HEALTHCARE GETS PERSONAL

SAP®

OXFORD ECONOMICS

Introduction

A new approach to research, pharmaceutical development, and clinical practice is remaking healthcare. Known as personalized medicine or precision medicine, it uses genetics, genomics, and Big Data to move beyond the familiar one-size-fits-all models of prevention, diagnosis, and treatment. The goal is individualized care, with a promise of improved patient outcomes and progress against previously intractable illnesses, along with cost savings and greater efficiency across the healthcare system.

This revolution is well under way, with rapid growth and maturation expected in the next two years. Investment is on the rise, including high-visibility programs like the $215 million Precision Medicine Initiative announced in 2015 by the Obama administration and a series of projects supported by the European Union. Yet substantial challenges remain to be addressed if personalized medicine is to deliver on its potential.

We recently surveyed 120 healthcare professionals from research, life sciences, and clinical organizations in Europe and North America, each with a meaningful focus on personalized medicine. We also conducted in-depth interviews with experts in the field. Among our key findings:

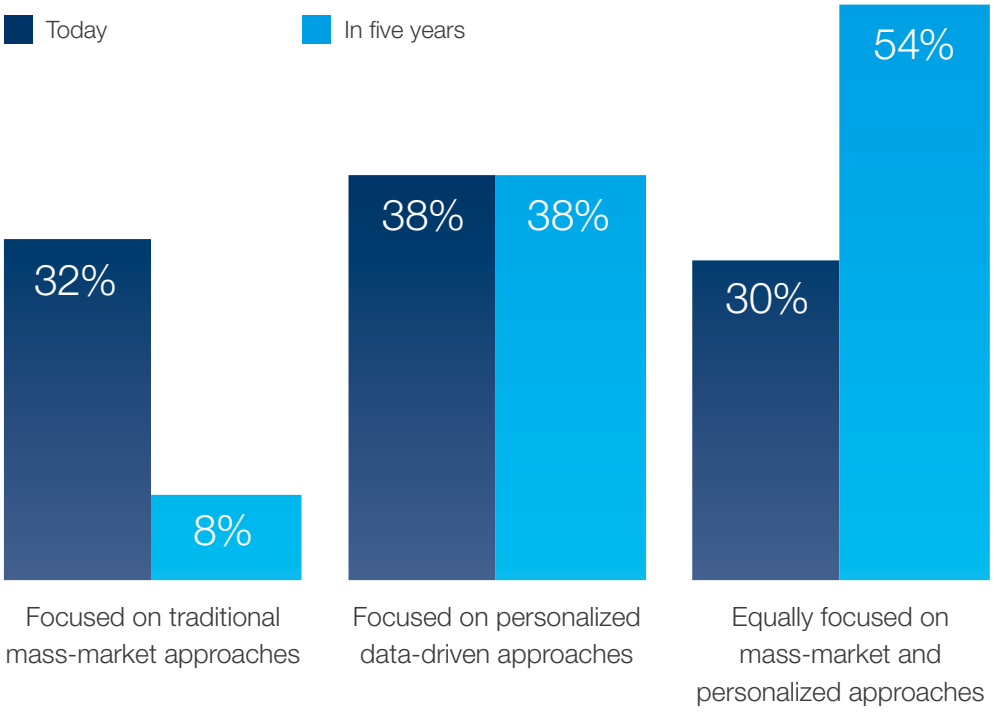
- **Early results are promising, and aspirations are high.** Over two-thirds of survey respondents say personalized medicine is having a measurable effect on patient outcomes, and roughly the same number say it will have an impact on their organization in the next two years.
- **A new approach to healthcare demands meaningful adjustments to culture and governance.** Most organizations are still learning to share data, and preparation for regulatory changes remains a work in progress.
- **Technology is at the heart of the shift to personalized medicine.** Substantial investments in Big Data and analytics are ongoing; a focus on specialized and basic IT capabilities is essential to success.
- **While business models are not fully developed, the economic case for personalized medicine is maturing.** Many organizations voice optimism about revenue growth and profitability over the next two years.

The traditional emphasis on mass-market approaches is shifting toward personalized medicine. The traditional model is not going away, and other movements (such as population health, which focuses on prevention at a community-wide scale) are also on the rise—but targeted approaches are increasingly ready for prime time.

