

# **Public Written Comments**

## **Submitted to PCAST**

**March 20, 2016 to May 15, 2016**

As specified in the Federal Register Notice, because PCAST operates under the Federal Advisory Committee Act (FACA), all public comments and/or presentations will be treated as public documents and will be made available for public inspection, including being posted on the PCAST website.

F William Weaver  
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04 20 2016

Mr. John P Holdren, Co-Chair  
Mr. Eric Lander, Co-Chair  
the President's Council of Advisors on Science and Technology

Re: The High Price of  
Hearing Aids

Dear Sirs:

I wear hearing aids and am nearly  
deaf without them.

The hearing aids that I have are many  
years old. New and better aids are out  
of my price range. I am 88 years old,  
retired and dependent on Social Security

I endorse your plans to encourage  
government actions to make the  
industry competitive.

Yours very truly,

*F. William Weaver*

F. William WEAVER

[REDACTED]

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**From:** Lloyd [REDACTED]  
**Sent:** Tuesday, April 19, 2016 7:46 AM  
**To:** [REDACTED]  
**Cc:**  
**Subject:** How PCAST + Creative Social Science Can Accelerate Recovery & Transition to 21st century Precision Medicine Healthcare  
**Attachments:** 2016.0418.BetterMonetaryPolicy\_BehavioralEconomics.pdf

Dear Colleagues:

I enclose a brief policy paper (6 pp.) showing how creative social science can accelerate economic recovery and underwrite the rapid transition to the 21st century Precision Medicine health system. It may require PCAST's leadership to bring these ideas to the President's attention.

Lloyd Etheredge

Dr. Lloyd S. Etheredge, Project Director

[REDACTED] [//www.policyscience.net](http://www.policyscience.net)<

The Policy Sciences Center is a public foundation that creates and develops knowledge and practice to advance human dignity.

It was founded in 1948 in New Haven, CT by Harold Lasswell, Myres McDougal, and George Dession, members of the Yale

faculty. Information about the Center, the Society of Policy Scientists and the Policy Sciences journal is available at >[www.policyscience.org](http://www.policyscience.org)<.

April 18, 2016

To: Interested Colleagues

From: Lloyd Etheredge – Director, Rapid Learning Economics Project <sup>1</sup>

Re: **Human Behavior & Effective Monetary Policy: Loaning \$1.5 Trillion for a Transition to the 21<sup>st</sup> Century Precision Medicine System**

Current interest rates are close to 0 %. Thus a simple key to faster G-20 economic recovery (and to a more effective monetary policy) is to organize and frame attractive options for governments, corporations, and individuals to borrow from the trillions of dollars of available funds and create additional demand. (Merely waiting for corporations to borrow for added plant and equipment – a traditional pathway – has not been working as it did in the past.) This paper outlines a (draft) option, with ideas from a new, multi-disciplinary, rapid learning system under development for economics. It recommends a creative package, building on an initiative by the Kaiser Health Plan, that requires leadership and further work, but that probably can be structured to induce \$1.5 trillion (or much more) in stimulus.

Also: 1.) The plan is politically attractive. It delivers benefits to the lives of many people. 2.) The plan is economically attractive. The transition to the 21<sup>st</sup> century Precision Medicine healthcare delivery system is a worthwhile individual and international investment to get underway. 3.) Although full implementation might require solving the political impasse in Washington and other foreign capitals, the new recovery plan can get underway quickly, with creative leadership and partnerships. 4.) The plan can leverage other investments and add confidence and excitement. 5.) It recognizes a uniquely-available pathway and opportunity to achieve two urgent global public goods: a.) Building rapid economic recoveries and sustainable economic health across the world's economies; and b.) Securing an investment to activate the world's rapid transition to the new, 21<sup>st</sup> century Precision Health delivery system.

→ The plan also has the unique characteristic that: 6.) If it is implemented as I outline it, the result is likely to be a massive train wreck and waste at least \$1 trillion. A bold stimulus project on this scale is an incentive for governments, healthcare providers, and especially the private sector to develop a coherent Grand Strategy. There will be even better results if stakeholders have a thoughtful roadmap to deliver the best Precision Medicine healthcare to everyone, as quickly as this can be discovered.

### The Kaiser Health Example - \$1,500/Adult Borrowing

The attached announcement from the Kaiser Health Plan reports its medical, civic (and business) decision to request its 10 million adult members to participate in a new investment in their 21<sup>st</sup> century, genetics-based, Precision Medicine healthcare. If they do, Kaiser provides privacy guarantees and it has

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<sup>1</sup> Lloyd Etheredge is Project Director for the Government Learning/Rapid Learning Economics Project at the Policy Sciences Center, Inc., a public foundation incorporated [REDACTED]. Comments welcome. URL: [REDACTED]. My appreciation to Lynn Etheredge (who does not agree with all of the details) for discussion of these ideas.

organized financing to pay the full cost for each member. The constellations are moving into alignment to activate a transition that secures a 21<sup>st</sup> century **Precision Health Investment** for each adult, in the US and worldwide.

[Kaiser's initiative reflects a cost of genetic profiling that has dropped a million-fold toward the \$1,000 range. Kaiser already has invested in electronic health records in standard formats (extending, in some cases, for fifteen years or more) for its 10 million members. Kaiser has gained leadership experience with making medical discoveries and improving care using these new capabilities: It is, *de facto*, adding an invitation to 9 million members after developing its California-based Research Program on Genes, the Environment and Health, a pioneering R&D biobank expanding from 500,000 to 1 million members, including statistical over-sampling to take full scientific advantage of California's social and ethnic diversity.<sup>2]</sup>

A reasonable estimate (that will have to be refined) is that it might cost \$1,500/adult for genetic testing and administration for everybody to have equivalent access to 21<sup>st</sup> century Precision Medicine. The stimulus effects can be available as soon as individuals (perhaps, typically, intermediaries acting on their behalf) can (by mechanisms to be created) access a near-zero % Best Terms borrowing system to make this one-time infrastructure loan for each adult. If we want \$1.5 trillion in added lending and expenditure, we will need to structure incentives for the first 1 billion adults. And this might be done quickly, especially since the national health systems in the other G-8 + EU countries can make more centralized decisions than in the US.<sup>3 4</sup> → And – an important historical reason to move quickly – if the decision is made now, the funds do not need to be appropriated! More than enough money already is available.<sup>5</sup>

Expected benefits are positive, but they are not yet guaranteed for each individual. There are good reasons for many people to be in a Kaiser-like Precision Health Medical system immediately. For example: NIH (attached) has announced the exciting discovery that there actually are at least three types of Type II diabetes, possibly with different genetic profiles pointing toward improvements in prevention and better treatment and already activating rapid research projects to discover new and improved drugs for each type. ***The 10 million Kaiser members are First-in-Line to receive the benefits of new discoveries***

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<sup>2</sup> The URL is [rpgeh.kaiser.org](http://rpgeh.kaiser.org)

<sup>3</sup> Roughly 1.4 billion people at the beginning of this decade: [http://www.g8.utoronto.ca/evaluations/factsheet/factsheet\\_demography.html](http://www.g8.utoronto.ca/evaluations/factsheet/factsheet_demography.html); the comparable estimate for the G-20 (including China and India) was about 4.7 billion people. The government of China might have a very high priority for precision medicine borrowing, as (with 1.4 billion people) it can have extraordinary savings from even small scientific discoveries.

<sup>4</sup> For governments to create credit at near-zero% interest, without requiring co-payment, is close to simply encouraging governments to print money – which, historically, has been risky. However, these **Precision Health Investment** loans probably can be structured with little risk of default

<sup>5</sup> I.e., the money is available as credit. The Obama Administration, and each national government, will need to work with central banks and the financial system to structure access to near-zero % interest and repayment packages (perhaps beginning in several years?) and assure credit-worthy individuals or intermediaries. If desired, the Precision Health Investments could be structured primarily as a voluntary individual option and a personal obligation, with a repayment schedule of \$100/year added to income tax bills, beginning in three years, until the loan is amortized.

***because their genetic profiles already are in Kaiser's Fast Track learning system.*** Nobody else with any chronic health condition, or at risk, can benefit quickly from equivalent discoveries until their DNA profile is linked to a Fast Track, rapid learning system. Everybody else in the world, who does not make such a Precision Health Investment under this plan (or have someone arrange for financing on their behalf), must wait – possibly for too many years – while established institutions, with slow economic recoveries, go through the delayed pushing-and-hauling process, and often the political process, of informing themselves, debating ideology, setting agendas, and adjudicating competing claims in an appropriations process. It is wiser to solve the problem now.

## Additional Comments

- The new Precision Health Investment System needs to be structured carefully. Participation *must* be financed through new borrowing. (If the money redirects current expenditures, it does not have a new stimulus effect.) It should not be tax deductible. If insurance companies or other healthcare providers offer incentives or co-payments, these should be financed by new borrowing.
- To design the stimulus package, these behavioral economics/reframing ideas improve monetary policy by working around the need to improve economic confidence or restore trust in governments and the financial sector. The project requires only confidence in the progress of biomedical science and clear and vivid examples of how individuals can expect personal, future health benefits for themselves and others who they care about.
- To encourage enrollment, the stimulus investment package might be time-limited and available only while interest rates are near zero percent.
- It would be useful to develop a marketing strategy with the private sector that facilitates rapid signups and borrowing. Many healthcare providers will see competitive advantages to join Kaiser in offering the best quality medical care and First-in-Line notifications of relevant new discoveries for existing chronic or at-risk conditions. Universities and other progressive employers might step forward to create these options quickly for members of their own health plans.
- There should be early consultation with the private sector to assure that the FDA-certified Lab and other investments will be available as national and global DNA testing scales upward. Secure storage, DNA testing, interpretation, and notification systems will require planning on a global scale, as will the training of health professionals to implement the new capabilities for the best interest of their patients.
- Priority signups might be organized for all patients diagnosed with breast and other cancer, or other serious diseases for which precision medicine discoveries, linked to a genetic profile, are

available or can be expected.<sup>6</sup> All enrollees might receive initial Kaiser-level confidential reports, by means that they specify, of relevant discoveries that already have been made.

- The private sector might facilitate access to near zero % financing and participation by national health systems in other countries and individual foreigners. Currently, for example, US companies are among the leaders: There will be networks of FDA-approved labs and Big Data providers (e.g., Amazon Web Services, IBM and a network of international partners) who can get a share of global demand and markets from these investments. Also, citizens of other countries – including foreign employees of US-based multinationals – should have participation rights even if their own national health systems and governments are not yet ready to write direct contracts.
- The strategy for full global coverage – all UDCs and G-20 populations – deserves attention. A rollout might begin with loans and repayment guarantees by multinational corporations who can provide upgraded clinics and services to their employees and families in UDCs.<sup>7</sup>
- For individuals, this is a one-time, lifetime investment in better health.<sup>8</sup> It is the kind of infrastructure (and individual) investment that really does justify borrowing, especially at near zero % interest and with easy repayment terms.
- There are elements of risk, because scientists cannot prove that there will be \$1,500 of lifetime benefits to each individual. For now, the Precision Health Investment system should be viewed as transitional and voluntary – although eventually it might become standard.<sup>9</sup>

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<sup>6</sup> When DNA testing becomes established as essential to the diagnosis or treatment of specific diseases, it typically will be covered by existing health plans. There are strategic calculations that can be made, by each individual, about when to participate and whether to delay (although there may not be enough information to decide with confidence). Participating now for a one-time \$1,500 investment also is a form of buying insurance, inviting a calculation about the rate of medical discoveries and the useful discoveries that will be available to Fast Track participants before this later point of routine DNA analysis in the daily practice of medicine. For intermediaries (like Kaiser) this also is a form of civic, professional, and business decision by organizations who believe that they can better serve all of their patients or members, or gain market share, or develop better treatments, save costs or increase profitability, or acquire new knowledge or make new discoveries that have marketable value. For governments, borrowing to assure the full coverage of Veterans and their families might be a civic decision.

