A Rapid-Learning Health System

What would a rapid-learning health system look like, and how might we get there?

by Lynn M. Etheredge

ABSTRACT: Private- and public-sector initiatives, using electronic health record (EHR) databases from millions of people, could rapidly advance the U.S. evidence base for clinical care. Rapid learning could fill major knowledge gaps about health care costs, the benefits and risks of drugs and procedures, geographic variations, environmental health influences, the health of special populations, and personalized medicine. Policymakers could use rapid learning to revitalize value-based competition, redesign Medicare's payments, advance Medicaid into national health care leadership, foster national collaborative research initiatives, and design a national technology assessment system. [*Health Affairs* 26, no. 2 (2007): w107–w118 (published online 26 January 2007; 10.1377/hlthaff.26.2.w107)]

NATIONAL HEALTH POLICIES THAT USE government price setting and market competition are running out of steam. Neither approach is doing well at increasing the value Americans get from their "highest-in-the-world" medical expenditures. And neither government price setting nor markets has been effective at dealing with rising health costs driven by new technologies. With advances in human genome research and a doubling of the National Institutes of Health (NIH) budget in recent years, to $28 billion per year, an even faster stream of new products and therapies might be emerging. Strategies to encourage rapid learning—to quickly develop new evidence for daily medical practice and policy—might be able to increase the value of health care, assess such new technologies, and avoid draconian cost cutting.

■ **Electronic records.** Electronic health record (EHR) databases now being built by large organized delivery systems will dramatically expand the nation's research capacity. They will make it possible to include clinical experience from tens of millions of patients annually in computer-searchable databases for collaborative research. For example, the Department of Veterans Affairs (VA) is building a research database drawing on more than eight million patient records from its Veterans Health Information Systems and Technology Architecture (VistA) system. In the private sector, Kaiser Permanente is leveraging its EHR investments to create a national research

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database from its eight million enrollees; the Geisinger Health System in Pennsylvania is developing a similar capability, drawing on two million patients.

■ **Beyond EHRs.** The Cancer Research Network, sponsored by the National Cancer Institute (NCI) with the HMO Research Network, includes eleven health systems with more than ten million enrollees in a new national model for virtual research organizations.[1] The Vaccine Safety Datalink network at the Centers for Disease Control and Prevention (CDC) includes seven health maintenance organizations (HMOs) and six million patient records.[2] The American Medical Group Association, whose membership of multispecialty practices treats more than fifty million patients annually, has started a collaborative database with 1.5 million records and plans for expansion to 8–15 million patient records in the next three to five years.[3] These new research capacities augment research registries already being sponsored by physician specialty societies; the NIH's Roadmap plans for genetic research, clinical trials databases, and clinical research networks; and new prescription drug databases at the Centers for Medicare and Medicaid Services (CMS).

■ **Potential for rapid learning.** EHR research will not replace randomized clinical trials as a definitive research method for specific issues, but it will offer the capacity for real-time learning from the experience of tens of millions of people and will greatly increase the ability to generate and test hypotheses. If a rapid-learning strategy that uses all of the research and data capabilities that can be brought to bear is successful, the U.S. lead in biomedical science could be matched by its learning about how to deliver the most value for its health care spending.

This paper offers a national health policy perspective on these rapid-learning opportunities. First, it briefly reviews how current national policies leave major gaps and too many uncertainties in the evidence base for clinical care. Second, it discusses how a rapid-learning strategy could fill some of these knowledge gaps quickly. Third, it describes a new generation of national health policies to leverage such new knowledge into rapid advances in health system performance. Although there are many questions yet to be answered about a national rapid-learning strategy, extraordinary new research capabilities—from investments of billions of dollars and years of work on EHR systems design, implementation, and databases; predictive computer models; and software development—will be emerging over the next few years. It seems worthwhile to invest public and private resources in discovering the potential benefits and lessons of their use.

Knowledge Gaps And Uncertainties

Is national health policy now advancing the scientific evidence base for clinical practice as rapidly as possible? An approximate answer is that the United States leads the world in basic biomedical research. But there are stunning gaps in clinical research and the knowledge base for evidence-based medicine.