The new US "moonshot" against cancer, announced by President Barack Obama in his January 2016 State of the Union address, will rely heavily on personalized medicine. The space-race imagery evokes an epic project and dramatic payoff to be realized all at once. But walking on the moon required years of basic engineering, incremental progress, and coordinated work. The same will be true of personalized medicine.

Fig. 1: A shift to personalized medicine

Which of the following best describes your organization, today and in five years?
Select 1 for each time period



About the research

SAP worked with Oxford Economics to survey 120 healthcare professionals from organizations that have a meaningful focus on personalized medicine. Our respondents—physicians, researchers, administrators, and executives—all have knowledge of and responsibility for their organization's use of personalized medicine.

Respondents come from eight countries in North America and Europe. Organizations surveyed represent a range of revenue sizes and research budgets; the university research institutions included have sizable budgets devoted to personalized medicine. In general, organizations are expecting growth in revenue and profitability over the next two years—a possible sign that personalized medicine is turning into a financially viable market.

In addition to the quantitative survey, Oxford Economics also conducted a series of in-depth interviews with physicians, executives, and researchers from AstraZeneca, the Biobank Core Facility at St. Joseph's Hospital and Barrow Neurological Institute, the George Washington University Cancer Center, Partners HealthCare, Einstein Medical Center, and the European Alliance for Personalized Medicine.

Fig. 2: Respondents by organization type

Please describe your organization.

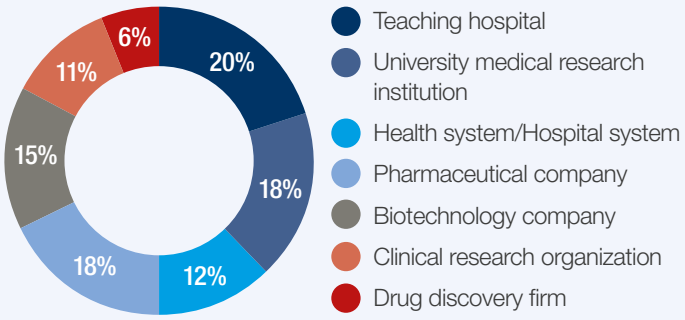
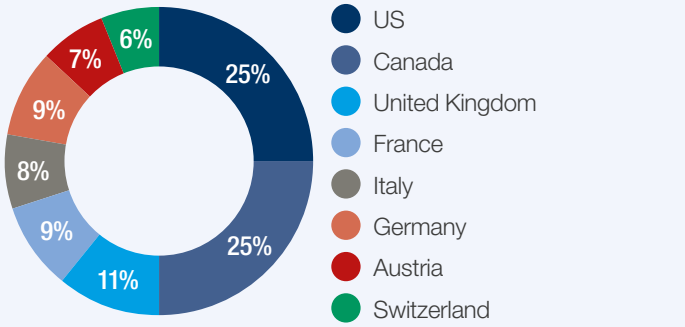


Fig. 3: Respondents by location

In which country is your organization headquartered?



Making medicine personal

Personalized medicine is changing patient care for the better. Take coronary disease: under the traditional treatment model, patients would be administered standard dosages of various medications after a heart attack. But individuals metabolize different medications at varying rates, meaning that the most effective dosage of a given drug is not consistent across broad populations. Now, pharmacogenetic testing—based on research into the ways a person's genes affect his response to drugs—allows doctors to prescribe the right dosages of particular drugs to specific patients, says Vincent Figueredo, MD, Chief of Clinical Cardiology at Einstein Medical Center in Philadelphia.

