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The Costs of a National Health Information Network

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Background: **The use of information technology may result in a safer and more efficient health care system. However, consensus does not exist about the structure or costs of a national health information network (NHIN).**

Objectives: **To describe the potential structure and estimate the costs of an NHIN.**

Design: **Cost estimates of an NHIN model developed by an expert panel.**

Setting: **U.S. health care system.**

Measurements: **An expert panel estimated the existing and the expected prevalence in 5 years of critical information technology functionalities. They then developed a model of an achievable NHIN by defining key providers, functionalities, and interoperability functions. By using these data and published cost estimates, the authors determined the cost of achieving this model NHIN in 5 years given the current state of information technology infrastructure.**

Results: **To achieve an NHIN would cost $156 billion in capital investment over 5 years and $48 billion in annual operating costs. Approximately two thirds of the capital costs would be required for acquiring functionalities and one third for interoperability. Ongoing costs would be more evenly divided between functionality and interoperability. If the current trajectory continues, the health care system will spend $24 billion on functionalities over the next 5 years or about one quarter of the cost for functionalities of a model NHIN.**

Limitations: **Because of a lack of primary data, the authors relied on expert estimates.**

Conclusions: **While an NHIN will be expensive, $156 billion is equivalent to 2% of annual health care spending for 5 years. Assessments such as this one may assist policymakers in determining the level of investment that the United States should make in an NHIN.**

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The Institute of Medicine (IOM) drew attention to the importance of patient safety through its landmark report, "To Err Is Human" (1), and highlighted the central role that information technology (IT) must play in improving the quality of our health care system (2). Information technology can help achieve the IOM's goals of more safe, effective, patient-centered, timely, efficient, and equitable health care. However, health care lags behind other industries in investment and use of IT in its frontline processes. As suggested in the IOM report "Crossing the Quality Chasm" (2), a national health information network (NHIN) is critical for advancing IT in health care today. However, despite much useful dialogue, the structure of the NHIN is still being defined and its costs are even more uncertain (3).

Increasing public policy attention is being directed toward an NHIN. In the 2004 State of the Union address, President George W. Bush noted that "by computerizing health records, we can avoid dangerous medical mistakes, reduce costs, and improve care" (4). In late April 2004, he created a new position of National Health Information Technology Coordinator at the U.S. Department of Health and Human Services, subsequently naming Dr. David Brailer to this role. In July 2004, the second annual NHIN conference was convened, culminating in testimony to the National Committee on Vital Health Statistics. This issue has received bipartisan support. For example, Senators Bill Frist and Hillary Clinton coauthored an editorial in *The Washington Post* calling for more IT in health care (5). Other governments, including those of the United Kingdom and Canada, have recently made major investments in health care information infrastructure (6, 7). The United Kingdom's government has allocated £8 billion, and Canada's government has invested $1.5 billion Canadian (although it is expected that much more will be necessary). The government of the United Kingdom plans to fund nearly all the required investment, whereas the government of Canada plans to catalyze investment by providing some central support but also requiring matching funds.

Because the United States may make a similar investment, we sought to make projections about the potential technical structure and costs of a model NHIN. Our specific aims were to define the structure of a model NHIN in terms of functionality and interoperability, to estimate its

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Context

The United States needs a national health information network (NHIN). To build one, we need realistic estimates of costs.

Contribution

An expert panel conceptualized a model NHIN and determined the costs of implementing the model throughout the United States. The model NHIN would require $156 billion in capital investment over 5 years and would incur $48 billion in annual operating costs.

Cautions

The authors used expert opinion to estimate some costs and assumed fixed prices for hardware and software and no major new technological developments.

Implications

The United States probably needs to spend more now if we want to implement an NHIN in the next decade.

–The Editors

costs, and to determine how much more would be required to achieve a model NHIN than that likely to be spent if historical spending trends persist.

METHODS

Overview

An expert panel delineated a model NHIN, defined as an achievable and desirable NHIN in 5 years rather than an ideal infrastructure. We then estimated the costs of achieving a model NHIN, defined as the costs of moving from current levels of IT investment to a model NHIN in 5 years. An NHIN must have 2 components: the ability to perform key functions, such as computerized physician order entry (CPOE), and interoperability, such as linking providers for the purpose of data exchange. We elected to separately assess the functionality and interoperability costs.

