



Using Mathematical Modeling to Make Informed Decisions on Health Care Alternatives

Building the Archimedes Health Care Simulator (ARChES)

SUMMARY

Many decisions in health care are made with little reliable information about the effects of various options on health or economic outcomes. While many fields rely on mathematical modeling to design services and monitor outcomes, the health care field has not embraced this approach.

Beginning in the 1990s, researchers at the nonprofit Kaiser Permanente health care system developed the Archimedes Model, a large-scale simulation of people and population groups, human physiology, clinical events, and health care systems. The model uses mathematical modeling to conduct virtual clinical trials that test health care alternatives over 5, 10, 20, or more years.

Under this grant, Archimedes, Inc., a spinoff of Kaiser Permanente, developed an Internet-based system, dubbed ARChES (Archimedes Health Care Simulator), that would allow health care practitioners and decision-makers to use the Archimedes Model themselves to make more informed decisions.

Key Results

- Created an Internet-based system, dubbed ARChES (Archimedes Health Care Simulator), that allows health care practitioners and decision-makers to navigate the model and use it to address their specific concerns, in their particular environments, for their patients.
- The beta first version of ARChES launched early in 2011 and a greatly enhanced version launched in May 2012. The Internet-based system allows users to simulate large-scale health interventions, outcomes, and clinical trials within a matter of hours.
- As of October 2012, 13 corporations, government agencies, nonprofit organizations, and academic institutions had purchased ARChES, including the federal Department of Health and Human Services. See the [Appendix](#) for a list of ARChES customers.

- ARChES simulated potential savings from a key provision of the Affordable Care Act of 2010.

Funding

The Robert Wood Johnson Foundation (RWJF) funded the project with a grant of \$15.6 million, from June 2007 through May 2012.

CONTEXT

Many decisions in health care are made with little reliable information about the effects of various options on health or economic outcomes. For example, questions such as these are being asked every day:

- Should a health plan try to increase the frequency at which providers test the blood sugar of their patients with diabetes?
- Should people over age 65 have routine CT scans to measure coronary artery calcium?
- Should an insurance company lower the co-payments for drugs that are cost-effective, and which drugs are actually cost-effective?

Mathematical modeling of alternatives and costs is common practice in many fields—aircraft companies build mathematical representations of planes and “fly” them inside a computer before building an aircraft, architects use models to design buildings, and UPS uses them to calculate optimal transportation routes. Despite widespread acceptance of modeling in other fields, however, the health care sector has not generally used this approach.

While there are many pieces of information available—epidemiological studies, surveys, clinical trials, cost information, and the like—decision-makers need to know how different options might affect health, economic, and other outcomes in their own practices.

The Archimedes Model

In 1992 David Eddy, MD, PhD, a physician with a doctorate in applied mathematics, approached officials at California’s Kaiser Permanente with the idea of a simulation model that would provide better information for making health care decisions. Kaiser officials liked the idea and underwrote the cost of creating the Archimedes Model, housing it within Kaiser.

The Archimedes Model is a large-scale simulation of people and population groups, human physiology, clinical events, and health care systems. The model uses

mathematical modeling to conduct virtual clinical trials that test health care alternatives over 5, 10, 20, or more years. Its simulations can address a variety of challenges in the health care field, including:

- Forecasting the effects of clinical management activities, such as:
 - Adherence to guidelines
 - Implementing disease management, performance improvement or pay-for-performance programs
 - Determining coverage policies
- Setting priorities for care delivery
- Conducting cost and cost-effectiveness analyses
- Monitoring progress against goals
- Planning and forecasting
- Adapting programs to changes in clinical knowledge and technology

By the mid-2000s, the Archimedes Model had been applied to important chronic diseases, and had been tested, validated, and used to answer a variety of questions. For example, in 2002 Kaiser used the Archimedes Model to show that a combination of generic drugs could reduce the risk of heart disease among patients with diabetes by 71 percent. A subsequent clinical trial involving 170,000 Kaiser patients found that those drugs reduced risks by 60 to 80 percent, depending on how often patients took the drugs over a two-year period. The study was reported in the *American Journal of Managed Care*.¹

In 2006, Kaiser Permanente spun Archimedes off as a stand-alone for-profit company called Archimedes Inc., with Eddy as medical director. The Archimedes [website](#) provides information about how the model works, how it has been validated, and the diseases or conditions included in it.