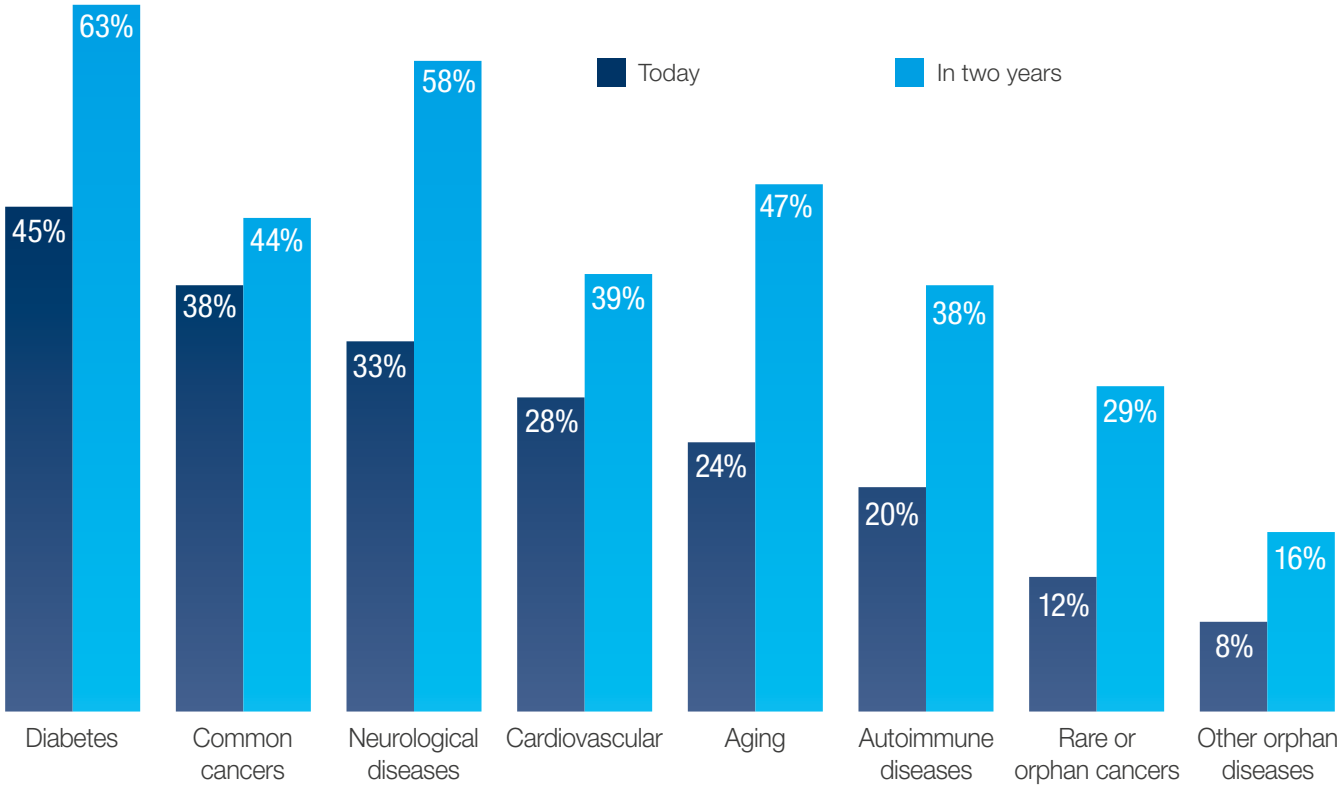
Individuals metabolize different medications at varying rates. Pharmacogenetic testing allows doctors to prescribe the right dosages of particular drugs to specific patients.

But personalized medicine solutions need not be individually tailored to deliver great benefits. For instance, large populations can be segmented into smaller groups, with patients then slotted into the appropriate group based on their own characteristics, including genetic and genomic information, age, and personal habits. This approach, analogous to the mass customization common to online purchases, can allow a physician with real-time access to the right data to make better decisions at the point of care.

"The database and computer system will tell me, okay, there are 500 patients similar to the one I am seeing in my office right now—and then tell me which treatments those patients received and which ones got the best outcomes," says Eduardo M. Sotomayor, MD, director of the George Washington University Cancer Center in Washington, DC. Information on clinical trials and response rates may also be available. "I may tell a patient, 'Regarding all the other treatments currently available for your particular type of cancer, this one has the best response rate for people like you.'"

Fig. 4: New hope for patients and families

On which illness or conditions does your personalized medicine program primarily focus? *Select all that apply*



In fact, over two-thirds of survey respondents report improved patient outcomes from their personalized-medicine initiatives, and three-quarters expect value in this area within two years. Improved patient and project volume is another early payoff, as increased efficiency allows physicians to serve more patients without sacrificing effectiveness. And the positive trajectory is expected to continue in the next two years, including growth in financial performance and government, grant, or donor funding.