<sup>7</sup> Hopefully, the full DNA analyses in the early research phase will yield specific sub-analysis requirements for any specific diagnosis – e.g., DNA sub-analysis to distinguish among only seven causal pathways producing asthma and seven Best Treatment options. These treatment sub-analyses might eventually be provided at the cost of a simple blood test. For UDCs, a key ethical question is whether the DNA analysis is the highest current public health priority.

<sup>8</sup> There may be further data investments, including biome analysis and neuroscience-informed analysis of brains, but the R&D costs to pioneer these methods still should be the current responsibility of NIH.

<sup>9</sup> There might be creative, but unusual, ways to structure assured repayment. For example, a one-time \$1,500 Precision Health Investment individual loan could be repaid by a (healthier, longer-lived) individual who agrees, now, to slide his/her future social security eligibility by three weeks.

- Kaiser has introduced a degree of political pressure on the federal government. Its 10 million members include many federal employees in the Washington, DC area. These federal employees – but not federal employees elsewhere, or the Armed Forces or Veterans – now have privileged access to 21<sup>st</sup> century Precision Medicine although others pay the same premium. The same *de facto* favoritism and two-tier health system also is created between federal employees in the Washington, DC area and all other Americans. This violates a fundamental American norm and many patient advocacy and other groups might be political allies to structure borrowing packages.
- Politically, in America, it may be possible to activate a Precision Health Investment national option (N=320 million) within existing legal authority, although full implementation or specific, targeted, lending mechanisms also might require Congressional approval. It can be a voluntary option for people covered by the Affordable Care Act, or Medicare or Medicaid, for all public employees, for all members of the Armed Services and for Veterans.<sup>10</sup> It can even be structured as a nearly-automatic Precision Health Investment loan to all standard health plans (with an opt-out that requires individual initiative) with borrowing and repayment options handled behind the scenes. (Everything, including the borrowing, can be almost routine: participation actually requires only a standard blood sample.)<sup>11</sup>
- It might not be necessary to enroll 1 billion adults before there is a major economic stimulus effect. A bold Precision Health Investment option sends messages, creates excitement, and can leverage the early investment. The new era of genetics-based Precision Medicine offers a cornucopia of new business opportunities, including new Big Data resources for all countries who want their companies to compete in global pharmaceutical development.
- This full global Grand Strategy can be phased-in, with part of the infrastructure investment in Precision Health held in reserve as a fast-trigger option if there is a threat of recession.

Enclosures:

- Kaiser Permanent Research Bank, “Enrollment Request to 10 Million Members” (<http://research-bank.kaiserpermanente.org/>). Downloaded 4/15/2016
- Francis Collins, “Big Study Reveals Possible Subtypes of Type II Diabetes,” blog posted on 11/10/2015.

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<sup>10</sup> The Veterans Administration already has underway a One Million Veterans, genetics-based, initiative. The program is not financed through new borrowing, which should be the VA package for the new one-time system upgrade for all Veterans. See: <http://www.research.va.gov/mvp/>

<sup>11</sup> The Kaiser project involves added research questionnaires to study social relationships and behaviors and the physical environment (e.g., access to safe parks and recreation, pollution levels and workplace exposures to various chemicals). Structuring a near-zero % loan option for individuals might be organized with an equivalent package to participate in research that might provide useful information.

- Foundation for NIH, "The FNIH Announces \$4 M Grant Award to Support Building of First International Arm of AMP Type 2 Diabetes Knowledge Portal" (<http://www.fnih.org/news/announcements/fnih-announces-4-million-grant-award>), 12/9/2015.

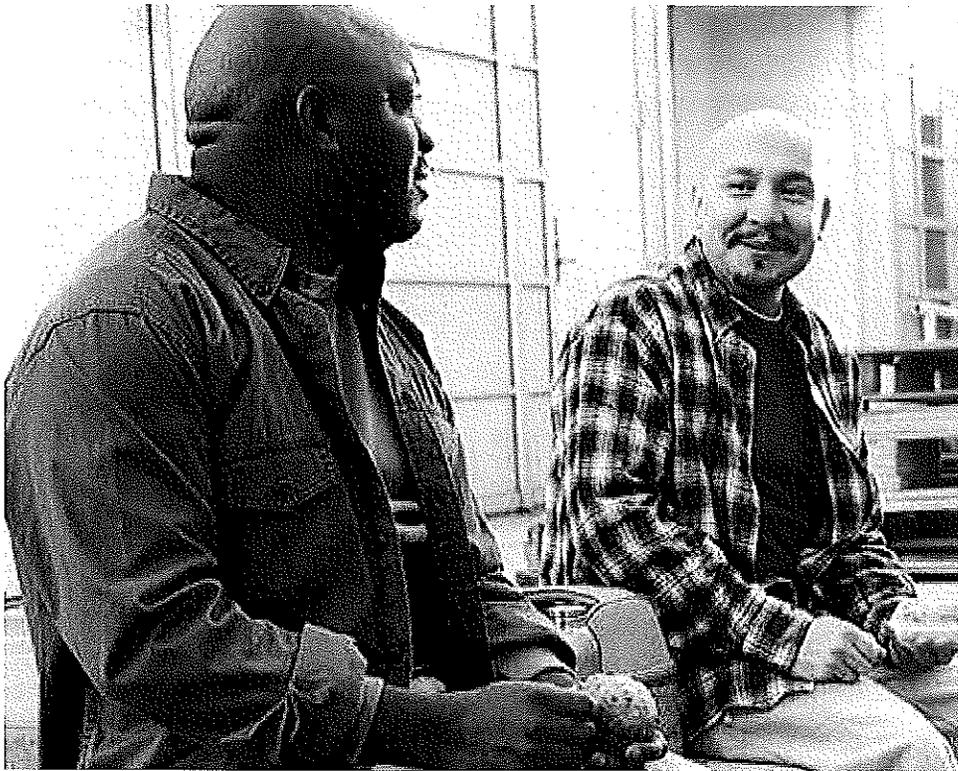
DRAFT - 4/18/2016



# KAISER PERMANENTE RESEARCH BANK

## DNA Could Help the KP Research Bank Discover New Ways to Prevent Disease

What causes diseases like cancer, asthma, and Alzheimer's? What are the impacts of lifestyle and history on a person's risk of disease? Scientists working with the Kaiser Permanente (KP) Research Bank are using DNA and other information to find new ways to help people live healthier lives.



## What Could this Research Mean?

It could lead to breakthroughs in ways to prevent or treat diseases. In the future, patients may receive health care based on their individual DNA, environmental, and lifestyle information.

DNA information could be used to:

- Test earlier for diseases;
- Prescribe the most effective medicines;
- Better understand the warning signs of disease;
- Predict the risk of getting a disease;
- Understand new ways to prevent disease.

The KP Research Bank has gathered DNA and information from thousands of people and used it in research about many diseases. Researchers need to collect DNA from people of all

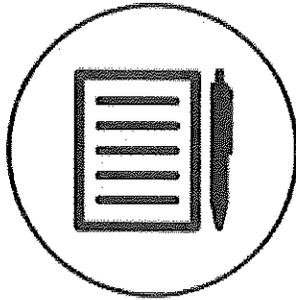
ages, genders, ethnicities, and backgrounds so discoveries can benefit even more people. The KP Research Bank invites all adult KP members to participate.

The KP Research Bank is asking all adult members of Kaiser Permanente to participate. Participation is voluntary and there's no cost to you. New participants can click join, and returning participants can log in below.

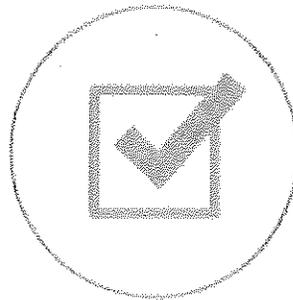
JOIN

LOG IN

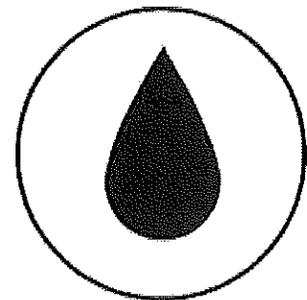
**Follow These 3 Steps to Begin**



**1** GO ONLINE TO  
FILL OUT THE  
**CONSENT FORM**



**2** TAKE A BRIEF  
**HEALTH  
SURVEY**



**3** GIVE A SMALL  
**BLOOD  
SAMPLE**

**1. Review and sign a consent form.**

This form explains your rights as a participant. Click here to review it. If you agree, sign the consent form to give samples, and past and future health information to the KP Research Bank.

**2. Fill out a health survey.**

Provide information about your health, lifestyle, and history. When you complete the consent form, this survey will automatically pop up. You can take the survey at any time.

**3. Provide a blood sample.**

Give a small sample of blood, about 2 tablespoons, at any Kaiser Permanente clinic or lab. This is collected at no cost to you. You can provide your sample before or after you take the survey.

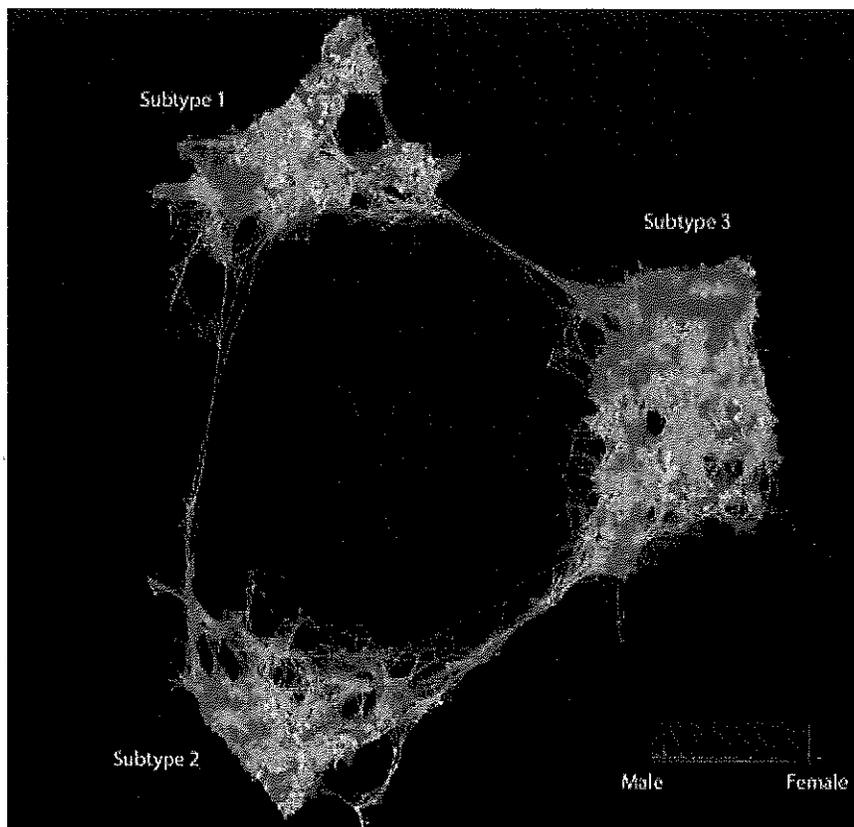
**Questions? Please call the KP  
Research Bank at 844-268-2947,  
Monday through Friday 8am-6pm**

Pacific Time (11am – 9pm  
Eastern, 9am – 7pm Mountain,  
5am – 3pm Hawaii), or email  
ResearchBank@kp.org.

