INDUSTRY DEVELOPMENTS AND MODELS

Supercomputer-Based Analytics Are Starting to Transform Healthcare

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IDC OPINION

In the United States and other nations with highly evolved healthcare systems, a long-term trend is in motion to replace today's predominantly fee-for-service, procedures-based medicine with outcomes-based medicine, that is, treatments that are customized to produce optimal health outcomes for each patient. Outcomes-based healthcare has strong potential to improve healthcare quality while better controlling the sharp rise of healthcare costs. Further:

- IDC believes that high-performance data analysis – using supercomputers for advanced analytics – will spearhead the drive toward outcomes-based healthcare. As the examples in this document illustrate, early outcomes-based initiatives under way around the world rely heavily on supercomputers to speed diagnoses, pinpoint efficacious treatments, and help manage complex medical cases, including chronic conditions that some estimates say represent 75% of healthcare costs. When placed into the service of pioneering researchers and clinicians, supercomputers are already helping save the lives of children and adults who have exhausted the possibilities of traditional medicine.
- By the time outcomes-based healthcare displaces procedures-based medicine, perhaps a decade from now, the analytics challenges requiring a supercomputer today will probably be done on tablet computers and smartphones – and tomorrow's still more powerful supercomputers will be addressing even more daunting challenges. CIOs and human resources leaders, especially those working for large, self-insured employers, should closely track the progress of outcomes-based healthcare. Chief medical officers and chief public health officers should seek opportunities for deeper learning through active participation in outcomes-based initiatives.

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IN THIS STUDY

This IDC study examines the role of supercomputers in the formative market for outcomes-based healthcare and describes examples of the growing number of initiatives in the United States and elsewhere that are paving new ground in healthcare with help from supercomputers.

SITUATION OVERVIEW

U.S. healthcare costs are among the highest in the world, amounting to about $3 trillion in 2013 and headed toward $4.8 trillion, nearly 20% of GDP, in 2021, according to the Centers for Medicare and Medicaid Services. (Costs in other developed countries are in the 9–11% range, less alarming but also very substantial.)

Despite improved cost-control measures, U.S. health insurance premiums are being driven upward by large-scale factors that are often beyond the control of third-party payers — UnitedHealth Group, Cigna, Aetna, Blue Cross Blue Shield, Kaiser Permanente, and others. These developments include the aging of the American population, the proliferation of expensive new medical equipment, increased consumer demand for healthcare services (healthcare consumerism), and burgeoning government regulations and coverage mandates.

The large insurers and managed care firms that cover most American employees have long maintained that better healthcare quality and cost control can go hand in hand (assuming that cost control means slowing rather than stopping or reversing cost increases). Wellness and other preventive medicine programs have shown that this counterintuitive principle can work in practice. But far larger benefits for quality and cost will come from the multiyear transition from today's procedures-based medicine to personalized, outcomes-based healthcare. (Personal medicine is sometimes also called precision medicine.) It's here where *high-performance data analysis* (HPDA) — using high-performance computing (HPC) for advanced analytics — is already beginning to make a difference. IDC believes that supercomputer-powered HPDA will pave the way for the outcomes-based healthcare of the future.

Outcomes- Versus Procedures-Based Healthcare

Today, doctors and other healthcare providers are compensated based on performing procedures — tests and services that have been carefully defined and linked to specific payment amounts or ranges by health insurers or government healthcare programs. The problem is that the financial incentives today are to perform more procedures because that produces more compensation. This can lead to overtreatment, which, like undertreatment, can compromise healthcare quality.

In outcomes-based healthcare, by contrast, provider compensation is based squarely on the patient's health outcome. This does not mean that providers receive no compensation if a patient under their care fails to recover fully from an illness or injury. It simply means that providers are rewarded for pursuing appropriate care, that is, courses of treatment that are associated with better outcomes for patients with the same or a similar condition. Appropriate care has been determined as follows:

- Historically, guidance for what constitutes appropriate treatment has come primarily from medical studies, augmented by clinical practice. But medical studies typically involve relatively small numbers of participants, often only one or two hundred per study. Outcomes-based healthcare, including some early initiatives now under way, seeks instead to review tens of

millions of archived patient records in order to gain insight into which treatments have worked best on large patient populations, especially for producing lasting health benefits.