■ **Diffused responsibility.** The knowledge gaps for evidence-based medicine result mostly from how national science policy has allocated responsibilities among

the NIH, biotechnology-based industries, and the Food and Drug Administration (FDA). In the broad schema of national science policy, the federal government has had the lead responsibility for support of basic research, primarily through grants to investigators at academic institutions. Private-sector biotechnology industries are expected to lead in turning this knowledge into new drugs, devices, and biological agents for clinical use. The FDA's primary responsibilities focus on requiring evidence of safety and effectiveness through carefully designed clinical trials before these products enter the market. The required FDA clinical trials (Phase III) typically include several hundred to several thousand patients. The FDA's approval standard for effectiveness is characterized by a leading pharmaceutical expert as follows: "A new drug must merely be slightly better than placebo in achieving a surrogate outcome over a few months, in modest numbers of highly selected patients."[4] After that point, the diffusion of new technologies and the accumulation of knowledge about how well they work have come to depend greatly on industry-financed research and marketing. By 2002, 80 percent of clinical trials were reported to be financed by the biotechnology industries.[5]

■ **Concerns about clinical trials.** If we are to make evidence-based medicine a paradigm for U.S. national health policy, we have to examine and improve the evidence base, its gaps, and its biases.[6] Clinical trials usually study selected younger-adult populations in carefully controlled circumstances. The evidence base is weakest in measuring the real-world effectiveness of the $2 trillion in U.S. health expenditures for typical patients seen in clinical practice—such as seniors and disabled people among the Medicare and Medicaid programs' eighty-five million enrollees. Scientific proof of effectiveness and safety are not required before medical and surgical procedures become part of clinical practice. Few studies effectively compare different therapies with each other for various patient groups.

For the most part, clinical trials report average effectiveness, yet there often are wide variations in treatment benefits among patient subpopulations. Moreover, there are growing concerns about (1) the extent to which the evidence published in research literature is financed by industry, (2) authors' conflicts of interest, (3) the dependence of leading professional journals on drug company advertising, (4) failure to report all clinical trial studies, and (5) failure to publish research with negative results. About two-thirds of clinical trials are reported to be done by for-profit research companies paid by the drug industry.[7] Widely cited initial findings have been found by subsequent research to be erroneous or overstated.[8] Many major technologies and clinical practices diffuse, over decades, into much broader and diverse patient populations, sometimes including millions or tens of millions of patients, than studied at initial entry.[9]

■ **Consequences of underinvestment.** The consequences of public underinvestment in evidence-based research are increasingly seen in the national media. Vioxx has become a prominent example of inadequate testing and monitoring for longer-term safety. It was an unwelcome surprise for tens of millions of women

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worldwide when hormone replacement therapy was found to have previously undocumented risks. The federal government's "food pyramid" nutritional advice has needed major revisions. There are recent studies showing that the previous knowledge base was in error about low-fat diets, vitamin E, calcium and vitamin D, and so on. All of these are examples of instances where a rapid-learning strategy could have produced much better knowledge, years—even decades—earlier.

■ **Genetics-based medicine.** The advent of genetics-based medical science also requires rethinking traditional strategies for evidence development. It is known that drugs can vary widely in benefits and risks based on patients' genetic characteristics.[10] To maximize health care value, today's pharmacopeias and new drugs might need to be evaluated for many patient subpopulations. This will be enormously expensive and time-consuming if it requires premarket entry clinical trials many times larger than the FDA's current requirements.

■ **Overall system performance.** An inadequate knowledge base also limits initiatives to improve health system performance. Quality measures and pay-for-performance (P4P) incentives can now be applied only to a relatively small fraction of medical care. Similarly, health plans need more scientific and professional consensus to change practice patterns and advance evidence-based care. Physicians and patients could become a more effective force for driving health system value if there were greater certainty about the benefits and risks of treatment options.

