possible. The data on which this function is based are readily available in a stripped down electronic environment. What is needed is a listing of symptoms and signs, possible diagnoses, and each test and its results.

Once the clinician reaches a threshold of benefit, the use of an IT interface in their actual workflow becomes increasingly rewarding and attractive. Ordering, referring, prescription writing, billing, and decision support are a considerable package of benefits and should provide enough functionality to make the use of IT quite attractive.

Finally, this system requires only that the doctor commit to order entry, not the full EMR. If one thinks of the IT environment as facilitating ordering rather than emphasizing medical record-keeping, one of the major barriers to acceptance of the record -- work effort and cost-- is greatly reduced. The details of history and physical and other elements of the EMR are not necessary to this functionality.

3. **Connecting the loops: Creating a logic architecture that can integrate, track, and pace the hundreds of transactions that constitute the process of care for an individual patient.**

The Problem:
When you mail a package with FedEx or its competitors, you can follow its progression and check its status. You know immediately if the package is not meeting its expected benchmarks and whether it was received at its destination in time. The same is not true when a doctor orders a test, makes a referral, or prescribes a treatment. Once the patient is gone from the office, most doctors are unable to determine easily if their orders have been carried out, and none receives this important information automatically. The result is patients lost to follow up, lost or unacknowledged data, and treatments not completed. The inability to track or pace workups is a major element in fumbled patient care processes and outcomes and a significant contributor to malpractice suits.

There are two design issues underlying this infrastructure failure. The first is the lack of ubiquitous interconnectibility, as described above in the first section. But even were this to be fixed, there is a second problem -- a flaw in the architecture of doctors' workflow process.

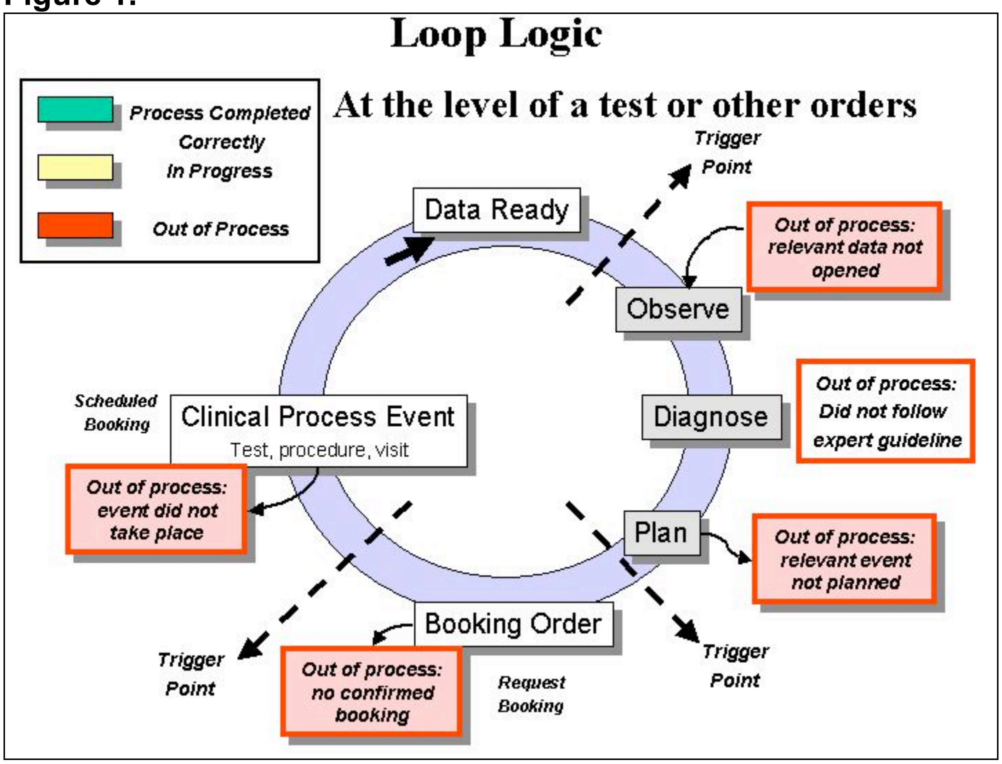
This flaw arises from the structuring of medical workflow as linear, sequential steps rather than as a series of interconnected feedback loops. In our current system, doctors' orders are initiated but then their steps on the path to completion are not tracked. The only confirmation of success is when the result has finally gotten back to them and the doctor views it. If there is a failure to complete, the initiator often does not know it.