Despite its increased use, the model had a crucial limitation—it could be used only by highly trained scientists who knew the details of its code. This made it costly and time consuming to use. Eddy describes its unwieldy process: “People would come to us, we would meet with them for a few months, ask them for a proposal, go back and forth negotiating the proposal, take months to do the analysis, send the client a written report with tables and charts we thought were important, and make revisions if needed.”

¹ Dudl, RJ, Wang MC, Wong M and Bellows J, “Preventing Myocardial Infarction and Stroke With a Simplified Bundle of Cardioprotective Medications,” *The American Journal of Managed Care*, October 2009. Available [online](#). See also Carey J, “Trimming Health-Care Costs Without Reforming the System.” *Business Week*, October 1, 2009. Available [online](#).

Obviously, such a process limited the usefulness of Archimedes.

RWJF's Interest in This Area

A core RWJF mission is to improve health care of all Americans. RWJF staff viewed the mathematical modeling and simulation inherent in Archimedes Model as holding promise for significantly improving clinical decision-making and health care management, and therefore contributing to fulfilling that mission.

The Archimedes Model was new to health care leaders, decision-makers, and RWJF staff in 2007. “This project helped to define our Pioneer portfolio,” says Nancy Barrand, RWJF senior adviser for program development and the program officer for the project. “When the portfolio was young, we were looking for ideas that had the potential to transform how we thought about health and practiced medicine,” Barrand says.

THE PROJECT

This \$15.6 million RWJF-funded project aimed to enhance the usefulness of the Archimedes Model by creating an Internet-based system, dubbed ARCHeS (Archimedes Health Care Simulator), that would allow health care practitioners and decision-makers to navigate the model and use it to address their specific concerns, in their particular environments, for their patients. In his proposal to RWJF, Eddy described ARCHeS as “the delivery system for Archimedes in the same way that Travelocity or Expedia are online tools for delivering complex travel reservations systems directly to consumers.”

Eddy led the project team, which included scientists, medical staff, software developers, and sales and marketing professionals. A multidisciplinary [advisory board](#), comprising physicians, mathematicians, health care consultants, and others provided guidance and feedback throughout the project.

RWJF funds supported only the development of ARCHeS, not its operation. From the outset, Archimedes, Inc., planned to offer ARCHeS through a business model that would bring in sufficient revenue to make it financially self-sustaining.

During the project, Eddy and his colleagues:

- Assembled and convened four meetings of the ARCHeS project advisory board
- Converted the Archimedes model from Visual Age Small Talk (VAST) to Java, for delivery over the Internet
- Created the core simulation engine (called Mercury)
- Developed web-based user interfaces required for simulations
- Created a tool for users to view simulation results over the Internet

- Updated health care costs and processes to current guidelines and positioned them for continual updating
- Promoted the use of ARChES to government officials, including the Food and Drug Administration (FDA) and the U.S. Department of Health and Human Services

A Marketing Strategy

RWJF contracted with [Burness Communications](#), a Bethesda, Md., firm, to help Eddy present ARChES to potential customers, especially government agencies. To help the dissemination effort, RWJF President and Chief Executive Officer Risa Lavizzo-Mourey, MD, MBA, wrote to senior officials of several federal agencies about ARChES.

Burness Vice President Ben Milder, who directs the company’s public policy team, worked with Eddy to develop and implement a “boots on the ground” strategy for engaging federal officials. “Our charge [from RWJF] was not ‘go get big media attention,’” Milder notes. “It was to connect with policy-makers.... We said, ‘There aren’t a thousand people we need to interest, there were 20 to 25.’”

A key marketing challenge was overcoming initial resistance from people who viewed the model as a “black box.” “How do we really know what is behind the curtain?” was a fairly common reaction, according to Milder.