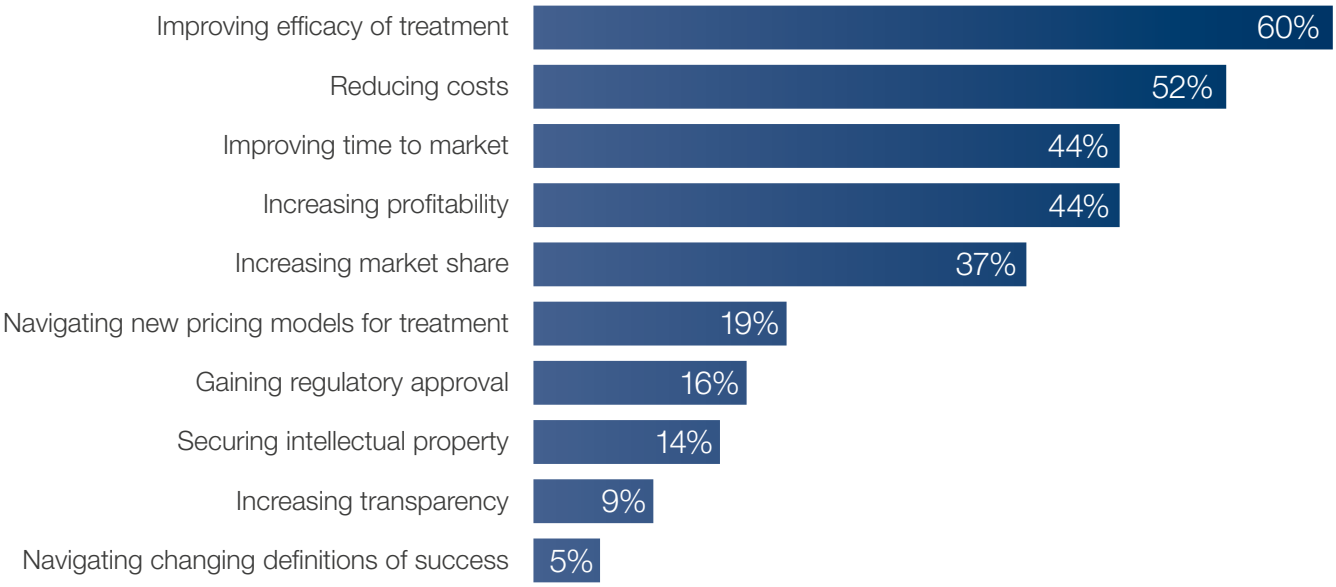
Tailored treatment plans can reduce wasted resources, time, and expenses, and ultimately help move people through the healthcare system more rapidly.

The applications of personalized medicine are far-reaching. Key areas of research include cancer, diabetes, and even aging—all important areas of focus today that will see growing attention over the next two years. Personalized medicine is also being applied with increasing frequency to so-called orphan diseases, including rare cancers, which often do not attract as much attention from researchers, yet in aggregate take a large toll in terms of mortality.

Beyond better patient outcomes, personalized medicine promises cost savings and increased efficiency. Both are badly needed: for example, a 2016 study from researchers at Memorial Sloan Kettering Cancer Center estimates that insurers waste nearly $3 billion every year on cancer medicines that are thrown out because the drugs are distributed in one-size-fits-all vials that contain proper dosages only for the physically largest patients. Tailored treatment plans can reduce wasted resources, time, and expenses, and ultimately help move people through the healthcare system more rapidly. In fact, improving efficacy of treatment, lowering costs, and improving time to market are leading forces driving personalized-medicine research.

Fig. 5: What drives treatment and drug discovery

What are the primary pressures on your drug and treatment discovery/development processes? *Rank the top 3*



But much remains to be done: the basic scientific framework for personalized medicine is still in the development phase, and advanced concepts such as genomics and other advanced biological fields are not yet fulfilling their full potential. Institutions remain focused mainly on the building blocks (e.g., efficacy of treatment, cost reduction), leaving key areas such as regulation and security with substantial room for development.