A Proposed Solution:
Feedback loops are crucial to determining if an initiated action is, in fact, completed satisfactorily. In medicine, a completed loop would connect the orders initiated by the responsible doctor through their implementation and then back to the initiating doctor for analysis and subsequent action. For example, if a test is ordered, the patient must get to the testing location, which must do the test, prepare the result, and return it to the doctor. The feedback loop is only completed when the doctor finally looks at the result, assesses its contribution to the workup or treatment, and, based on this diagnostic process, initiates the next round of the workup or treatment.

A feedback loop supports the critical function of tracking. Using the concept of a loop that must progress through its process steps and reach its intended destination (the ordering doctor's use of the result in the next assessment and plan), a system of checking of the process flow steps can be constructed using information technology. These IT-based functionalities are now standard operating procedure in industry, known as supply chain management. Technology can facilitate and check for the completion of each step and then notify if there is a failure to meet specifications.
Specifying expected outcomes is the next step in improving workflow support. When a doctor initiates an order, its conditions of performance should be specified. By this, I mean to whom or where the order should be routed, by when the test or referral should be done, how much time should elapse before the system recognizes the order as out of specification, and what triggers should be built in to assure that appropriate remedial actions are taken.

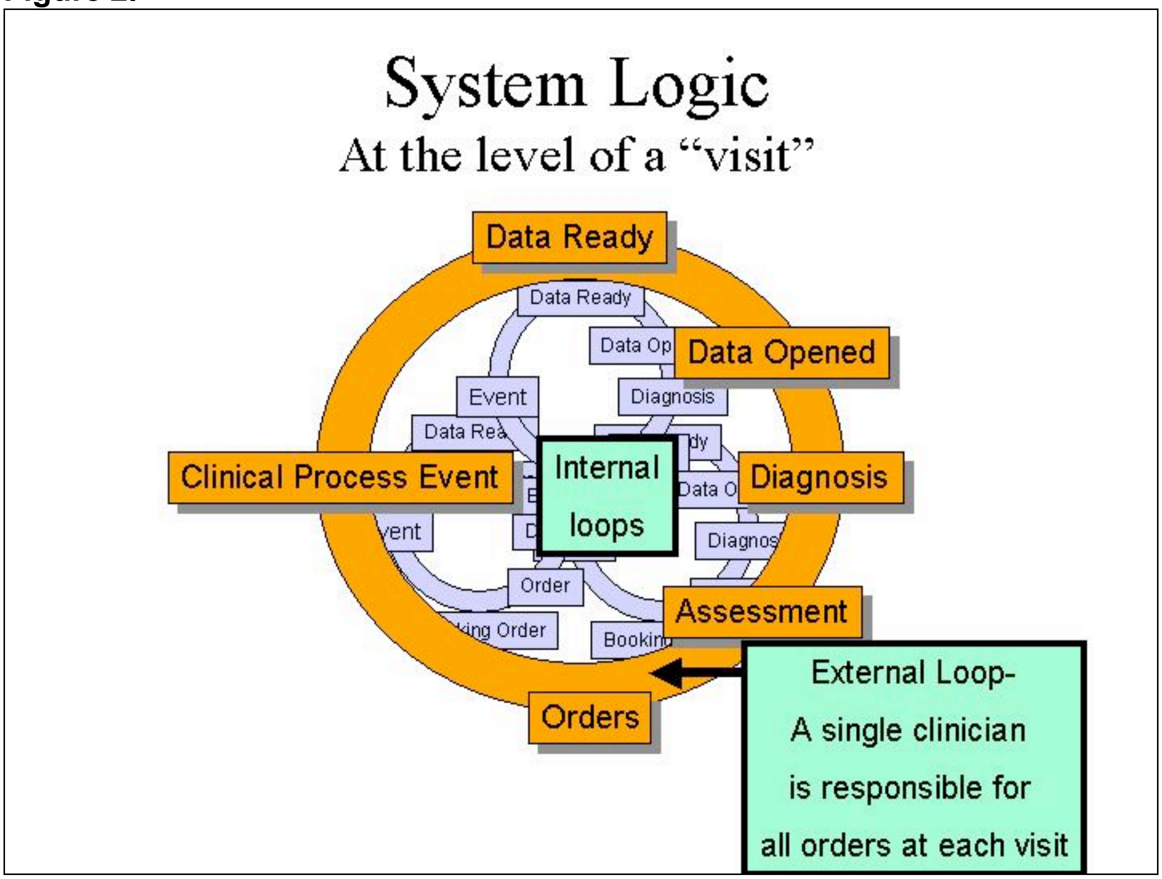
At best, this is now done in a haphazard fashion. In the new architecture, each step for every action would have a default specification (capable of being over ridden by the initiating clinician responsible for care) so that pacing of the workup can be monitored. When any step is "out of specification", appropriate actions and notifications would occur automatically and responsibilities routed in the most economical and effective fashion. The vast majority of warnings and remedial actions can be implemented with electronic "wizards", without involving the doctor and expensive personnel. IT managing of the loops should take people out of the process and reduce the work effort of clinicians. This process is shown diagrammatically in Figure 1.