We based the functionality costs on expert panel estimates of the percentage of key providers that currently have specified IT functionalities, the percentage of providers that the expert panel anticipated will have those functionalities within 5 years without a major influx of either money or policy pressure, and the cost of implementation in each domain. Supplementing the expert panel's estimates with data on the number of facilities within each provider group, we extrapolated costs to the national level by determining the cost to evolve from the current level of functionality to a model NHIN. We also sought to estimate the amount that would be expended by our health care system if current trends persist over the next 5 years and no policies are implemented to change these trends.

To estimate the national costs of achieving interoperability among key providers, we used the technical approach and experience of the Santa Barbara County Data Exchange (SBCDE) as a template (8). The SBCDE is a network of health care providers within Santa Barbara County, California, linked through a central host to allow data exchange. Although this is only one of many potential methods for clinical data exchange, the network is likely to be effective and good data on costs are available. To extrapolate the SBCDE experience to the national level, we estimated the cost of replicating the SBCDE nationwide to create regional networks, then added a layer of "super" and "national" hosts to allow data exchange between the regional networks.

Providers and Functionality Domains

We convened a panel of IT experts (listed in the Acknowledgments section) to develop a model of an achievable NHIN within 5 years given current technology. This panel consisted of health care IT experts from industry, academia, and government. We identified the most important providers and the critical functional domains of an NHIN. The expert panel reached consensus by using a modified Delphi approach (9–11). The experts' opinions generally converged.

After considering a wide range of providers, the expert panel identified the key providers as physician offices, hospitals, skilled nursing facilities, home health agencies, clinical laboratories, payers, and pharmacies. The panel focused on functionalities available to health care providers rather than patients, because health care providers make most decisions on investments for health care IT. Physician offices were segmented into small practices with 1 to 4 providers, medium practices with 5 to 20 providers, and large practices with more than 20 providers. Similarly, hospitals were divided into small hospitals with 300 beds or fewer and large hospitals with more than 300 beds.

Providers or Facilities

We estimated the numbers of facilities within each provider group by using data from the U.S. Census Bureau's County Business Patterns, 2000 (12). We supplemented these data with data from the National Center for Health Statistics (13), the U.S. Census Bureau's 1997 Economic Census (14), and other published sources to augment and adjust provider data (15).

Functionalities

The panel also identified a set of critical functional domains for a model NHIN: inpatient and ambulatory result viewing, inpatient and ambulatory electronic health record (EHR), inpatient and ambulatory CPOE, electronic claims submission, electronic eligibility verification, secure electronic patient communication, and electronic prescription acceptance by pharmacies. In general, each of these functional domains was relevant for only a subset of the key providers.

We describe these functional domains in more detail in another paper (16). Briefly, results viewing allows elec-

tronic viewing of test results, such as laboratory tests or radiologic examinations. Electronic health records are computerized systems that maintain relevant health information, including electronic charting. Computerized provider order entry refers to an application that allows all medical orders to be entered electronically. Electronic claims submission and eligibility verification are methods of computerizing communications with third-party payers. Secure electronic patient communication refers to computerized e-mail or messaging systems that allow private communication between patients and their health care providers. Finally, pharmacy electronic prescribing refers to the ability of a pharmacy to accept electronic prescriptions. The expert panelists achieved very good consensus during the development of a model NHIN.

Functionality Estimates

The expert panel estimated the current state of IT functionality and the expected state in 5 years if we continue on our current trajectory of investments, along with 95% CIs around their projections. To simplify the response burden, the expert panel estimated an overall average by provider type. However, since physician offices and hospitals were divided into subgroups, we used the expert panel's average and 95% CIs to impute functionality percentages for these subgroups. We constrained the imputation so that a weighted average of the subgroup functionalities would equal the overall average estimated by the expert panel. The expert panel's consensus surrounding the estimates of IT functionalities was good, except for 1 member who felt unable to provide informed estimates.

Cost Estimates

The expert panel determined average estimates of functionality cost after a presentation of a summary of the published, peer-reviewed literature on health care IT costs. The literature has many limitations. We assumed annual operation and maintenance costs to be 25% of capital costs on the basis of expert consensus. Most physician office costs were estimated on a per physician basis, while other capital costs were estimated on a per facility basis.