- Appropriate outcomes-based healthcare must be highly personal. What constitutes a good outcome for a broken hand will vary, depending on whether the patient is an office worker or a concert violinist.
- One relatively new diagnostic weapon added to the medical arsenal is individual genome analysis (i.e., DNA sequencing). This approach can be highly effective in pinpointing the best available treatments for individuals.

A major goal of outcomes-based healthcare is identifying appropriate, highly effective treatments in near real time — while the patient is still in the office — by comparing an individual's genetic makeup, health history, and symptomology against tens of millions of archived patient records. Today, a high-performance computer is needed to process all this data and generate efficacy ratings for a range of treatment options in short order. When this capability matures, it will likely serve as a decision-support tool of unprecedented utility for the global healthcare community. By then, perhaps a decade from now, the analytics challenges requiring a supercomputer today will probably be done on tablet computers and smartphones, and tomorrow's even more powerful supercomputers will have moved on to address more daunting challenges.

Where Do Things Stand Today?

Early outcomes-based initiatives involving HPC are well under way. Consider the evolution of IBM's famous Watson supercomputer:

- In 2011, the IBM Watson cognitive supercomputer stunned a huge American television audience by defeating two human past champions of the *Jeopardy!* game show in a competition match. The great achievement of this digital brain was its ability to "understand" natural language — specifically, natural language expressed in the narrow interrogatory syntax of the *Jeopardy!* game show. On the heels of this triumph, IBM announced in January 2014 that it would invest $1 billion to advance Watson's decision-making abilities for major commercial markets, including healthcare. Not much later, in May 2015, IBM said 14 U.S. cancer treatment centers had signed on to receive personalized treatment plans selected by a Watson supercomputer. Watson has contracted since *Jeopardy!* days "from the size of a master bedroom to three stacked pizza boxes." Watson will parse the DNA of each patient's cancer and recommend what it deems the optimal medical treatment.

IBM Watson is not the only supercomputer battling cancer and other terrible illnesses. Several initiatives are finding success using standard HPC clusters:

- The Center for Pediatric Genomic Medicine at Children's Mercy Hospital, Kansas City, Missouri, has been using supercomputer power to help save the lives of critically ill children. In 2010, the center's work was named one of *Time* magazine's top 10 medical breakthroughs. Roughly 4,100 genetic diseases affect humans, and these are the main causes of infant deaths. But identifying which genetic disease is affecting a critically ill child isn't easy. For one infant suffering from liver failure, the center used 25 hours of supercomputer time to analyze 120 billion nucleotide sequences and narrowed the problem down to two genetic variants. This allowed the doctors to begin treatment with corticosteroids and immunoglobulin. Thanks to this highly accurate diagnosis of the problem and pinpointed treatment, the baby is alive and well today. For 48% of the cases the center works on today, supercomputer-powered genetic diagnosis points the way toward a more effective treatment. The center's five-year goal is to provide a fast, accurate diagnosis for every critically ill child that comes under their care.

- The Neuroblastoma and Medulloblastoma Translational Research Consortium (NMTRC) is a group of 18 universities and children's hospitals based in Grand Rapids, Michigan. NMTRC and the Translational Genomics Research Institute (TGen) launched a personalized medicine clinical trial for pediatric cancer. This initiative employs rapid analysis of tumors and predicts the best drugs for a specific patient. An HPC cluster analyzes, shares, and stores hundreds of billions of measurements in just six hours compared with the 10 days it took without a supercomputer.
- The University of Toronto's SickKids Centre for Computational Medicine uses a supercomputer operating at 107 trillion calculations per second to predict the minute differences between individual children in order to identify the best treatment for each child under their care.
- By combining genetics, neurobiology, and supercomputing, researchers at the University of Rochester Medical Center, New York, identified a genetic mutation responsible for a potentially deadly seizure disorder found in infants and young children. Young people with the condition who survive beyond infancy often struggle for the rest of their lives with developmental disabilities, autism, and uncontrollable seizures. The researchers used a supercomputer cluster to quickly obtain a full genetic profile — more than 20,000 genes — for each study subject and to compare the results with data from other families. The findings are expected to influence clinical treatment soon.