Figure 1.



Finally, process flow monitoring can clarify responsibility and accountability. Each time that a patient sees a clinician who orders diagnostic or treatment actions, it is assumed that doctor is responsible for care. In our current medical model, a single clinician is responsible for assimilating the feedback data from a set of orders (each a loop) and interpreting it and then making a new plan of action. Each time the clinician reassesses the patient (either in person or not), that clinician is the initiating link for the next set of orders. In this way, the loop architecture is conceptualized as an "external loop" showing the responsibility of the doctor for assessing all the orders and initiating the plan, or next set of actions. The concept of a loop that tracks the responsible doctor's process flow is shown in Figure 2 below.

Figure 2.



When a patient is referred to another doctor today in the course of management of an episode of illness, it is often unclear who is then responsible for the management of the patient – the referring doctor or the receiving specialist. In the proposed architecture, at the time that a responsible clinician decides to refer the patient to another clinician, primary responsibility can be checked and clarified as one of the conditions of the handoff. The referring doctor may continue to hold primary responsibility or may wish to transfer it to the referral specialist. In the latter case, the request is a condition of the initiation of the next loop in the sequence of patient flow in the management of the episode and is contingent on acceptance by the receiving doctor. The default is that the referring doctor remains responsible until the acceptance notification by the other doctor is received. In this way, accountability is clear at every step of patient care.

Figure 3 provides a case example and Figure 4 illustrates the concept of linked or interconnected loops of responsibility.

Figure 3.