We based the costs of claims and eligibility processing, patient communications, and pharmacy acceptance of electronic prescriptions on the numbers of transactions. We estimated the volume of transactions as a function of outpatient visits, hospitalizations, and similar events that were likely to trigger a transaction. We multiplied the volume of transactions by the cost of an individual transaction to determine the costs of these 3 functionalities.

National Functionality Model

We estimated 2 sets of national costs: 1) advancing from current IT functionality to the proposed model NHIN and 2) expected expenditures over the next 5 years if current levels of spending on IT continue unchanged. We assumed no temporal pattern of provider adoption over the next 5 years because of a lack of information on such patterns. Thus, capital costs were not discounted for adoption over time, and operating and maintenance costs represent annual operating and maintenance for all eventual adopting providers over 5 years. If we assume uniform patterns of provider adoption over the next 5 years (for example, 20% per year in each of the next 5 years), then the present value of costs would be 7% less than the values shown when discounted by using a 3% real rate. We calculated the national cost estimates by provider and domain as the change in percentage of facilities that are functional multiplied by both the number of providers and the cost per facility for that functional domain. We summed these over all providers and functional domains to determine the national total.

Interoperability Model

After considering several models, we chose the SBCDE model because granular financial data were available. Conceptually, the SBCDE can be described as a brokered peer-to-peer network. *Brokered* indicates that the network uses a central host, and *peer-to-peer* means that files containing clinical information are directly exchanged between users and file content is created by users. The central host provides security and linking functions but does not store data.

All providers may be data users, data suppliers, or both. Supplying data is much more costly than just receiving it, since suppliers must internally integrate relevant data from several systems and make it available for exchange on a dedicated server. Large institutions, such as hospitals, might have to integrate pharmacy, laboratory, and radiology records, as well as physician orders, dictations and operative notes, and patient demographic data. To use the network without supplying data requires little more than a computer; Internet link; browser; and software for user authentication, security, and data access. We conservatively estimated that all providers would both use and supply data.

Cost per facility can be divided into fixed costs, security and interoperability software costs, server and T1 line costs, administrative costs, and internal system interface and aggregation costs. Again, we conservatively assumed that all providers must purchase all components to attain interconnectivity. Fixed or start-up costs comprised hardware, software, integration, installation, testing, technical support, and project management. Security and interoperability software is required for data security, patient matching, and user authentication. Although SBCDE software costs were in the range of $35 000 to $55 000 per facility, we anticipated that these costs would decrease to about $20 000 per facility as the software becomes standardized and is nationally produced. Each data supplier requires a dedicated server to store aggregated data for exchange, and we assumed that participants would select a fractional T1 line (or other high-bandwidth service) to allow efficient data transmittal. Training costs were relatively small since the system relies on user-friendly browsers. Costs to inte-

Table 1. **Estimated Proportion of Providers with Information Technology Functionalities at Present***

Provider	Result Viewing	EHR	CPOE	Claims	Eligibility	Patient Communication	Electronic Prescribing
Physician offices							
1–4 physicians	23	9	5	78	10	5	–
5–20 physicians	32	12	8	85	16	7	–
>20 physicians	35	15	9	90	19	8	–
Hospitals							
≤300 beds	53	11	7	84	18	–	–
>300 beds	68	18	17	92	24	–	–
Skilled nursing facilities	8	1	1	77	17	–	–
Home health agencies	6	–	–	73	16	–	–
Laboratories	86	–	–	90	–	–	–
Pharmacies	–	–	–	93	76	–	5

* Values are percentages. CPOE = computerized physician order entry; EHR = electronic health record.

grate or interface internal data systems and aggregate the data on a dedicated server were a function of 2 attributes: the number of systems requiring integration and the difficulty of integration. On the basis of the experience of SBCDE, an easy integration would cost $15 000 per system (estimated to apply to 20% of current systems), a moderately difficult integration would cost $45 000 per system (30% of current systems), and a difficult integration would cost $90 000 or more per system (50% of current systems). We assumed that all providers incurred the same integration cost per system and that the degree of difficulty occurred in the same proportion (that is, 20% easy, 30% moderate, and 50% difficult).