EMAIL THE KP RESEARCH BANK

# Big Data Study Reveals Possible Subtypes of Type 2 Diabetes

Posted on November 10, 2015 by Dr. Francis Collins



**Caption:** Computational model showing study participants with type 2 diabetes grouped into three subtypes, based on similarities in data contained in their electronic health records. Such information included age, gender (red/orange/yellow indicates females; blue/green, males), health history, and a range of routine laboratory and medical tests.

**Credit:** Dudley Lab, Icahn School of Medicine at Mount Sinai, New York

In recent years, there's been a lot of talk about how "Big Data" stands to revolutionize biomedical research. Indeed, we've already gained many new insights into health and disease thanks to the power of new technologies to generate astonishing amounts of molecular data—DNA sequences, epigenetic marks, and metabolic signatures, to name a few. But what's often overlooked is the value of combining all that with a more mundane type of Big Data: the vast trove of clinical information contained in electronic health records (EHRs).

In a recent study in *Science Translational Medicine* [1], NIH-funded researchers demonstrated the tremendous potential of using EHRs, combined with genome-wide analysis, to learn more about a common, chronic disease—type 2 diabetes. Sifting through the EHR and genomic data of more than 11,000 volunteers, the researchers uncovered what appear to be three distinct subtypes of type 2 diabetes. Not only does this work have implications for efforts to reduce this leading cause of death and disability, it provides a sneak peek at the kind of discoveries that will be made possible by the new Precision Medicine Initiative's national research cohort, which will enroll 1 million or more volunteers who agree to share their EHRs and genomic information.

In the latest study, a research team, led by Li Li and Joel Dudley of the Icahn School of Medicine at Mount Sinai, New York, started with EHR data from a racially and socioeconomically diverse cohort of 11,210 hospital outpatients. Of these volunteers, 2,551 had been diagnosed with type 2 diabetes, which is the most common form of diabetes.

Without focusing on any particular disease or condition, the researchers first sought to identify similarities among all participants, based on their lab results, blood pressure readings, height, weight, and other routine clinical information in their EHRs. The approach was similar to building a social network with connections forged, not on friendships, but medical information. When the resulting network was color-coded to reveal participants with type 2 diabetes, an interesting pattern emerged. Instead of being located in one, large clump on this “map,” the points indicating people with type 2 diabetes were actually grouped into several smaller, distinct clusters, suggesting the disease may have subtypes.

To take a closer look, the researchers rebuilt the network to include only participants with type 2 diabetes. They then reanalyzed the EHRs based on 73 clinical characteristics, including gender, glucose levels, and white blood cell counts. That work confirmed that there were three distinct subtypes of type 2 diabetes among study participants.

Type 2 diabetes is associated with potentially serious complications, including nerve damage, vision problems, kidney disease, and an increased risk for cardiovascular disease. The study found differences in the distribution of such complications among the three subtypes of type 2 diabetes. People with subtype 1 were more likely to be diagnosed with microvascular complications, including blindness/vision defects. This group of participants was also the youngest and most likely to be obese. People with subtype 2 showed the greatest risk for tuberculosis and cancer. As for subtype 3, such people were more likely than others to be HIV positive, have high blood pressure, and develop arterial blood clots. Both subtypes 2 and 3 displayed a greater risk for heart disease than subtype 1.

Next, the researchers performed a genomic analysis, identifying hundreds of genetic variants that were enriched non-randomly in each of the three groups. Interestingly, some of the genetic variants linked to each subgroup were associated with genetic pathways that appeared relevant to the distinguishing clinical features of those subgroups.

These findings suggest that some of the clinical differences observed between the different type 2 diabetes subtypes are rooted in lifestyle or environment, and others may be influenced by inherited factors. Still, more research needs to be done to replicate and expand upon these findings. The hope is that by gaining a more nuanced understanding of type 2 diabetes, we may be able to identify more precise ways of helping to detect, manage, and, ultimately, prevent this serious, chronic disease that currently affects about 1 out of every 11 Americans [2].

#### References:

[1] Identification of type 2 diabetes subgroups through topological analysis of patient similarity. Li L, Cheng WY, Glicksberg BS, Gottesman O, Tamler R, Chen R, Bottinger EP, Dudley JT. *Sci Transl Med*. 2015 Oct 28;7(311):311ra174.

[2] Diabetes Latest Fact Sheet. 2014 June 17. (Centers for Disease Control and Prevention)

[<http://fnih.org/news/announcements/fnih-announces-4-million-grant-award#.VmhdMottRfY>]

## The FNIH Announces \$4M Grant Award to Support Building of First International Arm of AMP Type 2 Diabetes Knowledge Portal

The Foundation for the National Institutes of Health (FNIH) has awarded a 4-year grant award in the amount of \$4 million to the European Molecular Biology Laboratory — European Bioinformatics Institute (EMBL-EBI), the University of Oxford, and the Broad Institute of the Massachusetts Institute of Technology and Harvard University to support the buildout of a European arm of the Type 2 Diabetes (T2D) Knowledge Portal. The award is part of the Accelerating Medicines Partnership Type 2 Diabetes (AMP T2D) initiative. This is the first in what the project hopes to be a buildout of a broader network of interconnected, international portal sites.

The AMP T2D Knowledge Portal is a sophisticated research tool that allows the public to search and analyze genetic and clinical information on individuals with type 2 diabetes and serious complications of the disease, while maintaining strict confidentiality of individual level data. The Knowledge Portal is intended to generate new understanding of the disease by revealing relationships between human genome-wide sequence variation in potential targets and either risk for or protection from diabetes and its complications. The portal is planned to contain data integrated from existing genetic studies from close to 100,000 individuals by early 2016.

In June 2015, the FNIH issued a Request for Proposals (RFP), which solicited applications to build and maintain secure, distributed database hubs for the project's Knowledge Portal outside of the United States. Establishing one or more new hubs outside of the United States allows researchers to store their data at any of the portal's hubs and enables analyses across global datasets while maintaining compliance with regional data privacy regulations. This FNIH award funds the buildout of a European hub, based in the United Kingdom, over the 4 year period. AMP T2D hopes to expand this pilot hub to various other international federated sites that could allow participation from groups on any continent.

The portal's U.S. hub resides at the Broad Institute in Cambridge, MA, and is funded by a grants from both the National Institute on Digestive and Kidney Disease (NIDDK)/National Institutes of Health (NIH) and the FNIH.

### **Funding Partners:**

American Diabetes Association, Janssen Research and Development LLC, JDRF International, Eli Lilly and Company, Merck Sharp & Dohme Corp., NIDDK/NIH, Pfizer Inc., and Sanofi US Services. Read more about the AMP T2D initiative

## **About the Accelerating Medicines Partnership:**

A public private partnership that brings together NIH, biopharmaceutical companies, and not-for-profit organizations, AMP's mission is to transform the current model for developing new diagnostics and treatments by jointly identifying and validating promising biological targets of disease. AMP's goal is to generate diverse, high quality, pre-competitive, disease-specific clinical data to be made publicly available for the purpose of accelerating drug development. The FNIH raises and distributes private sector funds for AMP, provides central project management to AMP initiatives, and convenes the governing committees that oversee the partnership on behalf of all the stakeholders.

[REDACTED]

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**From:** HAROLD HELSLEY [REDACTED]  
**Sent:** Friday, April 29, 2016 12:37 AM  
**To:** [REDACTED]  
**Cc:** Hal [REDACTED]  
**Subject:** A solution to the world energy problem ...  
**Attachments:** 37 Years of HIF Endorsements4-'16.doc

Attention: Dr. Cherry Murray and John P. Holdren  
(please forward if necessary)

A very exciting happening ...

I have watched some of the Congressional Energy Hearings and, much to my dismay, find that there is a complete lack of knowledge on the subject of RF Accelerator Driven HEAVY ION FUSION (HIF) efforts for power generation, both from staff and committee members and much of the academic community. Even the NAS report, that is referred to at times, is lacking information on what is happening here in the US and abroad in relationship to Inertial Confinement Fusion (ICF) HIF for the NAS report addressed basically only the fusion efforts using plasma or laser approaches.

There have been bi-annual HIF symposiums in the US and other special conferences on HIF since the 1980s, but that information apparently does not get to the desks of members of Congress or to the Office of Science/DOE. Since these are International Conferences/Workshops, and reports back only happens if a person is in attendance (or one takes the time to read the obscure gray literature). At the meetings I have attended, no representative of the Office of Science/DOE, or Congress has even been in attendance.

I have attended a number of these, participating in the break-out workshop sessions and spoken before the NAS committee before they prepared their report to Congress. But since I spoke about HIF, and it was not the main topic before the committee, at that session, my input seems to have fallen on essentially deaf ears. Since 2010, there has been a thread of excitement occurring in ICF HIF, in my way of thinking, that has gone totally unobserved.

Starting at the HIF Symposium in Darmstadt, Germany in 2010, with a paper presented by Dr. Robert J. Burke, CTO of Fusion Power Corporation (FPC) from California, on "Single Pass RF Driver" (SPRFD) and a presentation on commercialization of HIF, that, despite being the last presentation of the conference, was very well attended by the delegates, and as you well know the last presentation is seldom well attended at conferences like this.

In May of 2011, there was the Accelerators in Heavy Ion Fusion Workshop (AHIF), at LBNL and this meeting included a two day RF Accelerator Working Group. It was literally 'History in the Making' as at the opening session Dr. Robert J. Burke, the CTO of FPC, walked the group thru the 'Single Pass RF Driver' showing how, with currently known technologies, one could get enough energy to a DT pellet (using techniques similar to those Basko described back in 2002) to assure that fusion ignition would occur, to quote John Foster in his report to Congress on the ERAB meeting on Accelerator Driven HIF having no "show stoppers" at Berkeley, May 3, 1979, "Now, that is kind of exciting"!

At the AHIF - RF Accelerator Working Group, break out sessions, on the second and third days, having gone thru the details of Burke's presentation, even Dr. B. Grant Logan, Director of the Virtual NL for HIF, concurred with Dr. Burke that he indeed had enough energy deposited at the pellet to cause fusion of DT. Now that was historical! There was now a way to have controlled DT fusion ... but, what has happened since 2011? I was expecting 'headlines' in the science papers of this great accomplishment, but NOTHING! A vacuum.

I had thought that this AHIF Workshop was in partial preparation of a report to the NAS Committee on what is happening in fusion, but, alas, no such report was forwarded, nor acknowledged. The Working Group made some recommendations, but to whom, I do not know! (I was at all of the working group sessions!) I went to the NAS Committee meeting in San Diego and presented a written statement and a 5 min. verbal presentation, wherein Dr. R. Bette, a committee member, concurred that FPC's SPRFD would have enough energy at the DT pellet to have fusion ignition occur. One of the co-Chairs came up afterwards and asked the President of FPC "What he wanted?" ... and his response was "a level playing field" as RF Accelerator Driven HIF program has lacked funding for over twenty years in the US and has NO home in the US sciences or DOE. But again, NOTHING! ... this has not happened. (I have read the NAS report. I have watch DOE's activities - see Dr. Richter's letter, attached)

We, the US, have put \$400+ million in ITER and more hundreds of millions in National Ignition Facility (NIF), annually, since that time, but "\$0" in SPRFD HIF, the most conservative method to achieve fusion, and supported for over 3 decades by the scientific community in report after report, 1979-2014. (attached)

At the 2012 HIF Symposium in Berkeley, CA, FPC presented two papers, both of which have been published. (Economic Viability of Large-scale Fusion Systems, ELSERVIER  
><http://www.sciencedirect.com/science/article/pii/S0168900213007067><, & The Single Pass RF Driver: Final Beam Compression, R. Burke, Nuclear Instruments & Methods in Physics Research A (2014),  
><http://www.sciencedirect.com/science/article/pii/S0168900213006918>< ... but who reads these? (attached)

In May of 2013, FPC was awarded a patent for the process in RUSSIA! (No. 2477897). This last year, 2015, FPC has had the US Patent Office indicate that they have accepted the main body of the FPC application of 2009 for a US patent, this patent has been published 3-29-2016 - #94299416!