Care should be a sequence of completed loops linked by a doctor's plan and orders

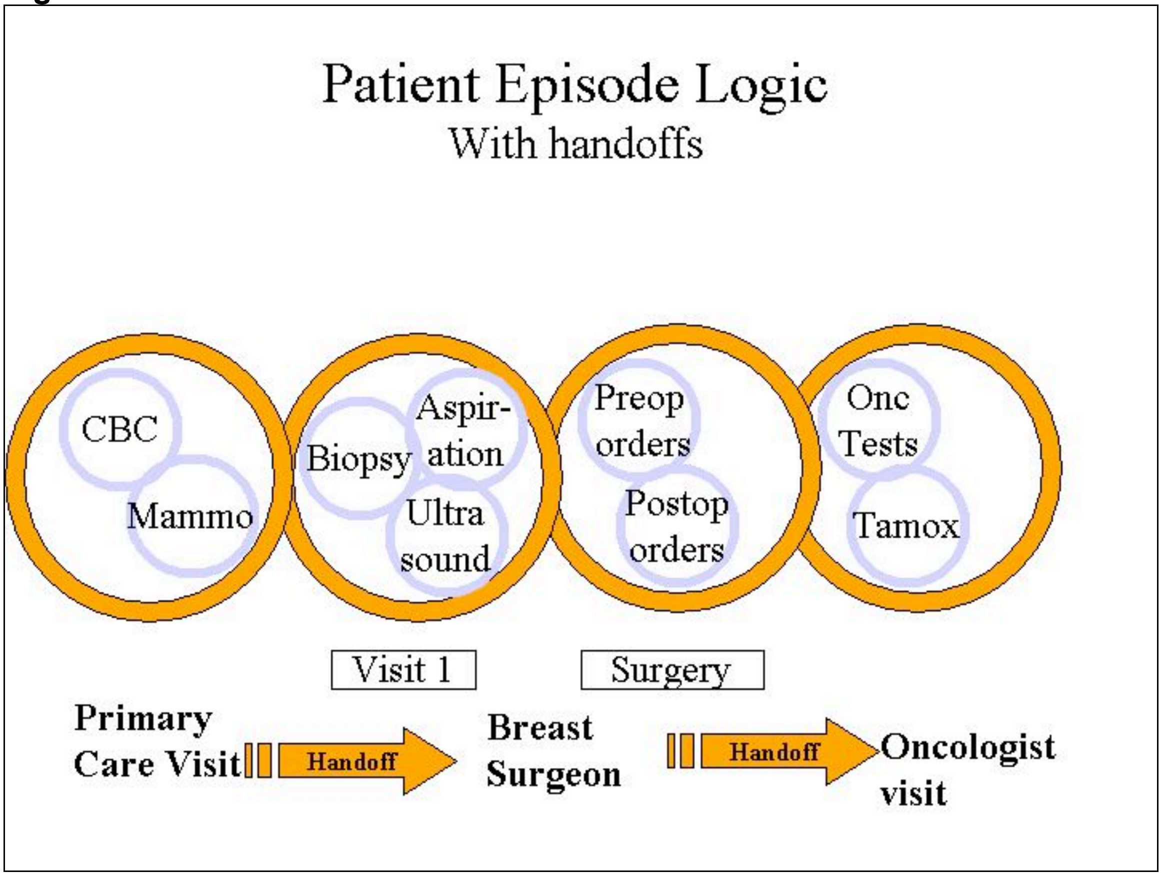
A sample medical episode

A 30 year old woman presents to her primary care doctor with a self-discovered breast lump. The doctor orders return visit in a month and Orders tests and a mammogram, which comes back with a suspicious reading.

The PCP refers patient to a breast surgeon who orders an ultrasound of the mass. The result shows a solid mass, which is followed up by a guided biopsy that reveals breast cancer.

The surgeon sees the patient and schedules surgery, which shows a localized malignancy. Patient is referred to oncologist, who picks up responsibility for cancer care.

Figure 4.



Another problematic assignment of responsibility occurs in the team management of the care of complex patients. Team care is increasingly necessary, but there is very little infrastructure to assure clear assignment of task function, responsibility for decision-making, and accountability. The same mechanism described above for clarifying the responsibility of doctors applies to the multiple parties involved in complex team care. Each party might be initiating and carrying out orders. By assigning sub-responsibilities (such as what a physical therapist is ordering and doing), the loops under that persons control will be managed by them, but the overall care (the collection of linked loops of each team member) would be visible to all on demand but routinely reviewed and fed back to a primary responsible person, whose function would be to oversee and integrate the care using electronic support.