Provider facility counts were identical to those used in the functionality model. We used the number of Health Referral Regions (HRR) as defined by *The Dartmouth Atlas of Health Care* (17) as the basis for the number of regional networks and central hosts.

The framework described allowed for data exchange within the regional networks but not between the regional networks. National data exchange was conceptually achievable by adding a layer of 5 to 7 super hosts for the regional hosts and 1 national host for the 5 to 7 super hosts. Because no suitable real-world model of a super or national host currently exists, we assumed, on the basis of expert opinion, that super host costs were 5 times more than regional host costs and national host costs were 2 times more than super host costs. The Appendix (available at www.annals.org) provides further information about the assignment of costs.

Role of the Funding Sources

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RESULTS

Functionality Model

The total costs to achieve the functionality of a model NHIN in 5 years would be $103 billion in capital costs and $27 billion in annual operating costs. In contrast, the health care industry is expected to invest $24 billion in capital costs and $7 billion in annual operating costs over the next 5 years on our current trajectory.

Structure

The expert panel decided that a model NHIN should encompass the work of 6 major stakeholders: physician office practices, hospitals, skilled nursing facilities, home health agencies, laboratories, and pharmacies. The panel further identified the critical elements of functionality for the first 3 providers to consist of result viewing, EHRs, CPOE, and electronic claims submission and eligibility checks. In this model, physician office practices also could securely communicate electronically with patients. For home health agencies, critical elements of functionality would be result viewing and claims submission and eligibility checks, while laboratories would have result viewing and claims submission. Finally, pharmacies would have electronic claims submission and eligibility checks, as well as the capability to accept electronic prescriptions.

Baseline Estimates

Table 1 shows the expert panel's estimations of the current national baseline level of adoption for IT functionalities (16). For physician office practices and hospitals, result viewing was more prevalent than EHRs or CPOE and larger entities were more advanced in adopting technology than smaller ones. Electronic claims submission was the most prevalent form of electronic functionality nationwide, while electronic eligibility checks lagged far behind. Secure patient communication was relatively rare, as was the ability of pharmacies to accept electronic prescriptions.

Five-Year Estimates

Given current adoption rates with no additional interventions to change current trends, the expert panel estimated that in 5 years, more than half of physician office practices and hospitals will have result viewing and only about one quarter of these establishments will have CPOE, except for the large hospitals (**Table 2**). Again, the larger

entities will be more advanced than smaller ones, with skilled nursing facilities and home health agencies lagging behind. However, electronic claims submissions will be nearly universal. About half of all entities, except pharmacies, will have electronic eligibility checks. About 40% of office practices will be able to securely communicate electronically with patients. Last, about 60% of pharmacies will have the ability to accept electronic prescriptions.

Costs To Advance from Current Functionality to a Model NHIN

Table 3 demonstrates the costs to advance from the current level of adoption of IT functionality to a model NHIN. **Appendix Table 1** (available at www.annals.org) presents these costs in more detail. As expected, multimillion-dollar EHRs were the functionality with the largest additional financial requirement, followed by CPOE. The least expensive functionalities were universal pharmacy acceptance of electronic prescribing, secure electronic communication with patients, and electronic claims submission. Of note, hospitals would incur the greatest costs ($51 billion), followed by skilled nursing facilities ($31 billion) and office practices ($18 billion).

Estimated Expenditures on IT over the Next 5 Years at Current Rates of Investment

Table 4 outlines the funds that will be spent on improving functionality over the next 5 years if we continue on our current trajectory without new policy directives or financial assistance. An estimated $24 billion or about one quarter of the total amount required to achieve the model NHIN posited by our experts will be spent over the next 5 years by various key providers. Hospitals will spend the largest amount ($14 billion), followed by skilled nursing facilities and physician office practices.

Interoperability Model

The total costs to construct a brokered peer-to-peer communication network nationwide are projected to be $53 billion in capital investment and $21 billion in ongoing annual operating costs, approximately half of our estimated requirements for achieving the functionalities of a model NHIN (**Table 5**).

Structure

The major health care providers included in our interoperability calculations were those included in the functionality estimates, as well as radiologic imaging centers and payers. In these estimates, we also included central, super, and national hosts, as defined in the Methods section. **Appendix Table 2** (available at www.annals.org) describes the major interoperability cost components for each provider.