In the past, there have been concerns that governmental initiatives to upgrade the clinical evidence base would involve far more regulatory requirements, large expenses, or long delays in technology diffusion.[11] The rapid-learning strategies that will now be possible will avoid many of these faults. With large, computer-searchable EHR databases and new research software, studies that would now take years will be doable, at low expense, in a matter of weeks, days, or hours. Rather than slowing the appropriate use of new technologies, a successful rapid-learning strategy could accelerate progress with more-definitive information for personalized medicine and greater professional and patient confidence in evidence-based guidelines. The biotechnology industries could benefit from public support for large EHR databases with genetic information, which involves far too great an expense for most individual companies to afford to construct and maintain on their own. Evidence from off-label uses in these data banks could provide important indicators about potential new uses of drugs.

Rapid-Learning Opportunities

Other papers in this collection discuss development history of rapid-learning capabilities—for example, at Kaiser Permanente, the VA, and the U.S. Department

of Health and Human Services (HHS)—and their potential use for breakthroughs in biomedical science and in clinical areas such as diabetes and cancer.[12] Here I focus on how rapid learning could provide comparable knowledge breakthroughs in several national health policy areas.

■ **Why are health care costs increasing?** For many years, health care costs and increases have been a major topic in health policy discussions. Yet the federal government does not yet have an adequate database to examine these rising costs. For example, national estimates that "intensity" of care—most likely new health care technology—accounts for 30–50 percent of annual spending increases are residual estimates; they are derived by subtracting population increases and inflation from health care spending increases.[13] We do not know what changes in clinical practices, for what patients, and for what conditions account for rising costs; nor do we know the extent to which such increases are from newly introduced technologies or diffusion of older technologies. Thus, it is very difficult to know for sure what we are buying, or to know whether or not the increases reflect evidence-based science. New national databases, with tens of millions of patient records, could quickly provide far more accurate information on these issues.

■ **What are the comparative benefits and risks of prescription drugs?** Seniors, children, women, minorities, and patients with comorbidities—the largest groups of prescription drug users—are frequently underrepresented in clinical trial data. There are also knowledge gaps about long-term benefits and side effects after the end of clinical trials—for instance, for chronic disease medications. The real-world effectiveness of drug therapies might differ, for better or worse, from the results in carefully managed clinical trials. As Jerry Avorn has noted, "We often cannot determine that a drug will turn out to be more effective or safe than its alternatives until it's been used for some time by large numbers of typical patients."[14] All of these concerns add to the need for new rapid-learning initiatives.

A comprehensive research agenda should be able to fill in important evidence gaps about prescription drugs. Drugs' effectiveness in population groups that were not adequately represented in randomized clinical trials could be checked with real-world data. New drugs could be assessed for effectiveness and safety, on a real-time basis, as they diffused into broader use. Heterogeneity in treatment responses could be analyzed to identify possible genetic and other still-unknown factors about diseases and their treatment and to design new clinical trials. Genetic information could be incorporated into EHR records where research has identified a target set of genes implicated in the benefits and risks from a particular drug. With such a system, Vioxx-type problems might be spotted quickly, in the first one or two years, and possibly identified as adversely affecting only small fractions of patients with specific biomarkers. Given the great importance of drug therapies for the Medicare aged and disabled populations, national health policy could make particularly good use of new databases for the Medicare prescription drug program.

■ **What is the evidence base for procedures?** Medical and surgical procedures are the largest component of health care spending, but without FDA-type scientific testing, many questions exist about their safety and effectiveness. There are wide variations in rates at which procedures are used for different populations and in different areas. One major research need is for definitive comparisons of minimally invasive surgery versus standard surgery. Physicians and patients could also use more-definitive knowledge about issues of medical versus surgical treatment. EHR systems can report data about all of these issues, making it feasible to learn from large numbers of patient experiences, rapidly and relatively inexpensively.

■ **What explains variations in health care spending and use?** Medical care practices differ widely among states, small geographic regions, and cities and even among leading hospitals and within health plans. Studies using EHR databases should allow much better analyses of variations, such as the extent to which they reflect health status differences. The appropriate federal policies could differ depending on these research results.

■ **How do environmental factors affect disease patterns?** Many health problems, including some cancers, birth defects, and heart disease, have concentrations in specific geographic areas. This suggests that environmental factors might add an as-yet-unknown factor, such as low-level chemicals in the water supply leading to birth defects or microbes that could produce clogging of arteries. Research epidemiologists could make good use of EHR databases for studying areas with high and low prevalence of health problems and correlating these findings with environmental data. Genetic information could be incorporated into EHR databases to assess damage from environmental factors.