4. **Creating Performance-based health information for research and management**

The Problem:
In today's health care system, patient data are difficult to aggregate, retrieve, and use in research, patient care management, and system improvement. First, the most data available now are secondary, not primary from the doctor; these mostly comprise claims data. This database is at best indirect, and often unreliable, information about what is

happening clinically, behind the exam room door. Thus, we are missing the critical clinical data that might allow a system to document the actual elements and processes of care to buttress malpractice defense, measure and reward clinical performance, and support clinical research and management information.

To create such a database will require satisfactory resolution of issues such as patient privacy, doctor's acceptance, ease and cost of collection, and ownership of the database. Nevertheless, given the creation of the electronic backbone and its presumed use, the collection of such data is technically feasible now, in real time.

Privacy of patient data must be protected. There are many methods, however, that already exist for either stripping such data of identifying information or creating a statistical method of de-identification for specific uses. These technologies could be applied automatically to patient-specific data entering the database or before its outputs as specific uses.

Doctor resistance can be anticipated to be a stumbling block. However, once these data require no additional effort for the doctor to produce and privacy is protected, they may find it difficult to put forth a rationale for resisting. Doctors could, of course, choose not to use the electronic backbone for their ordering, receiving, and communication of clinical information. But there are significant inducements to both collecting and using the data, which could make it difficult for them to not participate. First, use could be mandated or rewarded by insurers (Medicare, Medicaid, and commercial). Bill payment could be expedited for participants. Malpractice rates could be reduced (because using the system described earlier should reduce errors, document steps taken, and improve patient satisfaction – the three major causes of medical liability). Finally, patient quality could be improved by their doctor's participation, surely a pressure to participate.

To whom should the database belong? Its uses include scientific study to improve care, management information to facilitate competitive advantage (which presumably redounds to the patients benefit by offering new products, better service, and improved results), or even the early detection of epidemics or bio-terrorism. Should a patient be asked to give permission to include their data or should this be treated like vaccination? – which is mandatory because of the benefits that it confirms on the public's health. Note that the question of who "owns" the genome raises some similar issues. I raise this issue not to provide an answer, but to put this on the table for discussion.

Proposal:
If a universal HIPAA-secure backbone for patient data exchange is constructed and doctors use it to support their workflow processes, it is feasible to trap, strip, and deposit these data in a population-based database. Once such a database is available (like the Medicare database,) experts should be invited to apply to use it for research, management and improvement.

One of the most important uses of the database would be to support Bayesian decision-making. One of the major impediments to widespread application of this decision tool is the absence of what are called prior probabilities. This probability is an estimate of the likelihood of a proposed diagnosis, given the patient's specific symptoms and physical findings. The benefit of any test or procedure depends on the accuracy of this probability estimate. The database could be used to develop constantly more accurate estimates of prior probability. By using a Google type of search mechanism, a doctor could enter their patient's presumptive diagnosis, key symptoms, and physical findings. With this information, the benefit of any proposed test or treatment could be calculated automatically and provided to help the doctor in making a decision about what to order.

Conclusion

Information technology offers one of the few opportunities to transform the delivery of medical care. Properly utilized, it can remove many sequential and parallel functions that are today done through human effort at great expense and with often erratic results. By creating an electronic backbone for what might be seen as medicine's version of supply chain management, we can gain speed, accuracy, shorter cycle times, work effort reliability, and all at reduced cost. Medicine can enjoy tremendous productivity gains.

This paper argues that the technology is here. I further believe that doctors are not the barrier. What is holding us back is products that are commercially available in the cost/productivity/quality space that we need to be in.   If we can begin to create products that are useful to doctors and patients in that arena, we will be creating the beginning of a virtuous circle in which each addition facilitates the next as growing participation and benefit reinforce each other.