Case study: Changing the clinical paradigm

A patient experiencing chest pain used to get a nuclear stress test, in which a small amount of radioactive material is injected and then tracked with a special camera. The downside: exposure to non-trivial levels of radiation, especially if multiple tests are needed over time. So finding an alternative—a blood test that determines the patient's likelihood of having a coronary artery lesion—was a big deal. Nearly half the population will require no further testing after the blood screening, says Vincent Figueredo, M.D., Chief of Clinical Cardiology at Einstein Medical Center in Philadelphia. That means a substantial number of people will see reduced risks and lower costs.

The test relies on gene expression via RNA, the copy of a person's DNA made by their cells to produce proteins and enzymes. While genetic testing based on DNA measures lifetime risks, "RNA is real time—a molecular signature of what's happening in your body now," says Dr. Figueredo. "These tests are really good at ruling out or identifying diseases, and determining the efficacy of a given treatment."

And gene expression testing is just one way that Dr. Figueredo, a practicing cardiologist for nearly three decades, has seen personalized medicine transform his clinical work in the past several years. Currently, he is engaged in a large research program aimed at identifying genes that put people at risk for coronary artery disease. "This stuff was of pure scientific interest when I started out," he says. "Now it is part of everyday practice, and it makes a huge difference to patients in terms of diagnosis, prevention, and treatment."

Still, the transition from older methods will take time. Many doctors struggle to keep up with the fast-evolving state of the art. Challenges in key areas like data-sharing have technological fixes, but cultural issues persist. Yet Dr. Figueredo is optimistic about the progress of personalized medicine. "So many things that are just starting to happen now will be in common use within a decade."

Building a new branch of medicine

Real-world advances in personalized medicine can feel like science fiction—but making them viable and scalable takes work, and sophisticated science and new treatments are just part of the equation. For personalized medicine to thrive, organizations need to take a tactical approach to its development. They must figure out the basic economic framework and funding flows, adapt to an emerging regulatory structure that reflects the realities of this new approach, and navigate cultural issues around patient empowerment, institutional cooperation, and privacy.

Solving these problems requires investment from both government and private institutions, but even blue-chip organizations may find themselves scrambling for funds. At Partners HealthCare, the healthcare system that includes top-rated Massachusetts General Hospital, resources are cobbled together from a variety of sources. "We have a small annual budget from Partners," says Scott Weiss, MD, the unit's Scientific Director. "We've got several federal grant funds that we're using to help develop the infrastructure. We occasionally get a project with industry. We utilize all these different sources to try to advance the mission."

The marketplace must adjust, too, because the economic value of personalized treatments may not fit conventional models. Over two-thirds of survey respondents expect changing payment models to have an impact on their organization in two years, up from 48% today. While the nature of this impact remains uncertain, there is some optimism about its direction, says Joachim Reischl, PhD, vice president and head of policy, portfolio, and externalization for AstraZeneca's personalized healthcare and biomarkers function. "We've heard from payer representatives that they welcome this approach, as it helps them to improve management of their healthcare resources and avoid waste."

Getting the numbers right means more than some spreadsheet exercises: It requires fresh thinking on assessing the value of innovation.

Getting the numbers right means more than some spreadsheet exercises: It requires fresh thinking on assessing the value of innovation. This new mind set might take a more systemic view of economic benefits rather than looking at a P&L statement for a given product in isolation. This broader approach includes the risk/benefit profile of each treatment, the waste and adverse events avoided, and the consequences of more effective resource allocation.

AstraZeneca retools the development process

AstraZeneca is updating its drug-discovery and -development processes for the era of personalized medicine. The $25 billion pharmaceutical and biologics firm now uses biomarkers—biological characteristics that indicate an illness or condition—to identify subsets of patient populations before it begins to develop treatments, and about 80% of its clinical pipeline aligns with a personalized healthcare approach.

"The focus on selecting the right patients throughout clinical development is an integral part of how we work," says Dr. Joachim Reischl, vice president and head of policy, portfolio, and externalization for the company's personalized healthcare and biomarkers group. "An increasing number of AstraZeneca's medicines in the future will be linked to companion diagnostic tests."

In addition, the availability of new diagnostic technologies such as next-generation sequencing is leading to new clinical trial designs, including so-called "basket trials" that work on the assumption that a given biomarker indicates a particular response to treatment. "Basket trials use a single diagnostic test from each patient's tumor sample to create a molecular profile. This extensive profile is then used to assign patients to the targeted therapy most closely matched to their individual biological characteristics," says Dr. Reischl. "By using genomic profiling, basket trials are redefining information-sharing, providing better access to drugs for patients and better patient recruitment for researchers—requiring less time and investment before investigational drugs can be tested."