■ **How can the health of minorities and special-needs groups be improved?** The gaps in our evidence base disadvantage minorities and people with special needs, who are often underrepresented in FDA-required clinical trials and industry-financed studies. Yet there are many health issues that need to be understood for minority populations, such as higher incidence of certain diseases and differing treatment patterns. Many Medicaid patients have special needs. For example, Medicaid enrolls many children with serious, long-term, and expensive disabilities, such as autism, cerebral palsy, cystic fibrosis, hemophilia, HIV/AIDS, sickle cell anemia, spina bifida, muscular dystrophy, epilepsy, and mental retardation. Their care is often fragmented among specialists and lacks good coordination; primary care also is often lacking. Large-scale EHR databases for such groups could provide valuable new resources to document current care and its successes and failures, engage more researchers, advance the evidence base, and reengineer patterns of care.

■ **What does this mean for patients like me?** One of the insights from studies of patient decision making is that people are much more interested in information about "patients like me" than in general statistics about risk factors and treatment options. But physicians and patients are often uncertain about treatment choices. Search software for large EHR databases could be designed to provide more-rele-

vant information. A patient or physician could enter personal profile information and pose questions about the health experiences of and outcomes for large numbers of similar patients. If genetic information were included in EHR databases, it would be possible to move much more quickly toward a future of personalized medical care, where "patients like me" questions can be answered with greater accuracy.

■ **Components of a rapid-learning system.** A national rapid-learning system could include many databases, sponsors, and research networks. Its databases could be organized by enrolled populations (private health plans, VA, Medicare, Medicaid), providers (multispecialty clinics, academic health centers, specialist registries), conditions (disease registries), technologies (drug safety and efficacy studies, outcomes research), geographic areas (the Framingham Heart Study), age cohorts (the National Children's Study), minority populations (human genome studies), and other ways. With national EHR data, registry, connectivity, reporting, and privacy protection standards, all EHR systems could be compatible and capable of multiple uses; information in one data bank could be supplemented with that from another.

■ **Patient confidentiality.** A national legal and regulatory framework, the Health Insurance Portability and Accountability Act (HIPAA), exists for computerized medical records, and research organizations nationwide are required to have institutional review boards (IRBs) to approve and oversee studies that use individually identifiable data.[15] These laws and regulations also allow the development and use of research databases with non–personally identifiable information.[16] Rapid-learning organizations have been able to carry out research programs within current laws and regulations, and some EHR research data banks exclude personal identifiers. So far, a rapid-learning strategy does not seem to require changes in confidentiality laws; however, these issues are likely to attract ongoing scrutiny.

National Policies To Support Rapid Learning And To Use The Information Generated

National investment in rapid-learning initiatives would enable a new generation of health policies to realize the benefits of our expanding knowledge base.

■ **Reenergized markets.** The professionals and organizations that adopt EHRs and use EHR research databases could emerge as leaders for market-driven change. EHR use has advanced quickly, particularly among HMOs and multispecialty practices. A leading EHR software company, for example, reported that its EHRs were in use for fifty-eight million people as of November 2006.[17] EHR research databases could be the key technology for advancing the evidence base, and EHRs could be the key management technology for applying it. By supporting rapid learning, national health policy could reenergize competitive markets, led by those health plans, multispecialty clinics, hospitals, and physicians that make best use of EHRs.

To realize such competitive benefits for Medicare, investment in rapid-learning initiatives for Medicare's populations will be needed. Medicare health plans and multispecialty clinics with EHR research databases, such as Kaiser Permanente

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and Geisinger, could be partners. In the public sector, the VA could have a similar role, particularly in assessing new technologies, refining evidence-based protocols, and conducting practical clinical trials. The VA has a growing Medicare-age service population, it is a national leader in EHR systems and research databases, and it has affiliations with 107 medical schools and a research program of about $1.5 billion annually. Another federal player, the Agency for Healthcare Research and Quality (AHRQ), has a national network of evidence evaluation centers, including centers to assess research for Medicare, Medicaid, and the State Children's Health Insurance Program (SCHIP). By partnering with the VA, health plans, and others, Medicare could create a stronger evidence base for its beneficiaries, physicians, hospitals, clinics, and health plans.