If we want fusion to be part of the energy mix in the next decade in the US, SPRFD HIF is the way to go. It has a potential energy return of 50 to 90 times it's energy use!! >[www.fusionpowercorporation.com](http://www.fusionpowercorporation.com)< and Basko's 2009 paper. In 2014, a paper published at Cambridge University, by Ramis and Meyer-ter-Vehn, both fusion pellet experts from Europe, that supports Dr. Burke's position of SPRFD having more than enough energy deposited on the fusion pellet to have ignition. (><http://dx.doi.org/10.1017/S0263034615000099><). This is an independent third party, validating FPC's conservative position. Where are the hooplas, yea, RF Accelerator Driven fusion works!!

Global interest in SPRFD is high. But interest in the US is nowhere to be seen. The US needs to remove their blinders.

SPRFD needs a computer model/simulation done. It has great world importance ... a clean, green and very safe power generation facility improves the health and well being of ALL the world, reversing global warming and NO materials for bomb proliferation!!

I go thru this so that at least you can be informed of what I think is a very exciting happening ... SPRFD should be a US project priority, not a project in another country. It is US technology!

The US needs to encourage a demonstration project, built in the US, maybe at a NL site preferably near the ocean so it can make acre feet of potable water with the lower temperature heat, as soon as possible. But here the US and others are continuing to support modified FISSION and plasmas, with all their associated problems!, for a solution that maybe sometime in the next 50 years ... well, the the world can not wait that long! ... and should not!

It seems to me, the US would want to pull out all the stops and get this done here in the US before a foreign country commits to doing it. Like the mission to the moon! The problems of fission do not need to be continued nor expanded, when we have fusion on the doorstep.

FUSION is clean, green and very safe!

I hope you can assist in spreading the great news.

Sincerely,

Hal [REDACTED]  
[REDACTED]

"If you don't make a difference, think about who will . . ."

## 37 Years of HIF Endorsements

- 1976 “[HIF] warranted high confidence ... heavy ion fusion faces no show stoppers.” *ERDA Summer Study of Heavy Ions for Inertial Fusion, Final Report December 1976 LBL 5543(1976)*
- 1979 “...heavy ion accelerators have great promise as reactor candidates because of their inherently high efficiency, developed repetitive-pulse technology, and favorable theoretical predictions of target coupling.” *Foster Committee Report to the Energy Research Advisory Board at its May 3, 1979, meeting.*
- 1983 “We conclude that the uncertainties in coupling physics for high-energy heavy ions are minimal.” *The Jason Report of January 1983 (JSR82-302).*
- 1986 “Heavy ion beams may well be the best eventual driver for energy applications.” *The National Academies of Sciences Report of March 1986 entitled, “Review of the Department of Energy’s Inertial Confinement Fusion Program”*
- 1990 Recommended parallel development of inertial and magnetic fusion with a budget level of about \$30 million per year for HIF. *The Fusion Policy Advisory Committee Report 1990 (Stever Panel)*
- 1993 “We recognize the great opportunity for fusion development afforded the DOE by a modest heavy-ion driver program that leverages off the extensive target program being conducted by the Defense Department...” *Fusion Energy Advisory Committee (Davidson Panel).*
- 1994 “heavy ion accelerators are still regarded as “the best bet for drivers.” What is not said is that nearly 16 years after the first Foster panel report, the heavy ion program is still starved for funds, and we have made very little progress on “the best bet.” *SCIENCE Magazine Letter VOL. 01/28/1994 Burton Richter, Director, Stanford Linear Accelerator Center.*
- 1996 “In agreement with previous reviews, we consider the heavy ion accelerator to be the most promising driver for energy applications.” *FESAC (Sheffield) Report.*
- 1998 *The HIDIF-Study, GSI-98-06 Report, August 1998.*
- 2010 “Abundant clean energy can be generated from pure fusion ... on a timeline consistent with the urgency of the world’s energy, economic, and environmental problems.” *Physics Today Letter, June 2010 Page 58, Robert J. Burke, Chairman, Fusion Power Corporation.*
- 2010 “... we know that inertially confined fusion (ICF) is possible since we can create nuclear explosions.” *Physics Today Letter, October 2010, Page 8, Martin Stickley, Director of Office of Laser Fusion at Energy R&D Administration (ERDA) in 1976-1979.*
- 2011 Recommendations from the *RF Accelerator Working Group* at the *AHIF Workshop, Lawrence Berkeley National Lab* in Berkeley CA., May 2011:
1. Now is the time for developing detailed conceptual designs for economical energy production that take advantage of decades of progress in accelerator physics and RF accelerator technology. .... A more detailed examination of the Single-Pass HIF Driver concept ... a good starting point.
  2. National and international collaborations (including industry) should be encouraged to develop heavy-ion fusion energy.
  3. Economy of scale issues should be studied. Conclusions could have significant impacts in defining the most viable approaches for energy production. Scale economies should increase profitability by lowering cost per kWh.
- 2012 **FPC encouraged by ARPA-e** to submit a full project to simulate the pellet ignition using SPRFD, FOA 0670-4536 - Funding not provided to DOE by Congress
- 2013 **Russian Patent** No. 2477897 granted March 20, 2013, *SINGLE-PASS, HEAVY-ION FUSION, SYSTEMS AND METHOD*
- 2013 **Economic Viability of large-scale fusion systems**, ELSERVIER 0068-9002/\$, Helsley-Burke and **The Single Pass RF Driver: Final beam compression** R. Burke, Nuclear Instruments & Methods in Physics Research A (2013), <http://dx.doi.org/10.1016/j.nima.2013.05.080i>
- 2014 **Thermonuclear burn propagation ... R. Ramis and J. Meyer-ter-Vehn**, *Laser and Particle Beams* (2014) 32,41-47 Cambridge University Press
- 2016 **US Patent to Fusion Power Corporation # US 9299461 B2**

[Redacted]

**From:** Lloyd [Redacted]  
**Sent:** Monday, May 2, 2016 5:57 PM  
**To:** [Redacted]  
**Cc:** [Redacted]  
**Subject:** PCAST & Better Scientific Growth/Macroeconomic Policy: 2 updates  
**Attachments:** 2016.0430.NewTheoryofEconomicStimulus.pdf

Dear Dr. Holdren, Dr. Lander, and Members:

I enclose a new theoretical framework showing how a system-level design for rapid learning science (healthcare) upgrades traditional macroeconomic policy tools for stimulus. As leaders in PCAST and the Obama Administration know, the evolving theoretical framework for the design of rapid learning systems (now with the Economics Nobelist Joseph Stiglitz as a fellow traveler) is beginning to prove useful and exciting for human progress and economic growth of healthcare.

- The enclosed prospectus identifies three elements and recommends that the Obama Administration use them to test the model in a second sector, via a rapid learning education system (including STEM education). A creative upgrade in the use of monetary policy/credit markets also is involved.

By combining these elements, the theory predicts much faster scientific discovery, innovation, and growth, human benefit, and a new and exciting universe of motivating business opportunity, worldwide (for Apple, among others).

Testable. I hope that this can have your support at the White House & bringing pieces together with requisite leadership.

Lloyd E.

Dr. Lloyd S. [Redacted] ct Director - Rapid Learning Economics/Government Learning

[Redacted]

The Policy Sciences Center is a public foundation that creates and develops knowledge and practice to advance human dignity.

It was founded in 1948 in New Haven, CT by Harold Lasswell, Myres McDougal, and George Dession, members of the Yale

faculty. Information about the Center, the Society of Policy Scientists and the Policy Sciences journal is available at >[www.policyscience.org](http://www.policyscience.org)<.



Subject: A New Approach to Economic Growth and Stimulus  
Date: Mon, 2 May 2016 00:34:57 -0400

Dear Dr. Calhoun and Berggruen Institute Colleagues:

The enclosed paper and attachment summarize lessons for an additional approach to economic recovery, stimulus, and growth, based on a system-level design for rapid learning in different sectors. Three design elements are identified, based on the success of the Obama Administration's and UK's design for rapid learning health.

The proposal for a rapid learning education system is likely to work. The results will come more quickly if there is international data-sharing and cooperation for a shared goal.

best regards,  
Lloyd E.

Dr. Lloyd S.  Director  
Policy Sciences Center, Inc.



The Policy Sciences Center is a public foundation that creates and develops knowledge and practice to advance human dignity. It was founded in 1948 in New Haven, CT by Harold Lasswell, Myres McDougal, and George Dession, members of the Yale faculty. Information about the Center, the Society of Policy Scientists and the Policy Sciences journal is available at >[www.policyscience.org](http://www.policyscience.org)<.

May 1, 2016

## A New Theory of Economic Stimulus: The Example of a Rapid Learning Education System

By Lloyd S. Etheredge<sup>1 2</sup>

**Proposal:** As a stimulus investment: Design and activate a national rapid learning system for K-12 education that meets three requirements (digitization, discovery, and implementation). Incorporate ideas and cross-sector conversations from the first national rapid learning system (for health):<sup>3</sup>

- 1.) **Digitization**. An immediate step: Transition to a full (digitally-supported) national rapid learning education system. Near 0-% loans will enable state and local school systems, K-12, to make additional infrastructure investments to equip each classroom and student with suitable individual tablets/computers for daily instructional and home use.<sup>4</sup> Participating school systems will create privacy-guaranteed, digital educational records for each student that contain a core of basic data and meet software compatibility standards for data sharing to support agreed-upon learning projects.
- 2.) **Discovery Functions**. Participating teachers, schools, and school districts can elect to be part of leadership networks (created by the federal government and including foundations, academic researchers and other stakeholders) to establish the learning priorities and methods for specific subjects, technologies, grade levels, and students. (These might include more efficient testing and grading; experiments to explore comparative effectiveness of teaching materials, methods, and software; creative R&D partnerships with the private sector to develop and explore new ideas; the swift testing and improvement of personalized learning software for all students and especially disadvantaged minorities and learning-challenged and handicapped students, etc.)
- 3.) **Implementation Functions**. Change does not occur quickly if discoveries only are published in academic journals or produce successful demonstration projects. Implementation needs to be managed - a local task that requires leadership and motivation, multi-year persistence, a system-level perspective, adaptation to local needs and circumstances, and its own learning process. The federal government will work with stakeholders to create learning and training programs for (local) implementation science to support interested schools and school systems.<sup>5</sup>

→ The goal of the rapid learning education system is to create the best educational experiences for each student as quickly as these can be invented.