When Did the Marriage of Medicine and Supercomputers Begin?

The marriage of healthcare and HPC started more than 20 years ago. In the early 1990s, Women's Clinic, Mannheim, Germany, began routinely using HPC to predict which expectant mothers would require surgery for cesarean births, with the goal of avoiding traditional, riskier last-minute decisions during childbirth. The supercomputer analyzed the elasticity of the woman's tissues to see if they could accommodate the likely size and shape of the baby's head. For this work, the clinic was nominated for a prestigious Computerworld-Smithsonian Award.

In the same era, the Department of Radiology at Georgetown University Medical Center (Washington, D.C.) began routinely employing a supercomputer to "read" digital mammograms with better-than-human accuracy to spot early signs of breast cancer (microcalcifications). Hospitals in Europe and the United States began using HPC in surgical training, especially to convey the "feel" of various procedures as experienced by veteran surgeons, a science known as haptics.

These early collaborations between supercomputers and healthcare relied on traditional modeling and simulation — analyzing virtual models of physical objects. The Human Genome Project introduced a new approach based on finding value in the data itself. The Human Genome Project took $3 billion and 10 years to complete in 2003. But by the late 2000s, the original process was already outmoded. Today, with the help of supercomputers, a human genome can be sequenced in a couple of days at a cost of under $1,000. Without that major progress in time and cost, the outcomes-based initiatives described above would be impractical.

Initiatives Elsewhere in the World

Supercomputer-driven research and clinical initiatives have been springing up not just in the United States but across the world. Consider these examples:

- Researchers at the University of Oslo (Norway) are using a supercomputer to help identify the genes that cause bowel and prostate cancer, two common forms of the disease. There are 4,000 new cases of bowel cancer in Norway every year. Only 6 out of 10 patients survive the

first five years. Prostate cancer affects 5,000 Norwegians every year and 9 out of 10 patients survive. The researchers are employing the supercomputer to compare the genetic makeup of healthy cells and cancer cells, paying special attention to complex genes called fusion genes.

- Ariana Pharma (Paris, France), a spin-off of the renowned Pasteur Institute, is developing supercomputer-based software to help healthcare providers manage cancer patients, from prediction to diagnosis, treatment planning, and integrated case management. This approach, like many others, relies heavily on employing a supercomputer to quickly obtain a full genetic profile of each patient, and then using this profile to create a personal, outcomes-based treatment regime.
- Doctors at Australia's Victor Chang Cardiac Research Institute are using supercomputer-based gaming technology to identify how individuals' genetic makeups can affect the severity of their heart rhythm diseases. The researchers built a virtual heart, then applied the recorded heartbeats of patients to the digital heart model in order to spot abnormal electrocardiogram signals. The whole process took 10 days using HPC, instead of the 21 years it would have taken with a contemporary personal computer. In other words, this important work would be impractical without the supercomputer.
- The Frédéric Joliot Hospital Department (Orsay, France) is using the powerful supercomputer at the French Alternative Energies and Atomic Energy Commission (CEA) in Bruyères-le-Châtel to improve understanding of how tracers used in PET scans for cancer diagnosis distribute themselves through the body. The goals of this research are to optimize PET scan data analysis and, later on, to personalize the PET scan process for each patient in order to produce better outcomes.
- Researchers at Russia's Lobachevsky State University of Nizhni Novgorod are pairing tomography with a supercomputer to create "virtual clones," that is, detailed 3D models of individual medical patients. As opposed to the customary 2D images produced by tomography, the 3D virtual clones can reveal even minute anomalies in bones, organs, and tissues. They can be used to determine how a patient is reacting to a treatment, with the goal of zeroing in on the treatment that is likely to produce the best health outcome for the patient.