■ **New payment policies.** When Medicare's diagnosis-related group (DRG) and resource-based relative value scale (RBRVS) payment policies were adopted, they were designed as national payment schedules, with various adjustments, to replace Medicare's original payment methods that reimbursed each hospital on the basis of its costs and each physician on the basis of his or her billed charges. The main objective was a rational payment system, where the federal government could decide on payment amounts. Quality of care was assumed to be something that payers did not need to worry about. Today, however, we know that quality variations must be a central concern for future national health policy. The health system delivers care whose quality meets professional standards only about half the time.[18] Yet Medicare pays the same amount for care of below-average quality as for the best care. Quality report cards and P4P are important initiatives to adjust the payment amounts, but they now cover only a fraction of medical care.

With a rapid-learning strategy, it will be possible to develop a new Medicare payment system based on evidence-based protocols. With this approach, health care providers would be paid for delivering courses of treatment that have been scientifically proven to achieve the best outcomes and for documenting, such as through EHRs, that they provided such care. Health care that did not meet scientifically validated standards would be paid for at a lower rate.[19] Such a new system will require fast-track research to assess alternative evidence-based protocols. If national health policymakers intend to end mediocrity and outdated practices, Medicare's $400 billion of annual spending can be leveraged to advance science-based medicine.

Organizing Medicare's payment requirements around evidence-based protocols could be a powerful strategy for advancing clinical science. Pediatric oncology is often cited for its rapidly improving patient outcomes.[20] In this field, most children with cancer are in clinical trials with defined protocols of care, and treat-

ment results are rapidly reported to other specialists, so that the knowledge base expands from the experience of every patient. In contrast, only a small percentage of Medicare cancer patients are now part of clinical trials, and Medicare does not require reporting on cancer treatment protocols and results. A Medicare rapid-learning system could be designed, however, to learn continuously from the experiences of its forty-three million beneficiaries.

■ **Medicaid as a rapid-learning leader.** Medicaid and SCHIP could be one of the highest-payoff areas for new EHR-based learning strategies and program management. Not only are these, combined, the nation's largest health program, in terms of enrollees (more than fifty million) and costs (about $350 billion this year), but they also cover large numbers of the poorest, sickest patients, including many minorities. The Medicare/Medicaid dual-eligible population of seven million accounts for over 30 percent of spending for Medicare's enrollees and more than 40 percent of Medicaid spending; they need much more attention for better care.[21] The two programs are also the nation's largest payer for pregnancy care and a leading payer of care for children; the frail elderly; and people with serious, long-term disabilities. Asthma, chronic mental illness, alcoholism, drug abuse, and AIDS are also health problems of particular importance to Medicaid. However, no state Medicaid program is yet using EHR systems, and it is unrealistic to think that Medicaid-participating public hospitals, clinics, emergency rooms, and physicians are going to be able to buy commercial EHR products.

Medicaid and SCHIP could become national leaders in EHR adoption and in use of EHR research databases. A rapid and low-cost way to implement an EHR strategy for them would be for states to create EHRs for enrollees on a central computer server that could be accessed by their Medicaid providers. The National Health Service (NHS) in England is a leading example of this implementation strategy. State EHR choices could include the VA's VistA system, which is already in the public domain and sponsored by HHS as a low-cost option for physicians and clinics, as well as EHR systems offered by Medicaid's contractors. Since federal law already offers a 90 percent federal match for computerized Medicaid management information systems, a national strategy to encourage states to adopt EHRs could move quickly. A centralized EHR system could be an enormous advance in a state's capabilities to understand and manage Medicaid and SCHIP. Medicaid/SCHIP research databases could become a valuable resource for advancing clinical science for people enrolled in these programs. The federal government could invest in partnerships with leadership states—perhaps up to three states initially—to develop comprehensive EHR systems and databases and to become "rapid-learning laboratories" for SCHIP and Medicaid nationwide.