Costs for Interoperability

Because costs for interoperability depend on the number of providers, physician office practices will require the bulk of funds ($31 billion), followed by pharmacies ($10 billion), skilled nursing facilities ($5 billion), and hospitals ($2 billion). Laboratories, imaging centers, and payers will require relatively fewer funds. The hosts require relatively little money (about $100 million).

Sensitivity Analyses

Physician Office Practices

Because of the large number of physician offices, we performed sensitivity analyses varying the numbers of physician office practices in each group. We derived the total number of physician offices from census data, which should provide the most accurate estimate possible. However, the categorization of physician offices into size classes may have variability. Therefore, we performed a sensitivity analysis by moving 20% of physician office practices into the next larger size class. This resulted in a 12% increase in the overall costs of achieving a model NHIN. Moving 20% of office practices into the next smaller size class resulted in a 1% decrease in the overall model cost.

Table 2. **Estimated Proportion of Providers with Information Technology Functionalities in 5 Years on the Basis of Current Trends***

Provider	Result Viewing	EHR	CPOE	Claims	Eligibility	Patient Communication	Electronic Prescribing
Physician offices							
1–4 physicians	51	25	21	99	53	33	–
5–20 physicians	63	31	28	99	55	40	–
>20 physicians	69	38	32	99	64	46	–
Hospitals							
≤300 beds	69	29	37	99	58	–	–
>300 beds	83	41	54	99	65	–	–
Skilled nursing facilities	29	14	14	99	54	–	–
Home health agencies	29	–	–	99	56	–	–
Laboratories	91	–	–	99	–	–	–
Pharmacies	–	–	–	99	92	–	58

* Values are percentages. CPOE = computerized physician order entry; EHR = electronic health record.

Table 3. **Capital and Operating Costs To Advance from Present Levels of Information Technology Functionalities to a Model National Health Information Network***

Provider	Result Viewing	EHR	CPOE	Claims	Eligibility	Patient Communication	Electronic Prescribing	Total by Provider
Physician offices								
1–4 physicians								
Capital	0.38	6.72	1.65	0.11	0.45	0.11	–	9.5
Operating	0.10	1.70	0.41	0.06	0.16	0.12	–	2.5
5–20 physicians								
Capital	0.18	3.55	0.87	0.04	0.23	0.06	–	4.9
Operating	0.05	0.89	0.22	0.02	0.07	0.08	–	1.3
>20 physicians								
Capital	0.14	2.81	0.70	0.02	0.18	0.05	–	3.9
Operating	0.04	0.70	0.18	0.01	0.05	0.07	–	0.1
Hospitals								
≤300 beds								
Capital	0.68	21.60	7.90	0.05	0.20	–	–	30.4
Operating	0.17	5.40	1.98	0.03	0.11	–	–	7.7
>300 beds								
Capital	0.17	14.79	5.24	0.01	0.10	–	–	20.3
Operating	0.04	3.70	1.31	0.01	0.07	–	–	5.1
Skilled nursing facilities								
Capital	1.79	12.86	16.07	0.16	0.43	–	–	31.3
Operating	0.45	3.22	4.02	0.04	0.11	–	–	7.8
Home health agencies								
Capital	1.63	–	–	0.08	0.23	–	–	2.0
Operating	0.41	–	–	0.03	0.06	–	–	0.5
Laboratories								
Capital	0.19	–	–	0.001	–	–	–	0.2
Operating	0.05	–	–	0.04	–	–	–	0.1
Pharmacies								
Capital	–	–	–	0.01	0.03	–	0.10	0.1
Operating	–	–	–	0.18	0.49	–	0.07	0.7
Total costs								
Capital	5.2	62.4	32.4	0.5	1.9	0.2	0.1	102.7
Operating	1.3	15.6	8.1	0.4	1.1	0.3	0.1	26.9

* Values are U.S. billion dollars. CPOE = computerized physician order entry; EHR = electronic health record.

Decreased Productivity with EHR Implementation

Decreased productivity with EHR implementation is an important concern, although 2 recent studies suggest that this decrease may actually be more modest and short-lived than generally expected (18, 19). However, to test the impact of training costs on total costs, we increased training costs by 100%. Total capital costs of the interoperability model increased less than 1%.