### Discussion:

- **Digital Capacities and Learning**. The digitally-supported national education system can eliminate much of the classroom time now devoted to testing, including standardized testing. By drawing items for homework and classwork from new, national, standardized databases, student learn-

ing can be assessed routinely from achievement in their daily work.<sup>6</sup> By the same shift, all comparative effectiveness research for software and other research priorities [perhaps especially for Common Core-related learning] can – for the first time! - be conducted quickly and efficiently with random assignment and a large N of students in participating schools and districts with rapid answers for teachers.<sup>7</sup>

- **The Time is Right.** We still are in an era of experimentation and discovery. However, a full investment in digitization probably is justified for access to digital content and software-based improvements. There already are areas (and there will be more) where new technology probably can assist teachers and students, across subjects, to use time more efficiently and get superior results.<sup>8</sup>
  - o MOOC creators like Coursera and edX and innovators like Khan Academy have conducted more randomized experiments to test and improve educational methods than were published in all scientific journals prior to this decade. For example: An Active Mastery design presents new material for 15-20 minutes (about the limit of full classroom attention). Then software kicks-in and begins to challenge students to shift the new material from short-term memory into active problem solving. The software continues to present problems, and make diagnoses and offer coaching, until the student masters the new concept or wants to stop. (Later, the personalized software can resume and also will recommend optimum review schedules.) The Active Mastery improvements contrast with traditional methods in which a teacher might present a 45- to 50-minute lecture (with fading attention) and then problem sets are assigned for homework – when they are done that night . . . or before the next class . . . or the night before the exam . . . if ever! Active Mastery is more efficient, a steadier process, apparently raises mean scores, and reduces failure – in fact, it is very difficult for a persevering student to fail, since both students and teachers know very quickly whether each concept is being mastered.<sup>9</sup> Rather than “cram” studying the night before an exam and guessing that they have learned the material – and then discovering reality when they receive their graded exam (and the class moves-on to the next subject) – students know whether they have achieved mastery.
  - o Another discovery by the Khan Academy, Gates Foundation, and others is the unique psychological contribution of online software with a distinct coaching and cheerleading spirit that explicitly enrolls students to an “Anybody Can Learn Anything” mindset. (This includes a discussion of the “grit” and “perseverance” that, with good teaching and coaching, achieves mastery.) The discovery contrasts with traditional “Bell curve” ideas that can be reinforced in the mindsets of students who fall behind and decide that school subjects are too hard, or that they are dumber students and not smart enough to learn the material.<sup>10</sup>

- **Costs.** About \$2.5 billion for hardware and \$1.5 billion/year to \$1.8 billion/year for other costs over the next decade. Estimates will require further work but here is the basis for the hardware numbers. (Estimates of other costs are discussed in the attachment.)
  - o One basis for an estimate is that there are about 55 million K-12 students in the US (including 4.9 million attending private schools) and 99%+ of schools already have Internet connections of growing capacity.<sup>11 12 13</sup> Schools report about one computer for every five students, although probably half of the school systems recently have been acquiring tablets for Common Core and mandated standardized testing.<sup>14</sup> (Concerning home availability: about 70% of American households have at least one computer or tablet.)<sup>15</sup> The newest Kindle Fire tablet sells for \$49 (although more capability probably is desirable for schools). If we assume the purchase of 25 million devices that students can take home if needed, and an average price of \$100/device, the digitization infrastructure investment will be about \$2.5 billion.<sup>16</sup> [However, a national cost might be lower: a potential competitor for providing these 25 million devices (Apple) has \$215+ billion in unspent reserves. Apple could develop a bold hardware and software strategy that expands its current position and uses about 1% of its reserve to take ownership of the entire educational market in the US for rapid learning. Next, it could use rapid learning capabilities to produce a Golden Age of online resources, worldwide.<sup>17</sup>]
  
- **Global Competitiveness.** With these US investments the global education industry becomes a potential market for rapid growth via digital technologies and improvements pioneered here.<sup>18</sup> Before the new capability for efficient, independent, scientific testing, startup companies struggled with marketing costs. Innovation was slow and giant print publishers and their sales forces dominated the new software market. Now, the equations change. Innovators with scientifically demonstrated improvements (e.g., for foreign language instruction) can render obsolete the US and world's entire stock of textbooks overnight. Open Courseware also can improve quickly: there are huge global shortfalls in the availability of high quality K-12 education for which extraordinary online resources will be essential contributions to realize human potential.
  
- **A New Theory for Economic Stimulus and Growth.** For economic science and higher growth rates, the new theory and strategic idea is to identify what is missing, by sector, and to create a rapid learning system (including an inspiring, imagination-capturing, psychological component) to solve the problem.<sup>19</sup> The requisite chemistry likely will involve organizing and managing (with self-reflective learning) three dimensions: 1.) Full digitization (designed for data-sharing and data-mining), 2.) Discovery functions (including curated, pre-populated, large N, Everything Included data systems and analysis capabilities in the public domain and shaped by networks of users), and 3.) Implementation functions that support rapid learning cycles for an entire sector and concomitant growth.
  
- The theory of rapid learning systems still is evolving, but I think that it is going to work. We do not yet know how quickly the sectoral growth and American global leadership, and full human benefits empowered by the new rapid learning health system, will occur. However, billions of

dollars of new capital are pouring into health- and cancer-related startups at a rate matching the early investment for Silicon Valley.<sup>20 21</sup> And this is just the beginning.

**Attachment:** Lynn M. Etheredge, "A Rapid Learning Education System: Lessons from a Rapid-Learning Health System. Prospectus" (Working paper, April, 2016).

DRAFT – 5/1/2016

### Notes

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<sup>1</sup> Lloyd Etheredge is Project Director for the Government Learning/Rapid Learning Economics Project at the Policy Sciences Center, Inc., a public foundation incorporated in New Haven, CT. Comments welcome. URL: [REDACTED] My thanks to Lynn Etheredge for many discussions of these ideas. His contributions to the (first) rapid learning system for health, and to the evolving design for education and science of learning systems, are reflected in the attached paper.

<sup>2</sup> This paper continues a series of ideas from the Rapid Learning Economics Project, suggesting how creative social science – e.g., the new science of learning systems - can accelerate economic recovery.

<sup>3</sup> Lynn M. Etheredge, "A Rapid Learning Education System: Lessons from a Rapid-Learning Health System. Prospectus" (Working paper, April, 2016). Attached.

<sup>4</sup> The national stimulus loans can purchase (for physical loan to parents) suitable devices for home use.

<sup>5</sup> For the evolving state of implementation science in K-12 public education see the example of the Baldrige Award process (Montgomery County, Maryland) described by Michael Perich, <https://www.youtube.com/watch?v=Eu2SKd8D2hg>.

<sup>6</sup> National standardized testing at the end of 4<sup>th</sup> and 8<sup>th</sup> grades could still be justified during the school day. See Harold Kwalwasser, "Standardized Tests Don't Help Us Evaluate Teachers," Los Angeles Times, September 10 2015. Online <http://www.latimes.com/opinion/op-ed/la-oe-0910-kwalwasser-standardized-testing-problems-20150910-story.html>.

<sup>7</sup> See I. Glenn Cohen *et al.*, "The Legal and Ethical Concerns That Arise From Using Complex Predictive Analytics in Health Care." Health Affairs, 33:7 (2014), pp. 1139-1147. Routinely investigating the comparative effectiveness of treatment alternatives that are reasonably believed to be beneficial, and without prior knowledge of which is superior, is one of the issues that has been addressed in developing the rapid and routine experimentation capabilities in healthcare.

<sup>8</sup> Although research is greatly aided by Common Core, there already is sufficient agreement about school subjects that the fast discovery infrastructure for comparative effectiveness research created by the new system can generate useful information. For example, for \$3 billion/year purchase decisions for digital content and specific assessment of the best options for the characteristics of any single school or school district.

<sup>9</sup> Andrew Ng, "Education for Everyone" <https://www.wolframdatasummit.org/2013/attendee/presentations/>.

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<sup>10</sup> See the implementation of these discoveries in the design of LearnStorm Challenge 2016: <http://www.learnstorm2016.org/> .

<sup>11</sup> Benjamin Herold, "Technology in Education: An Overview" *Education Week*, February 5, 2016. Online: <http://www.edweek.org/ew/issues/technology-in-education/>

<sup>12</sup> Terrance F. Ross, "When Students Can't Go Online," *The Atlantic*, March 13, 2015. <http://www.theatlantic.com/education/archive/2015/03/the-schools-where-kids-cant-go-online/387589/> . Internet connectivity is good enough to begin, although improvements may be needed. "Full Internet" for all students throughout the day may not be the right answer. We do not yet know whether a blend of electronic and paper-and-pencil methods and human face-to-face interactions (e.g., teaching a new concept to somebody else) might help the brain to create new pathways more quickly.

<sup>13</sup> Home Internet connectivity will be valuable, but it may not be necessary, especially for lower grades if software and problem sets are available on smartphones. Internet connectivity can be provided by smartphones if there is a waiver of connection and data transfer charges when using agreed-upon education sites.

<sup>14</sup> "Schools purchased more than 23 million devices for classroom use in 2013 and 2014 alone." And "The biggest development on this front has been states' adoption of online exams aligned with the Common Core State Standards. During the 2014-15 school year, 10 states (plus the District of Columbia) used exams from the Partnership for Assessment of Readiness for College and Careers (PARCC), and 18 states used exams from the Smarter Balanced Assessment Consortium, all of which were delivered primarily online. Many of the other states also used online assessments

"The 2015-16 school year will be the first in which more state-required summative assessments in U.S. middle and elementary schools will be delivered via technology rather than paper and pencil, according to a recent analysis by EdTech Strategies, an educational technology consulting firm." Herold, *op. cit.*

<sup>15</sup> Monica Anderson, Technology Device Ownership, 2015. Pew Research Center. <http://www.pewinternet.org/2015/10/29/technology-device-ownership-2015/>

<sup>16</sup> Smartphones already are used by many secondary school students for homework and they provide alternative connectivity. A policy under discussion in UDCs is to provide free connection time and unlimited data transfer for users connecting to educational and health information Websites.

<sup>17</sup> Jeremy C. Owens, "Apple Isn't Really Sitting on \$216 Billion in Cash," *Market Watch*, January 27, 2016. <http://www.marketwatch.com/story/apple-isnt-really-sitting-on-216-billion-in-cash-2016-01-26> . Mr. Owens' point is that the money is invested, mostly overseas (to avoid US tax liabilities), and is not technically cash. There might need to be a limited tax negotiation for Apple to use 1 % of its wealth to complete the infrastructure investment for the new rapid learning system. It has focused on educational software since the days of the Apple II but has not yet had the rapid learning capabilities and potential Everything Included data and real-time, fast, and affordable large N experiments of the new system.

<sup>18</sup> We do not yet know how cultural and other differences affect the best approach to learning. It would be timely for governments, researchers, and the private sector to build global standards for data-sharing and research. The equivalent global project for genetics-based medicine came together quickly (<https://genomicsandhealth.org/>).

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<sup>19</sup> See an extended argument in this direction: Bruce Greenwald and Joseph Stiglitz, Creating a Learning Society: A New Approach to Growth, Development, and Social Progress (NY: Columbia University Press, 2014).

<sup>20</sup> Ariana Eunjung Cha, "There's a New Sheriff in Town in Silicon Valley – the FDA." Washington Post. April 28, 2016. <https://www.washingtonpost.com/news/to-your-health/wp/2016/04/28/theres-a-new-sheriff-in-town-in-silicon-valley-the-fda/> . About \$10.1 billion in startup funding (US only) was invested in 783 deals in 2015, close to the level of the dot-com bubble. More broadly: Carey Murphy et al., Global Healthcare Private Equity Report, 2015, <http://www.bain.com/publications/articles/global-healthcare-private-equity-report-2015.aspx> .

<sup>21</sup> By way of illustration: Other sectors that may be ready for similar organizing and investment in rapid learning systems include such diverse fields as: 1.) Economics (for which the "Everything Included" cross-disciplinary data systems are one of the missing ingredients; 2.) Genetics-based agriculture; 3.) Rapid learning for equal justice under law; 4.) Rapid growth of comparative national security/intelligence agency studies where repeated and predictable cycles of misperception and misjudgment (sometimes reflecting *hubris* by American leaders, but also by foreign leaders and enemies about the US, and about each other) cause prolonged, expensive, sometimes unnecessary, and often unwinnable, wars. [For world politics, the growth of professional graduate training for international relations creates a new potential for implementation of discoveries and for a much wider set of investigations extending beyond the study of US mistakes.]; 5.) Popular music, for which virtually all songs, performers and performances are digitized and sales and other measures of listener responsiveness could be linked. The learning functions are not yet organized to identify the active ingredients that produce superior effects (by different definitions and measures) for sub-groups of listeners. A rapid learning system might improve the quality of the world's popular music (and sales), perhaps eventually with integration of neuroscience variables.