RWJF Program Officer Barrand recalls a similar skepticism: “They don’t understand what this is, and even when they do, they don’t believe it.”

Eddy believes that because it is easy for nontechnical people to learn, ARChES itself is a solution to the “black box” problem of the Archimedes Model. Eddy takes a computer to meetings with potential customers and lets them use it. This “allows people to ‘kick the tires,’” he says. “It’s like looking inside a car—some people will understand what they see and others won’t. The best approach, like with a car, is to let people drive it. If it does what they like, they will trust it.”

RWJF’s Involvement

Unlike most RWJF-funded initiatives, this project required a grant to a for-profit entity. While grants to for-profit entities are allowed under applicable IRS regulations, they require careful thought and structuring to ensure that private foundation funds are used to further a charitable purpose and not for private benefit. As RWJF Senior Counsel, Edmond Ghisu, explained, “We sought to find a way to define charitable purpose that could be measured from Archimedes’ success in marketing and selling ARChES.” In the end, the grant was structured so that Archimedes would return the full amount of RWJF’s grant in the form of price discounts to charitable organizations (i.e., government, nonprofit, and academic entities). Charitable organizations would receive discounts of up to 98 percent off the retail price charged to for-profit entities. RWJF also made this a

“recoverable grant,” so that the Foundation could recoup its grant funds if ARChES were no longer controlled by Archimedes/Kaiser.

RESULTS

The project team reported the following results to RWJF:

- **The first beta version of ARChES launched early in 2011 and a greatly enhanced version launched in May 2012.** The Internet-based system allows users to simulate large-scale health interventions, outcomes, and clinical trials within a matter of hours. These simulations enable users to:
 - Analyze prevention activities and management of chronic conditions for patients
 - Design guidelines, performance measures, and incentive programs
 - Compare the effectiveness of different treatments
 - Design clinical trials
 - Analyze and improve health processes
 - Forecast the cost of health care
 - Estimate the cost-effectiveness of interventions

ARChES features three components, working in sequence:

- The *ARChES Setup Tool* sets up a virtual clinical trial. The web interface has built-in editing functions for setting up populations, specifying what care is currently provided, noting eligibility criteria, applying standard or custom interventions, designing custom care processes, and setting up a study.
- The *Archimedes Model* receives the study after setup and simulates each person in the population through several disease models and protocols that deliver standard care and the user-specified interventions. The output captures person-specific health and economic outcomes for each year of a virtual 20-year period.
- The *Archimedes Outcomes Analyzer* reports the data back to users. The analyzer allows users to create their own tables and figures that examine different combinations of interventions, outcomes, populations, and time periods. Users can also explore the effects of changing a variety of assumptions, creating new tables and figures for each new assumption.

The [Resource Center](#) section of the Archimedes website gives users access to tutorials, webinars, help pages, and consultations with Archimedes staff in using all of these features.

“Now, anyone with some training can go onto the Web and get access to the model, set up an analysis, submit it, wait a short period for the ‘bell to ring,’ open the Outcomes Analyzer, get and analyze the results, and create and modify their own tables and charts,” Eddy says. “That is *fundamentally* different from the way we used to work.”

- **As of October 2012, four for-profit corporations were using ARChES, along with two nonprofit agencies, one academic institution, and six government agencies.** See the [Appendix](#) for a list of ARChES users. In May 2012, Archimedes received a contract from the U.S. Department of Health and Human Services to make ARChES available to its agencies, including the Centers for Medicare & Medicaid Services, the Centers for Disease Control and Prevention, and the Food and Drug Administration.
- **Eddy used ARChES to simulate potential savings from a key provision of the Affordable Care Act of 2010.** Eddy simulated the impact of the Medicare Shared Savings Program—which rewards providers who lower costs while improving performance—for patients ages 65 to 75 with Type 2 diabetes. He found that a 10-percentage-point improvement in performance would reduce Medicare costs by no more than 1 percent, even before accounting for costs of implementing the quality measures. Findings were published in October 2012 in *Health Affairs*.²