DISCUSSION

We identified the critical providers, functional domains, and interoperability requirements for a model NHIN. In sum, $156 billion in capital investment and $48 billion in annual operating costs would be required to achieve a model NHIN in 5 years. Approximately two thirds of the capital costs would be spent on functionalities, while one third would be spent on interoperability. Annual operating costs would be more evenly divided, with about $27 billion spent annually on functionalities and $21 billion on interoperability. If we continue on our current trajectory of IT adoption, the health care system will spend about one quarter of the costs of the functionalities of a model NHIN and will probably not even begin to address issues of interoperability. These findings suggest that policy initiatives are needed if we are to close this gap.

In our model, hospitals incurred the highest costs for functionalities despite being currently relatively advanced in adoption of IT. These costs were largely driven by expensive EHR and CPOE systems that can cost millions of dollars per installation. Skilled nursing facilities likewise incurred very large costs, primarily since they currently have relatively little IT functionality in place.

The number of individual providers largely drove the interoperability costs. Therefore, office practices in aggregate incurred the largest costs, followed by pharmacies and skilled nursing facilities. Hospitals in aggregate incurred relatively lower costs for interoperability even though the individual costs were similar across all providers.

Clearly, the implementation of an NHIN will be expensive. However, the United States spent 15% of the gross domestic product or $1.65 trillion on health care in 2003. Costs after inflation have been increasing somewhat more than 5% per year (20).

Emerging data suggest that IT can decrease costs of health care while maintaining or improving quality. Targeting the investment to types of clinical information systems and health care providers can maximize returns on investment. For example, a recent study estimated $44 billion in annual cost savings with nationwide implementation of ambulatory CPOE systems capable of advanced clinical decision support (21). Further work is necessary to demonstrate the returns on IT investments.

A major barrier to widespread IT adoption is that costs are generally incurred by a few entities, while benefits accrue to many. For example, hospitals make an initial multimillion-dollar investment in CPOE, although financial benefits accrue to many (22). Institutions tend to invest in areas with direct financial benefits to themselves, such as new equipment or facilities. It seems unlikely that the private sector will move forward rapidly to adopt IT without public sector investment or incentives, both in terms of money and leadership, although this incurs the risk that public dollars will substitute for private dollars targeted to acquire IT functionalities over the next 5 years.

Public policy initiatives have already improved IT adoption rates. For example, high rates of automated claims submission are largely due to the Health Insurance Portability and Accountability Act of 1996 (HIPAA), which developed standards for electronic health transactions (23). By October 2003, the Centers for Medicare & Medicaid Services would only accept claims that were adherent with HIPAA standards, ensuring that payers and providers rapidly modified their systems (24). These types of standards decrease IT costs since they encourage uniformity. In addition, electronic claims submission is one of the few areas where financial incentives are well-aligned, since electronic transactions decrease the turnaround time and costs of processing bills while improving the number of paid claims (25).

One policy option is the widespread adoption of the

Table 4. **Expected Capital and Operating Expenses over the Next 5 Years at Current Trajectory***

Provider	Result Viewing	EHR	CPOE	Claims	Eligibility	Patient Communication	Electronic Prescribing	Total by Provider
Physician offices								
1–4 physicians								
Capital	0.14	1.19	0.28	0.10	0.21	0.03	–	2.0
Operating	0.04	0.30	0.07	0.06	0.08	0.04	–	0.6
5–20 physicians								
Capital	0.08	0.77	0.19	0.04	0.11	0.02	–	1.2
Operating	0.02	0.19	0.05	0.02	0.03	0.03	–	0.3
>20 physicians								
Capital	0.08	0.76	0.18	0.02	0.10	0.02	–	1.2
Operating	0.02	0.19	0.04	0.01	0.03	0.03	–	0.3
Hospitals								
≤300 beds								
Capital	0.23	4.37	2.55	0.04	0.10	–	–	7.3
Operating	0.06	1.09	0.64	0.02	0.05	–	–	1.9
>300 beds								
Capital	0.08	4.15	2.34	0.01	0.06	–	–	6.6
Operating	0.02	1.04	0.58	0.01	0.04	–	–	1.7
Skilled nursing facilities								
Capital	0.41	1.69	2.11	0.16	0.19	–	–	4.6
Operating	0.10	0.42	0.53	0.04	0.05	–	–	1.1
Home health agencies								
Capital	0.40	–	–	0.08	0.11	–	–	0.6
Operating	0.10	–	–	0.02	0.03	–	–	0.2
Laboratories								
Capital	0.07	–	–	0.001	–	–	–	0.1
Operating	0.02	–	–	0.04	–	–	–	0.1
Pharmacies								
Capital	–	–	–	0.01	0.02	–	0.05	0.1
Operating	–	–	–	0.15	0.33	–	0.04	0.5
Total costs								
Capital	1.5	12.9	7.6	0.5	0.9	0.1	0.1	23.5
Operating	0.4	3.2	1.9	0.4	0.6	0.1	0.4	6.6