**A Rapid-Learning Education System –  
Lessons From A Rapid-Learning Health System**

**Prospectus**

**By**

**Lynn M. Etheredge \***

**Working Paper**

**April 2016**

## Summary

The US is making large national investments to develop a rapid-learning health system. There is increasing evidence that this strategy works well. This paper suggests that the rapid-learning health system could be a useful model for developing a rapid-learning education system. Using this collaborative, voluntary model, national education strategy would include: (1) a national digital infrastructure for education; (2) a national technology assessment system for educational products and practices; and (3) a national infrastructure of rapid-learning schools, school systems and networks. Estimated federal budget costs are \$1.5 billion to \$1.8 billion annually over ten years.

## **I. Toward A Rapid-Learning Health System**

How much faster can the US accelerate our discovery and use of new knowledge and better practices – our rate of progress?

After nearly a decade of investments in a “rapid learning health system”, the health sector is starting to realize revolutionary new answers to this question. For example,

--A recent review of epidemiology research finds that study costs were 11 cents per participant for accessing new electronic health records databases (for 138,514 patients over eight years) generated from patient care, compared to traditional research registries costs of \$2,732, \$11,800 and \$17,750 per participant; <sup>1</sup>

--A multi-year clinical trial (TASTE) in an established research program with an electronic data registry cost \$300,000 (\$50 per randomized patient), compared to \$10 million (or much more) for conducting the trial in a traditional program that required creating new collaborations and data systems; <sup>2</sup>

--Population medical studies that needed 2-3 years of hand coding from paper records will be doable in 2-3 weeks using automated research tools and computerized national database networks with tens of millions of patient records. <sup>3</sup> A recent briefing on NIH's Collaboratory Distributed Research Network (DRN) reports that it now offers rapid response from quality-checked and formatted electronic databases; it accesses more than 90 million lives and 300 million person-years of observation. <sup>4</sup>

**Such metrics show revolutionary acceleration in the potential pace of scientific discovery. For the same budget levels, the amount of new knowledge that is discoverable each year can be multiplied by factors of 10:1, 20:1 and much, much more.**

**To fully appreciate this learning revolution, acceleration in discovery speed must be multiplied by vastly increased scale of electronic databases that can include much more clinically rich detail per person (e.g. genetics) as well as multi-national research with hundreds of millions of patients. Many more patient experiences can be**

studied, many more variables included, many more questions addressed, many more researchers can use (and re-use) data, biomedicine can become a digital science, the usable evidence base and discoveries can grow exponentially, more targeted, effective prevention and therapies can be developed, personalized medicine will be possible. Such vastly increased “big data” resources include the NIH Precision Medicine initiative with a 1 million person database with genetics and much more data, and three national cancer “cloud pilots” that will soon offer more than an exabyte of comprehensive cancer data (and growing rapidly) for open science (one exabyte = 1,000 petabytes). Similar investments are revolutionizing discovery science in the UK and European health systems. <sup>5</sup> **The potentials of artificial intelligence, e.g. IBM’s Watson, Google’s AlphaGo, other new computer and cyber-social learning software, and data science advances (e.g. predictive models) will also accelerate the pace and dimensions of learning.** <sup>6</sup>

**Healthcare delivery systems have needed upgrades to translate such explosive growth of new knowledge into better care for every patient, as quickly as possible.** Recent news shows that rapid-learning strategies are starting to have payoffs.

--Electronic health records now provide a national digital infrastructure for healthcare delivery and improved performance. In 2014, 76% of non-Federal acute care hospitals had adopted at least a basic EHR system, compared to 9% in 2008. <sup>7</sup> In 2013, 71% of physicians had adopted an EHR; the uptake was particularly rapid in larger physician group practices (92% in 11+ physician practices). <sup>8</sup> A national center offers electronic clinical quality improvement (eCQI) resources for EHR users. <sup>9</sup>

--A comprehensive review of progress in “implementation science” reports that high performing health systems now do far better than traditional methods that publish studies in academic journals and have 14% innovation uptake over 17 years. Health systems that develop expert implementation teams now achieve 80% success within three years.<sup>10</sup>

--Project ECHO uses weekly peer-to-peer video conferences to share specialists’ expertise and new knowledge with primary care practitioners in rural and underserved areas. It can make rapid learning a reality for physicians, nurses and patients who aren’t in academic medical centers and urban areas. Using a “hub and spoke” model it is now being implemented nationwide (e.g. community health centers, Veterans Health Administration). It is also expanding internationally with a goal of reaching 1 billion persons in underserved and rural areas worldwide. <sup>11</sup>

**--The American Society of Clinical Oncology has launched a rapid learning cancer system, CancerLinQ, so that all oncologists and their patients can share computerized patient data and have on-line access to the latest research and best practices. The ASCO initiative will collaborate with the new NIH cancer initiative so that the US has the world’s fastest and best cancer research – *and* can deliver the best care to every cancer patient. <sup>12</sup>**

**--Thirty percent of Medicare enrollees (10 million persons, \$117 billion of annual payments) are now in arrangements that gear payment to learning and achieving quality goals. HHS reports, for example, there was a 17% reduction in hospital-acquired infections from 2010 to 2014, saving 87,000 lives and \$20 billion.**

**With \$10 billion funds for an innovation center, CMS is now supporting hundreds of projects for implementing better care.** <sup>13</sup>

## **II. Toward a Science of Learning Systems and a Rapid Learning Society.**

Nearly every week brings new evidence that the “rapid learning health system” ideas are making revolutionary progress. They are starting to shape the future of our world-leading biomedical science agencies (NIH, FDA), our largest healthcare financing programs (Medicare and Medicaid, with 100 million enrollees), and the US health system (18% of GDP, \$3 trillion of annual spending, 320 million persons served).

What is being implemented in healthcare can offer useful models to accelerate scientific evidence and widespread use of new knowledge in many areas. The NSF has supported workshops for a new “science of learning systems” that expand cross-sector conversations among my colleagues and scientists, social scientists and experts from many disciplines. <sup>14</sup>

## **III. Toward A Rapid Learning Education System.**

This paper focuses on how lessons from the rapid-learning health system work may be useful for a rapid-learning education system. I have been engaged in such “cross sector” learning discussions since 2010. The US education system now has visionary leaders and the foundation for a national rapid-learning education system using three strategies that are discussed below.

Indeed, there are several reasons why a RL strategy could work even better in the education system than in the health sector.

-- First, the education system already has organized delivery systems (schools and school districts).

-- Second, education already has a culture of assessment and (now) a Common Core curriculum that can be a focus for computable data, methods assessments, and national rapid learning;

--Third, several million children are taking Algebra I every year (and many other subjects), so there are many learning opportunities;

-- Fourth, well designed education technology can make education better, easier, and more fun – and be very popular with teachers and students. For example it can lessen much of classroom time assigned to formal quizzes and testing – and steeply reduce teachers' homework time of grading tests.<sup>15</sup>

While this discussion focuses on K-12 education, rapid-learning initiatives may also be useful for medical and health professions education, pre-school education (e.g. the critical first three years), community college, college and university education, professional education, and life-long learning for all workers.

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#### Strategy #1. A National Digital Infrastructure for Education

In healthcare, major IT investments have included:

--National investments to assure that all Americans and healthcare providers have electronic health records that capture computable, comparable data that can be used for research, quality improvement, and personalized care. (\$32 billion of Medicare and Medicaid incentive payments to 479,000 healthcare providers from January 2011 thru February 2016).<sup>17</sup>

-- A vast expansion of pre-designed, pre-populated, quality-checked (“research-ready”) and computerized databases and networks, with automated on-line tools, so that, in the foreseeable future, it will be possible to do “rapid learning” on almost every topic for almost every patient group.<sup>18</sup>

-- More than 17,000 Apps that allow patients and physicians to use or share health-related data.<sup>19</sup>

Following this model, national education strategy would:

**A. Invest in a national IT system for every student – using a personal electronic health records model. The Education IT system will capture standardized, individual student data from class work, homework, use of digital textbooks and videos, quizzes and tests. It will support personalized education, quality upgrades, and research. The Common Core standards, now adopted in 43 states, provide a foundation for this kind of national investment strategy.**<sup>20</sup>

Schools and school districts will be able to make these investments knowing they will be part of a national collaborative system for accelerating educational progress.

Developers of digital textbooks, MOOCs, Khan Academy-like instructional videos, and others will see a national market for new, better products that work with such IT systems.

**B. Encourage and use first-rate learning software, digital textbooks, websites, videos, on-line courses, and Apps and other digital technologies, covering all subjects and grade levels, that work with the IT infrastructure.**

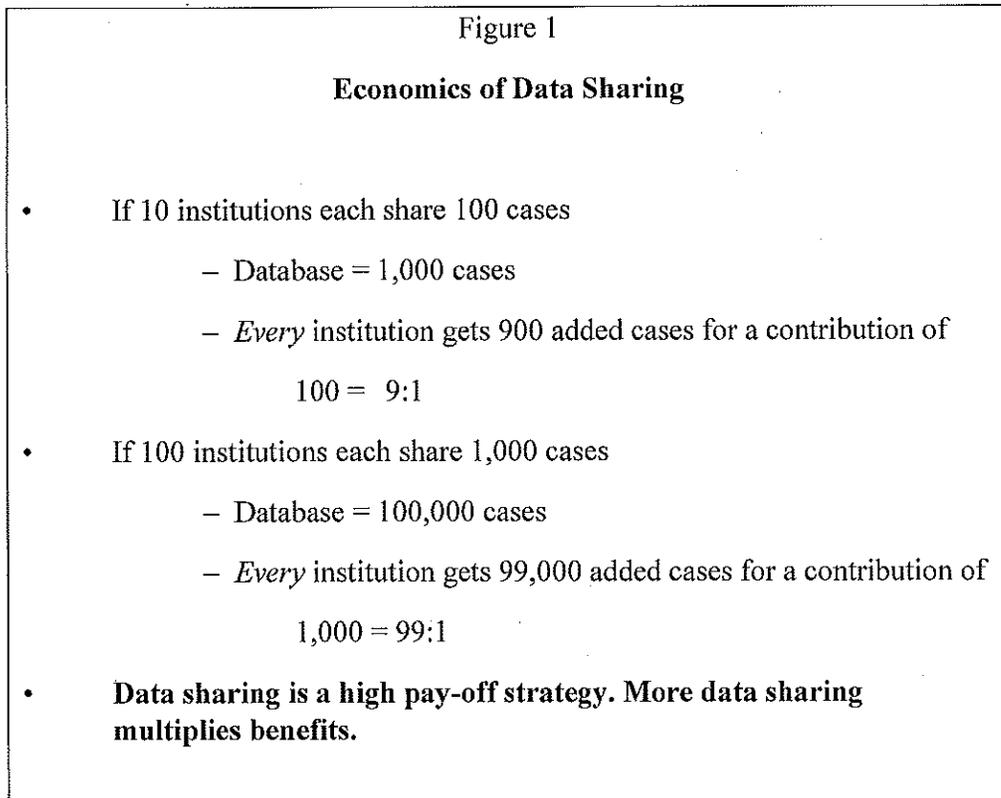
The Department of Education recently published a **2016 National Education Technology Plan** with many recommendations and resource information.<sup>21</sup> The standards for federally supported Education IT should include interoperability and open software (APIs). This strategy will expand the resources available for teachers, students, and families. Research studies from the IT system can help to assess the value of these materials and methods.