■ **National clinical trials databases.** A rapid-learning strategy could create national computer-searchable databases from NIH-funded and FDA-required clinical trials to make these studies available for further scientific scrutiny and convenient use by other researchers. There have been discussions of such HHS initiatives—and

even ideas for global networks of clinical trials data—but only modest progress to date.[22] At the FDA, for example, a typical new drug application (NDA) involves the delivery of hundreds of thousands of paper records, which often arrive by the truckful. How much simpler and user-friendly it would be for everyone if the FDA required these data to be reported in EHR-type formats for computer analysis. The NIH could require that all NIH-funded clinical trials, as well as the patient care at the NIH's selected national clinical care centers, be reported in EHR-type formats to national research databases. Researchers who try to reach conclusions from multiple studies now must engage in "meta-analyses" of reported statistics rather than being able to analyze combined data sets. Biomedical research could advance more rapidly, and these databases could also prove useful to evaluate new evidence-based protocols and new technologies, since the NIH funds leading-edge work at academic institutions. As the real-world analyses from EHR rapid-learning databases raise questions that require definitive answers, more public investment will be needed in clinical trials, particularly "practical clinical trials" that target important patient care issues.[23]

■ **National assessments of new technologies.** Medicare's recent proposals for "coverage with evidence development" (CED) offer a useful set of ideas for rapid learning about all new technologies. After FDA approval of a new drug or device or the introduction of a new procedure, Medicare (and other payers) would finance coverage for its broader use only when a required set of information was reported to computerized national EHR research registries. Research on these registries and other data would then be used for developing guidelines for use. The federal government and the private sector could jointly develop a national research plan for each new technology. The plan would identify needed research and suggest rapid-learning strategies, using EHR databases and other approaches; it would also set a target date for pulling together answers to these questions and for considering a subsequent research plan.[24] Learning as much as possible, as soon as possible, seems a sensible way to realize the full value of new technologies.

Next Steps

All of the research questions and new policies discussed in this paper are candidates for national initiatives. Growth in spending by Medicare and Medicaid—largely driven by use of new technologies and growing populations of beneficiaries as the baby boomers retire—is among the compelling fiscal reasons for new research. Together, these public programs already consume $600 billion of federal expenditures annually and enroll more than eighty-five million people. Medicare has embarked on a costly new drug benefit; there are many questions to be answered about the best use of drug therapies in senior citizens. Medicare and Medicaid populations are often excluded from the clinical trials evidence base. If these trends continue, without rapid learning about new technologies, the budget costs will be truly extraordinary.

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The key short-term issues for advancing a rapid-learning strategy are leadership, developing specific research programs, and funding. The HHS health agencies and the VA could be public-sector (and funding) leaders; in the private sector, today's rapid-learning networks and organizations, professional societies, and others that invest in EHR systems and develop EHR research capabilities will best be able to lead the advance of evidence-based care. A list of HHS agency-specific initiatives might include expanding on the NCI's Cancer Research Network with NIH networks for heart disease and diabetes; a broad expansion of AHRQ's research to address issues related to Medicare prescription drugs, Medicaid, national health spending, socioeconomic and racial disparities, effectiveness, and quality; expanding the CDC's Vaccine Safety Datalink network and the FDA's postmarket surveillance into a national FDA/CDC program for the evaluation of drug safety and efficacy, including pharmacogenomics; starting national EHR research programs for Medicaid special-needs populations; integrating NIH and FDA clinical studies into national computer-searchable databases; expanding Medicare's evidence development requirements for coverage into a prototype national EHR-based system for evaluating new technologies; developing rapid-learning evidence for Medicare "best practice" protocols and new payment systems in several areas; and integrating new evidence and EHR database search capabilities into the National Library of Medicine's Web site for consumers and professionals, Medline Plus (http:// medlineplus.gov). HHS investments could start at $50 million per year. Over the next five years, as research networks develop and research programs expand, new funding could rise to $300 million annually.

There is a compelling public interest to advance the scientific knowledge for health care as rapidly as possible. There is much to be learned quickly about the best uses of current technologies. For the longer term, a national goal could be for the U.S. health care system to learn about the best uses of new technologies at the same rate at which it produces those new technologies.

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NOTES

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