* Values are in U.S. billion dollars. CPOE = computerized physician order entry; EHR = electronic health record.

Table 5. **National Costs for Interoperability**

Provider	Amount, *n*	Average Costs, $*		Total Costs, $†	
		First Year	Operating	First Year	Operating
Physician offices					
1–4 physicians	168 017	0.16	0.06	26.94	9.58
5–20 physicians	16 376	0.24	0.09	3.96	1.42
>20 physicians	1418	0.39	0.16	0.55	0.22
Hospitals					
≤300 beds	4854	0.38	0.17	1.85	0.84
>300 beds	902	0.51	0.22	0.46	0.20
Skilled nursing facilities	12 989	0.38	0.17	4.91	2.24
Home health agencies	6928	0.24	0.14	1.69	0.97
Laboratories	5127	0.18	0.07	0.91	0.38
Imaging center	4623	0.18	0.08	0.84	0.37
Pharmacies	58 593	0.18	0.07	10.40	4.37
Payers	2000	0.19	0.07	0.37	0.15
Hosts					
Central	307	0.30	0.26	0.09	0.08
Super	5	1.00	0.96	0.01	0.005
National	1	1.88	1.84	0.002	0.002
Total	–	–	–	52.97	20.82

* Values are in U.S. million dollars.
† Values are in U.S. billion dollars.

Veterans Health Information Systems and Technology Architecture (VISTA), the IT system of the Department of Veterans Affairs. This open-source system has been successfully used in several Veterans Affairs sites with well-demonstrated quality benefits (26). However, an older programming language and a lack of billing and claims functionalities have limited its widespread adoption outside of the Department of Veterans Affairs to date.

Many other policy options are currently being considered. Data and communication standards have emerged as an important area. For example, there have been recommendations to adopt standards based on those developed by Health Level 7 (HL7) and others (27). The U.S. Department of Health and Human Services reached an agreement with the College of American Pathologists to allow free access to its medical vocabulary system, SNOMED, and had the IOM and HL7 describe functionality requirements for EHRs (28, 29).

Recently, several bipartisan legislations have been introduced that address IT and an NHIN. Senators Clinton and Frist introduced legislation on health information technology and quality (30), and Congressmen Kennedy and Murphy introduced the 21st Century Health Information Act (31).

Many policy initiatives will be essential if the United States is to establish an NHIN within a reasonable time frame. Some of the keys will be federal investment in areas of public goods, such as standard development and refinement, facilitating access to capital (particularly for smaller stakeholders), and aligning financial incentives through changes in reimbursement policies.

Our study has several limitations. Because of a dearth of primary adoption and cost data, we were often forced to rely on expert estimates. Accurate estimates from experienced institutions would enhance the accuracy of the model. Changes in the sets of stakeholders and functionalities would substantially alter functionality costs, as would changes in the model of interoperability. In addition, we made several conservative assumptions, particularly that of having all providers be data suppliers in a brokered peer-to-peer network. Changing these assumptions would reduce the cost estimates. It was beyond the scope of our study to ascertain the benefits associated with an NHIN. We assumed fixed prices for hardware and software. As volumes of sale increase, the costs may likely decrease. Finally, we assumed that no important new technological developments over the next 5 years, such as widespread use of standards or of application service provider software, would substantially decrease costs.