**C. Use these data to provide the best education for each student, to support Total Quality Management initiatives (identifying problems, planning and implementing change, and assessing results) and rapid-learning cycles, and to accelerate educational science.**

My local public schools (Montgomery County, Maryland) combined a student-level education IT system with APQC's Process and Performance Management methods to win the Baldrige Award as best national school system (2010).<sup>22</sup> MOOC developers and others are discovering that online courses offer low-cost ways to do many rapid randomized and sequential trials, formative assessments, and data analyses that can quickly improve products and educational science.<sup>23</sup>

**D. Use Education IT – with privacy-protected data - to develop a vibrant, interconnected 21<sup>st</sup> century education system -- with learning communities and networks.** <sup>24</sup>

The following table illustrates the high return for a national learning strategy that uses data sharing compared to traditional methods where every school or school district learns on its own.



There are many possibilities for schools, students, teachers, school districts, and others to create learning networks on common issues, e.g. (1) STEM education and computer-based mathematics, (2) assisting each child in reading to grade level by the end

of third grade, (3) dramatically improving pre-college preparatory mathematics, (4) blended classroom education/MOOC experiments, (5) personalized learning R&D and software development, (6) networks organized by subject matter (English, history, social studies, sciences, foreign language instruction), (6) networks organized by skill development, such as writing topic sentences, paragraphs, and compositions or using humanities to develop empathy, (7) networks organized by student characteristics (special needs students, gifted students, students who have a primary language other than English), (8) networks organized by student and teacher interests (math clubs, chess clubs, creative and performing arts, student government and leadership development, journalism and media, computer programming, robotics, video-game and Apps development, bio-engineering, 4-H clubs, entrepreneurship, (9) networks organized for teachers and principals (Project ECHO model peer-to-peer learning, early career development and mentoring), (10) networks to assess educational Apps and digital technologies. And much more. Leading schools and school districts could augment IT systems with specialized data modules for such areas of interests. New Education IT capabilities enable many collaborative learning possibilities.

**It is important to design, pre-position, and pre-populate new "big data" investments in the context of learning systems and networks that create communities, institutions, and processes that can collaborate in identifying questions, designing and building databases, and generating, testing, and rolling-out useful knowledge and innovations on an organized national scale.** Public and private sector health examples that might be useful for the education sector include: the Health Care Systems (HCS) Research Network,<sup>25</sup> the FDA Sentinel Network,<sup>26</sup> NIH's

Collaboratory Distributed Research Network,<sup>27</sup> PCORI's PCORnet,<sup>28</sup> patient sponsored networks (cystic fibrosis, chordoma),<sup>29</sup> hub-and-spoke systems (Project ECHO), and many more.

**It is also important to design effective research and data coordination mechanisms to support rapid learning research.** NIH, FDA, PCORI, the HCS Research Network and others have selected **the Harvard Pilgrim Health Care Institute and its PopMedNet; the Institute's leadership role and competency have been vital to progress in building a national RL health system**<sup>30</sup> Another model is NIH's "Commons" to assure that data from NIH-supported studies will be available in data "clouds" for open science<sup>31</sup>. A recently announced \$250 million grant to facilitate collaboration and coordination among six leading cancer centers offers a model for **philanthropy-led initiatives.**<sup>32</sup> These are critical investments to establish data standards, define core data sets, developed automated tools, assure quality checks and rapid response capabilities, and coordinate rapid research projects.

### **Strategy #2: A National Technology Assessment System for Educational Products and Practices**

With a flood of new ideas, knowledge, products and devices, and methods, it is important to make comparative assessments about what they offer for potential users. **In the health sector, a key initiative has been federal legislation to create the Patient Centered Outcomes Research Institute (PCORI), with \$600 million annual funding.**

<sup>33</sup> Its major initiative has been to create 29 learning networks to conduct studies on topics

of interest to patients and physicians. It also supports assessment studies directly. NIH has been re-organizing cancer clinical trials for simultaneous, parallel testing of many therapies, with comprehensive, standardized data collection, and matching of patients to therapies predicted to give each person the best outcome.<sup>34</sup> This framework produces useful comparative assessment of new therapies for personalized medicine.

**In education, a key initiative has been federal legislation to create Digital Promise (the National Center for Research in Advanced Information and Digital Technologies) to accelerate innovation.<sup>35</sup> Its activities include the League of Innovative Schools, 73 school districts that collaborate on exploring the best use of new digital technologies. In 2014, it had \$14 million in public and private support. As noted earlier, the Education Department is launching discussions about a national strategy for new educational technologies.**

**A. Create rapid-learning research and testing networks.**

It is now very difficult and confusing for school districts, schools, teachers and students to sort out the hype from the valid results about new digital products and software.<sup>36</sup> What Digital Promise has started needs to be done on a larger scale. A national system for comparative testing could help better products reach a large national market faster and also assist teachers, students, schools and school districts in making choices about best uses of new digital technologies. The new Education IT infrastructure could enable such initiatives, e.g. through organized research networks, registries and studies; the PCORI and comparative cancer trials models may be useful.

**B. Support widespread, rapid dissemination of useful research about comparative assessments.**

From PCORI's budget, about \$100 million per year is transferred to HHS's Agency for Healthcare Research and Quality (AHRQ) to support dissemination of results. A RL education system needs a dissemination strategy and budget.

**Strategy #3. A National Infrastructure Of Rapid-Learning Schools, School Systems And Networks.**

To use all of this new knowledge rapidly and effectively will require building new management capabilities, including HIT and "improvement science" methods and discipline for performance improvement into school systems.

**One of the major reasons for the health sector's quality, safety, cost and other performance problems is that it was built without modern performance improvement capabilities and management training.<sup>37</sup> In top US companies, process and performance management are core competencies and central to their success.** There are now many such "improvement science" technologies and success stories, such as APQC's Process and Performance Management, Toyota Production System, Lean, Six Sigma, Total Quality Management, and Continuous Quality Improvement.

**The new IT infrastructure of electronic health records gives health institutions, executives and physicians the ability to learn from their own data and**

**manage quality and costs, and new possibilities to improve performance through collective learning.** In healthcare, the Institute for Healthcare Improvement has been a leader in wider adoption of these new methods.<sup>38</sup> Other leaders in transforming the health sector through such methods include Kaiser Permanente,<sup>39</sup> Denver Health,<sup>40</sup> Cincinnati Children's,<sup>41</sup> Geisinger,<sup>42</sup> and the Pittsburgh area.<sup>43</sup>

**A key health initiative to accelerate learning and adoption of best practices was the creation of a \$10 billion Innovation Center at the Center for Medicare and Medicaid Services (CMS).** The Innovation Center adds billions of dollars of “demand pull” for faster adoption of new practices that will improve quality and save money. The Medicare and Medicaid programs cover more than 100 million enrollees and pay for more than \$1 trillion of services annually, so they have a lot of potential leverage – and high stakes in improved performance. CMS has prioritized national initiatives where there are large gaps between best practices vs typical care, e.g. for patient safety, heart attack and stroke deaths, and reducing premature delivery. CMS gains leverage by using strategies that combine purchasing power of public programs and third-party payers. Its initiatives include a Learning and Action Network with more than 5,000 collaborators in the public and private sector to speed national progress.<sup>44</sup> Several hundred projects are supported. For parallel capabilities:

**A. Develop and integrate top-level commitment, high potential innovations, professional implementation teams, and “improvement science” into schools.**

**Our educational system, like the health system, was built without modern performance improvement capabilities. Carnegie Foundation for the Advancement**

**of Teaching is now one of the leaders in transporting these methods into the education system.** <sup>45</sup> Its work draws on the process and performance management technologies used by the Institute for Healthcare Improvement, leading health systems, and high performance US companies. Carnegie has embarked on creating a national education system that uses these methods and “networked improvement communities (NICs)”. <sup>46</sup> APQC Education has extended APQC’s work with 750 of the global 1000 companies and 40 years of experience into work with leading educational systems. <sup>47</sup> Harold Kwalwasser’s study of 40 of the nation’s leading schools reports: “Nearly all of the districts and several of the charters I saw had adopted a form of TQM (Total Quality Management) or at least a disciplined version of continuous improvement.” These methods offer proven capabilities for achieving top performance.<sup>48</sup> Leading schools and school districts are achieving national recognition for how well they are using performance upgrade strategies; a rapid-learning education system can “go to scale” by fostering similar initiatives everywhere. <sup>49</sup>

#### **B. Create A National Implementation Plan for RL Education initiatives.**

In health care, the rapid-learning leaders have often included visionary organizations that have a mission to improve health science and healthcare. A comparable strategy would be to start with national investments in a collaborative, voluntary leadership group of enthusiastic school districts and schools as flagships for a national RL education strategy, e.g. the League of Innovative Schools that has 3.2 million children in 33 states and 73 districts, APQC Education (125 members of its North Star community), Carnegie’s Networked Improvement Communities (NICs) and collaborators<sup>50</sup>, and the Gates Foundation’s LEAP Innovations

**Network.<sup>51</sup> NIH leadership has been critical to creating new scientific research capabilities; US Education Department support, in collaboration with philanthropies, could have a similar role for education science.**

#### **IV. Implementation and Funding**

A rough estimate for new federal investments over the first ten years for rollout of the “rapid learning health system” strategy is about \$90 billion, to benefit more than 320 million Americans per year. The \$90 billion includes about \$65 billion for electronic health records subsidies, \$10 billion for the CMS Innovation Center, \$10 billion for NIH and FDA research investments and initiatives, and \$5 billion for PCORI comparative effectiveness research. **An overall accounting, however, should also include the benefits that are coming on line. HHS reports that per capita Medicare health spending was reduced by \$350 billion between 2009 and 2013, compared to 2000-2008 rates, and patients are receiving better care.** <sup>52</sup>

**Rough guesses at comparable education sector investments are \$15-\$18 billion over a decade.<sup>53</sup> These estimates need much further refinement with detailed proposals, as well as judgments about how quickly successful voluntary initiatives would spread. Nevertheless, these annual costs (\$1.5B to \$1.8 B) would be affordable in a federal budget now spending \$4 trillion per year (2016) –  $1.5/4,000 = .04\%$  – and recognizing the great importance of upgrading US school performance. Moreover, we can learn important savings and implementation lessons from the health sector experience. The largest expense, \$65 billion (over 70% of the total) for**

national EHR systems, could be sharply reduced by using “cloud” computing and centralized servers, e.g. at a school district level, rather than purchasing and maintaining stand-alone systems for each school; there are approximately 13,500 school districts (2013) compared to 129,000 K-12 schools (2012).<sup>54</sup> The education sector will gain economies by being able to focus on schools and school districts; while the US has about 4,900 community hospitals, federal EHR subsidies go to 479,000 providers to connect physicians’ offices and other locations to the healthcare system. Another important implementation lesson is to develop “Apps” and a rich universe of compatible modules for all users early, and to require subsidized Education IT systems to meet standards to work with them (APIs). The successes of smart phones, compared to basic cell phones, is largely due to the fact that one can do so much more (and so much more of interest) with them. In contrast, the HIT strategy emphasized purchase of basic EHRs with limited capabilities and ability to work with 3<sup>rd</sup> party Apps, resulting in slower adoption and less value.