LESSONS LEARNED

1. **Pay attention to project management.** According to Eddy, “This project spanned the duration of five years and involved nearly every employee at Archimedes at some point. Exceptional project management was essential to the success of the project, as was the retention of key software development staff.” The staff team met regularly, reported on milestones, managed challenges as they arose, and anticipated resource needs.
2. **Solicit input and feedback from end users as early as possible in such a project.** In this case, releasing initial prototypes to potential customers and rapidly incorporating their feedback were primary success factors for the project. “The lesson we learned is that the sooner you can be in a position to put a working prototype into a real user’s hands, the better your final deliverable will be,” Eddy said.
3. **Take the time to “knock on doors” when attempting to develop interest among potential users.** Nothing substitutes for calling on people. “If I understood how critical the boots on the ground would be,” says Burness Communication’s Milder, “I would have been more aggressive.”

² Eddy DM and Shah R. “A Simulation Shows Limited Savings from Meeting Quality Targets Under the Medicare Shared Savings Program.” *Health Affairs*, 31(11). Published online on October 3, 2012. Abstract available [online](#).

4. **At the same time, avoid soliciting more demand than the product can address.** “In some places, we deliberately took our feet off the gas a little, because we weren’t sure Archimedes could respond to more demand,” added Milder.
5. **When marketing a new product, be prepared to adapt on the fly.** Milder and Eddy first approached federal officials with the idea of offering them a limited free trial of ARCHeS before asking them to purchase it. This proved problematic within government procurement rules. “We had to say, ‘We get it’ and we changed our approach,” says Milder. “That led to the contract with HHS.”

AFTERWARD

Archimedes, Inc., continues to market ARCHeS to both for-profit and nonprofit entities. The latter receive discounts in accordance with the stipulations of the RWJF grant.

Eddy continues to refine and improve both ARCHeS and the model it connects to. “We are committed to maintaining the model in the sense of keeping it up to date with the advances in medical science, technology, and evidence. We are also committed to expanding its diseases and functionality.” His interests along these lines include introducing a program that would simulate performance improvement incentive programs, adding mental health conditions to the diseases included, and integrating the model with electronic health records.

Prepared by: Mary Nakashian

Reviewed by: Robert Narus and Molly McKaughan

Program Officer: Nancy Barrant

Program Area: Pioneer

Grant ID#: 57707

Project Director: David M. Eddy, MD, PhD (415) 490-0400; david.eddy@archimedesmodel.com

APPENDIX

ARChES Customers

(Current as of the end date of RWJF funding; provided by the program's management; not verified by RWJF.)

Commercial Customers

Eli Lilly and Company

Indianapolis, Ind.

Novartis

Basel, Switzerland

Novo Nordisk

Bagsvaerd, Denmark

Orexigen Therapeutics

LaJolla, Calif.

Non-Profit Customers

Kaiser Permanente

Oakland, Calif.

National Business Coalition on Health

Washington, D.C.

Academic Customer

University of North Texas Health Science Center

Fort Worth, Texas

Government Customers

McKinsey Consulting on behalf of the Australian Department of Health and Aging

Canberra, Australia

Centers for Medicare & Medicaid Services at the U.S. Department of Health and Human Services

Baltimore, Md.

Assistant Secretary, Planning and Evaluation at the U.S. Department of Health and Human Services

Washington, D.C.

Department of Veterans Affairs

Washington, D.C.

Oregon Office for Health Policy and Research

Salem, Ore.

BIBLIOGRAPHY

(Current as of date of the report; as provided by the grantee organization; not verified by RWJF; items not available from RWJF.)

Article

Eddy DM and Shah R. “A Simulation Shows Limited Savings From Meeting Quality Targets Under the Medicare Savings Program.” *Health Affairs*, 31(11), published online on October 3, 2012. Available [online](#).

Communication or Promotion

www.archimedesmodel.com. This website includes details about Archimedes products and services, publications, case studies of the model’s use, webinars, product specification sheets, pricing, and other information. Log-in is required to access some information.