FUTURE OUTLOOK

What Does This Trend Mean for Employers?

The movement now in progress toward outcomes-based healthcare has strong implications for American employers. (Many of these potential advantages would also apply to individuals covered under national healthcare programs in the United States and other countries with highly developed healthcare systems.) Benefits include:

- The most important benefit, of course, will be better outcomes and improved health for covered employees. This is turn contributes to increased worker productivity and well-being.
- An adjunct benefit will be greater control over escalating healthcare costs. This is because personalized, highly appropriate treatment is inherently more cost effective than undertreatment or overtreatment, both of which can increase costs while evading or even exacerbating the health problem.
- A less-obvious benefit of outcomes-based medicine is its ability to identify the small minority of providers who routinely operate outside the accepted norms of medical practice, such as by ordering expensive procedures that have little proven ability to produce good health outcomes. Under outcomes-based healthcare, providers will still be able to use their judgment in ordering

riskier procedures on a case-by-case basis, but physicians and others who make a habit of this may be dropped from third-party payers' approved provider networks. Some estimates say that 1-2% of providers are responsible for half of all the unnecessary healthcare given to patients today.

ESSENTIAL GUIDANCE

- CIOs and human resources/benefits leaders in large, self-insured companies, and their counterparts in state and national healthcare programs, should closely track the ongoing trend toward outcomes-based healthcare – with a particular eye on initiatives that enter clinical practice, however limited. IDC believes that employees and other covered individuals will increasingly demand access to promising new outcomes-based treatments and that these treatments have strong potential for helping control escalating healthcare costs.
- Chief medical officers and chief public health officers should also track this trend and should seek opportunities for deeper learning through active engagement of themselves or staff members in one or more promising outcomes-based initiatives.
- Large third-party payers that are not already involved in outcomes-based initiatives should find ways to get involved, either by joining existing initiatives or starting new ones.
- HPC vendors should also pay close attention to this trend. IDC forecasts that worldwide spending on supercomputers and other HPC systems in the biolife sciences market will grow from $1.1 billion in 2013 to $1.3 billion in 2018. When spending on storage, software, and service is added in, the 2018 figure will approximately double.

LEARN MORE

Related Research

- *PayPal Says More Fortune 2000 Firms Could Benefit from HPC for Big Data Analytics* (IDC #252836, December 2014)
- *Emergent Use Cases in High-Performance Data Analysis: HPC User Forum, September 15-17, 2014, Seattle, Washington* (IDC #251976, October 2014)
- *USPS Touts Benefits of HPC for Big Data* (IDC #IcUS25123014, September 2014)
- *Perspectives on High-Performance Data Analysis: The Life Sciences* (IDC #248348, May 2014)
- *High-Performance Data Analysis in the Life Sciences: HPC User Forum, September 2013, Boston, Massachusetts* (IDC #243774, October 2013)
- *Worldwide High-Performance Data Analysis 2013-2017 Forecast* (IDC #241315, June 2013)

Synopsis

This IDC study examines the role of supercomputers in the formative market for outcomes-based healthcare and describes examples of the growing number of initiatives in the United States and elsewhere that are paving new ground in healthcare with help from supercomputers. Healthcare costs consume more than 17% of U.S. GDP today and are rising quickly. In many European nations, healthcare devours a substantial 9–11% of GDP. Early initiatives are under way around the world that employ personalized, outcomes-based healthcare rather than the procedures-based medicine that predominates today. Outcomes-based care promises to improve healthcare quality while better controlling costs.

"IDC believes that high-performance data analysis — using supercomputers for advanced analytics — will spearhead a decade-long drive toward outcomes-based healthcare. When made available to pioneering researchers and clinicians, supercomputers are already helping save the lives of children and adults who have exhausted the possibilities of traditional medicine," said Steve Conway, IDC research vice president, High-Performance Computing and High-Performance Data Analysis.

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