Physicians have concerns about the amount of time they must spend in EHR data entry. **In contrast, well-designed education software should be a great time saver for teachers (and students), as electronic data can be captured from classwork and teacher grading time sharply reduced.** Since the education sector is much smaller than the health sector, system wide progress may be faster. Based on its experience in all industries and dozens of school systems, APQC Education has proposed a national initiative for K-12 schools development of process and performance management, using a hub-and-spoke teaching strategy, for a cost of \$44 million over five years.<sup>55</sup>

## V. Conclusion

There is growing evidence that a “rapid learning health system” – enabled by vision, leadership, investments, and much hard work – is accelerating a knowledge and performance revolution for health and healthcare. This experience offers lessons for a collaborative “rapid learning education system” that will deliver best-in-the-world education to every U.S. student.



and David Smith

<sup>1</sup> The registries also had many fewer participants (Framingham 5,209, ARIC 16,000, MESA 6,800). Joan Casey, Brian Schwartz, Walter Stewart, Nancy Adler “Using Electronic Health Records For Population Health Research: A Review of Methods and Applications” in *Annual Review of Public Health 2016* 37:61-81. Their review references six summary articles on a wide range of research uses of electronic health records (pg. 65). For an introduction to RL health system initiatives, see Lynn Etheredge “Rapid-Learning: A Breakthrough Agenda” *Health Affairs* July 2014 and Rapid Learning Project material at [https://www.researchgate.net/profile/Lynn\\_Etheredge](https://www.researchgate.net/profile/Lynn_Etheredge)

<sup>2</sup> Michael Lauer, Ralph D’Agostino “The Randomized Registry Trial – The Next Disruptive Technology in Clinical Research?” *New England Journal of Medicine* October 24, 2013, 36:1579-81; interview with Dr. Lauer at: <http://www.nhlbi.nih.gov/news/spotlight/fact-sheet/dr-michael-lauer-co-publishes-perspective-piece-on-randomized-registry-trials.html>. October 28, 2013

<sup>3</sup> Jeffrey Brown, Lesley Curtis, Richard Platt “Using the NIH Collaboratory’s and PCORnet’s Distributed Data Networks for Clinical Trials and Observational Research: A

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Preview” Nov 14, 2014 at <https://www.nihcollaboratory.org/Pages/Grand-Rounds-Hub.aspx>

<sup>4</sup> Jeffrey Brown “Use of the NIH Collaboratory Distributed Research Network” March 11, 2016, at <https://www.nihcollaboratory.org/Pages/Grand-Rounds-Hub.aspx>

<sup>5</sup> The UK databases have 65 million electronic health records, a national biobank, and a national cancer database. <http://www.farrinstitute.org>

<sup>6</sup> National Research Council Frontiers In Massive Data Analysis, National Academies Press; 2013; David Donoho “50 Years of Data Science” Sept 18, 2015 (Version 1.00) (section 6), available at:

<http://courses.csail.mit.edu/18.337/2015/docs/50YearsDataScience.pdf>

<sup>7</sup> <https://www.healthit.gov/sites/default/files/data-brief/2014HospitalAdoptionDataBrief.pdf> ONC Data Brief #23, April 2015

<sup>8</sup> ONC Data Brief #21, December 2014

<sup>9</sup> <https://ecqi.healthit.gov>. <https://www.cms.gov/eHealth/eHealthUniversity.html>

<sup>10</sup> Dean Fixsen, “Scaling and Implementation Science” December 2, 2015, presentation available at <https://www.nasi.org/civcrm/event/info?reset=1&id=201>. The author thanks Robert Gibbons, Arnold Milstein and participants in the “Bright Spots” workshop at the Center for Advanced Studies in the Behavioral Sciences, Stanford University for discussion of these issues, October 22-23, 2015.

<sup>11</sup> <http://echo.unm.edu>

<sup>12</sup> <http://cancerlinq.org>

<sup>13</sup> <https://www.cms.gov/Newsroom/MediaReleaseDatabase/Fact-sheets/2016-Fact-sheets-items/2016-03-03-2.html>

<sup>14</sup> Charles Friedman, Joshua Rubin, 10 co-authors “Toward A Science of Learning Systems: a research agenda for the high-functioning Learning Health System” *Journal of the American Medical Informatics Association* October 24, 2014

<http://jamia.bmj.com/content/early/2014/10/23/amiajnl-2014-002977.full.pdf+html> .

Lynn Etheredge “11 Models For A Science of Rapid-Learning Systems” August 2015, working paper at [https://www.researchgate.net/profile/Lynn\\_Etheredge](https://www.researchgate.net/profile/Lynn_Etheredge)

<sup>15</sup> I am grateful to Harold Kwalwasser for pointing this out to me. Student math performance, for example, can be continuously evaluated by drawing problem sets from national pools. Learning software, e.g. using “formative assessments”, can not only help to grade but also diagnose reasons for errors and suggest supplemental material

<sup>16</sup> My thanks to Rebecca Chopp for suggesting a professionals education initiative, to George Halvorson (Three Key Years, InterGroup Press 2015), and to Lloyd Etheredge for suggestions on MOOCs, global education, and life-long learning.

<sup>17</sup> <https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/DataAndReports.html>

<sup>18</sup> Examples include: the NIH and PCORI distributed research networks, FDA’s Sentinel network, NIH’s cancer cloud pilots and the 1 million person Precision Medicine Initiative, NIH’s Big Data To Knowledge initiatives, NIH’s national reference databases (<http://www.ncbi.nlm.nih.gov/guide/all/>), and more.

<sup>19</sup> <http://research2guidance.com/2010/11/10/500m-people-will-be-using-healthcare-mobile-applications-in-2015-2/>, imedicalapps.com

- <sup>20</sup> <http://www.corestandards.org>, <http://www.ed.gov/essa?src=policy>. Current standardized data systems and tests are typically designed for state, district, school and teacher assessment, rather than to personalize education and provide real-time feedback and student assistance.
- <sup>21</sup> Department of Education Future Ready Learning: Reimagining the Role of Technology in Education 2016, downloadable at <http://tech.ed.gov>
- <sup>22</sup> <https://www.youtube.com/watch?v=Eu2SKd8D2hg> For a software example: <http://www.hmhco.com/hmh-assessments/data-and-learning-management/edusoft>. Kevin Carey, Robert Manwaring “Growth Models and Accountability: A Recipe for Remaking ESEA” 2011 (downloaded from [www.educationsector.org](http://www.educationsector.org))
- <sup>23</sup> Andrew Ng “The Online Revolution: Education for Everyone” (Coursera) Wolfram Data Summit 2013, at: <http://www.wolframdatasummit.org/2013/attendee/presentations/>, Bror Saxberg (Kaplan), Education Sector panel on The Next Decade of Educational Data, December 7, 2010
- <sup>24</sup> Privacy of student-identifiable data must be guaranteed; the health records federal patient privacy statute (HIPAA) may be a useful model for education; in distributed database networks research is typically done with de-identified data and procedures to assure confidentiality.
- <sup>25</sup> <http://www.hcsrn.org/en/>
- <sup>26</sup> <http://www.fda.gov/Safety/FDAsSentinelInitiative/default.htm>
- <sup>27</sup> <https://www.nihcollaboratory.org/Pages/distributed-research-network.aspx>
- <sup>28</sup> <http://www.pcornet.org>
- <sup>29</sup> <https://www.cff.org>, <http://www.chordomafoundation.org>
- <sup>30</sup> [http://www.popmednet.org/?page\\_id=41](http://www.popmednet.org/?page_id=41), Richard Platt, Jeffrey Brown and their colleagues deserve much recognition for what they are accomplishing
- <sup>31</sup> <https://datascience.nih.gov/commons>
- <sup>32</sup> <http://wpo.st/-ceU1>, Ariana Cha “\$250 million, 300 scientists and 40 labs” *Washington Post* April 13, 2016. The grant is from Sean Parker.
- <sup>33</sup> <http://www.pcori.org>
- <sup>34</sup> [http://dctd.cancer.gov/MajorInitiatives/NCI-sponsored\\_trials\\_in\\_precision\\_medicine.htm](http://dctd.cancer.gov/MajorInitiatives/NCI-sponsored_trials_in_precision_medicine.htm)
- <sup>35</sup> <http://digitalpromise.org>
- <sup>36</sup> Frederick Hesse, Bror Saxberg Breakthrough Leadership in the Digital Age: Using Learning Science to Reboot Schools Corwin 2013. Textbook publishers and others are now moving to digital products, e.g. <http://www.pearsoned.com/prek-12-education/>, <https://www.khanacademy.org>, <https://www.knewton.com> (adaptive learning),
- <sup>37</sup> See the PCAST report *Better Health and Lower Costs: Accelerating Improvement Through System Engineering* [http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast\\_systems\\_engineering\\_in\\_healthcare\\_-\\_may\\_2014.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_systems_engineering_in_healthcare_-_may_2014.pdf)
- <sup>38</sup> <http://www.ihl.org/about/Pages/default.aspx>
- <sup>39</sup> Lisa Schilling, A. Chase, et.al, “Kaiser Permanente’s performance improvement system” *Joint Commission Journal on Quality and Patient Safety* 2010 Nov; 36(11) 484-98

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- <sup>40</sup> Patricia Gabow, Philip Goodman The Lean Prescription CRC Press, 2015.
- <sup>41</sup> <http://www.cincinnatichildrens.org/service/j/anderson-center/learning-networks/default/>
- <sup>42</sup> <http://www.geisinger.org/sites/provencare/pages/provencare-services.html>
- <sup>43</sup> Naida Grunden The Pittsburgh Way to Efficient Healthcare: Improving Patient Care Using Toyota Based Methods Productivity Press 2007
- <sup>44</sup> <https://innovation.cms.gov/initiatives/Health-Care-Payment-Learning-and-Action-Network/>
- <sup>45</sup> Anthony Bryk, et. al. Learning To Improve Harvard 2015; Anthony Bryk “Accelerating How We Learn To Improve” *Educational Researcher* Vol 44 No. 9, 467-477 December 2015; <http://www.carnegiefoundation.org>
- <sup>46</sup> <http://www.carnegiefoundation.org/get-involved/events/summit-improvement-education/2016-summit-program/>
- <sup>47</sup> <http://www.apqceducation.org>
- <sup>48</sup> Harold Kwalwasser Renewal: Remaking America’s Schools for the Twenty-First Century R&L Education 2012, pg 6. I thank Hal for many discussions about implementing these ideas throughout the health system
- <sup>49</sup> Baldrige prize winners ([http://patapsco.nist.gov/Award\\_Recipients/](http://patapsco.nist.gov/Award_Recipients/)), Broad prize winners ([www.broadprize.org](http://www.broadprize.org)), Kwalwasser op.cit. (pg xi)
- <sup>50</sup> <http://digitalpromise.org/initiative/league-of-innovative-schools/>;  
<http://apqceducation.org/images/pdf/conf2015/15Bentsen-Moving-Forward.pdf>;
- <sup>51</sup> [http://www.leapinnovations.org/images/PN\\_C1\\_Research\\_Brief\\_FINAL\\_red.pdf](http://www.leapinnovations.org/images/PN_C1_Research_Brief_FINAL_red.pdf)
- <sup>52</sup> endnote #13
- <sup>53</sup> The lower estimate pro-rates spending by number of beneficiaries, e.g. there are about 56 million children enrolled (K-12) compared to 320 million persons in the health system.  $56/320 = 17\%$ ,  $17\% \times 90 \text{ B} = \$15 \text{ billion}$  (2014). Using spending, US health spending was \$3.0 trillion (2014) while national elementary and secondary school education spending was \$621 billion (2011-2012);  $621/3,000 = 21\%$ ,  $21\% \times 90 \text{ B} = \$18 \text{ B}$ .
- <sup>54</sup> <https://www.edreform.com/2012/04/k-12-facts/>
- <sup>55</sup> Jack Grayson *Using Process and Performance Management (PPM) to Transform Education* APQC 2014