In conclusion, IT is an important tool to improve the safety and efficiency of U.S. health care, but its adoption remains limited largely because of a lack of aligned financial incentives and national standards, although progress has recently been made on this front. An NHIN will cost $156 billion in capital costs or approximately 2 years of real growth in U.S. health care costs. However, the benefits of such an investment, both in terms of money and quality, may be substantial.

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Appendix

To project capital costs for physician offices, we first developed cost estimates for a single physician in a small office. We then multiplied this cost per physician by the estimated average number of physicians per office in each size class. On the basis of purchasing experience, we discounted the cost per physician by 20% for medium-sized offices and by 30% for large-sized offices. We estimated the relationship between small-sized hospital costs and large-sized hospital costs in a similar manner to physician offices. We first estimated costs for small hospitals, then scaled them for larger hospitals. The scale for results viewing was a simple doubling of small hospital costs. However, because large hospitals are not only larger than small hospitals but are more complex as well, we scaled the costs for EHR and CPOE by a factor of 4.

Insufficient data were available to classify home health agencies by size or other characteristics. Therefore, we applied the expert panel's consensus cost estimates to all home health agencies.

To project costs for skilled nursing facilities, we took costs for small community hospitals as a starting point. However, because the similarities between a skilled nursing facility and a small hospital are much more complex than the similarities between a small physician office and a large physician office, the cost relationship is more complex as well. We projected a skilled nursing facility's capital costs for result viewing as 50% of those for a small hospital. In contrast, because a skilled nursing facility's functionality requirements for EHRs are lower than those for the acute care setting, we projected the skilled nursing facility's capital costs to be 20% of the small hospital capital costs for that component.

Appendix Table 1. **Capital and Operating Costs for Acquiring Various Functionalities***

Provider	Result Viewing	EHR	CPOE	Claims	Eligibility	Patient Communication	Electronic Prescribing
Physician offices							
1–4 physicians							
Capital	3	44	10	3	3	1	–
Operating	1	11	3	2	1	1	–
5–20 physicians							
Capital	16	246	58	16	16	4	–
Operating	4	62	14	7	5	5	–
>20 physicians							
Capital	155	2332	544	155	155	37	–
Operating	39	583	136	52	43	53	–
Hospitals							
≤300 beds							
Capital	300	5000	1750	60	50	–	–
Operating	75	1250	438	33	27	–	–
>300 beds							
Capital	600	20 000	7000	150	150	–	–
Operating	150	5000	1750	113	97	–	–
Skilled nursing facilities							
Capital	150	1000	1250	55	40	–	–
Operating	38	250	313	14	10	–	–
Home health agencies							
Capital	250	–	–	45	40	–	–
Operating	63	–	–	14	10	–	–
Laboratories							
Capital	265	–	–	2	–	–	–
Operating	66	–	–	90	–	–	–
Pharmacies							
Capital	–	–	–	2	2	–	2
Operating	–	–	–	43	35	–	1

* Values are U.S. thousand dollars. CPOE = computerized physician order entry; EHR = electronic health record.

Appendix Table 2. **Capital Cost Components per Facility for Interoperability**

Provider	Fixed Costs, $*	Security and Interoperability Software, $*	Server, T1 Line, and Systems Administration, $*	Systems Requiring Interface, *n*	Systems Interface Costs by Degree of Difficulty, $*			Training Costs, $*
					Easy	Moderate	Difficult	
Physician offices								
1–4 physicians	8	10	19	2	30	90	180	0.6
5–20 physicians	15	20	19	3	45	135	270	3
>20 physicians	50	35	27	4	60	180	360	28
Hospitals								
≤300 beds	60	40	27	4	60	180	360	8
>300 beds	80	50	35	5	75	225	450	36
Skilled nursing facilities	60	40	27	4	60	180	360	5
Home health agencies	60	40	19	2	30	90	180	1
Laboratories	15	20	19	2	30	90	180	0.5
Imaging center	15	20	24	2	30	90	180	0.4
Pharmacies	15	20	19	2	30	90	180	0.3
Payers	15	20	19	2	30	90	180	8
Central hosts (2 hosts)	125	50	126	–	–	–	–	–
Super hosts (3 hosts)	625	250	126	–	–	–	–	–
National hosts (3 hosts)	1250	500	126	–	–	–	–	–

* Values are in U.S. thousand dollars.