Dr. Reischl emphasizes that personalized medicine is in its early days. "We are only seeing the tip of the iceberg," he says. But AstraZeneca is thinking big. "We can fundamentally change the way we run healthcare systems and, consequently, shift the economics of healthcare systems."

A changing approach to regulation and privacy

Personalized medicine requires new infrastructure, support systems, and governance. At a basic level, this can mean creating facilities like biobanks that support specialized work in genetic research. "You need to have the availability of tissue samples or blood samples or serum samples or whatever is available so that researchers can identify mutations and then use that information to help develop diagnostic tests to detect diseases earlier, to develop new drugs," says Catherine Seiler, PhD, Program Manager for the Biobank Core Facility at St. Joseph's Hospital and Barrow Neurological Institute in Phoenix.

Regulators are struggling to keep up. Dr. Catherine Seiler calls the proposed new version of US policies "one of the most convoluted sets of regulations I have ever read."

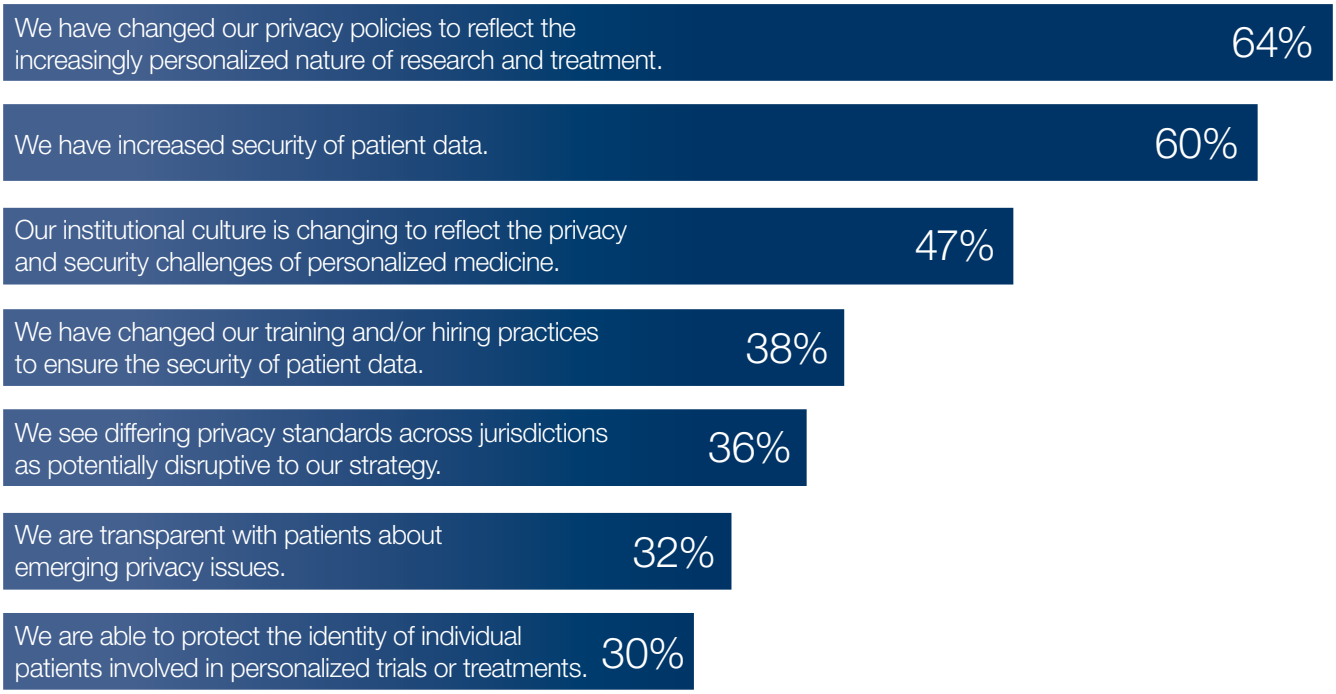
Catherine Seiler, PhD, Program Manager for the Biobank Core Facility at St. Joseph's Hospital and Barrow Neurological Institute

The way these samples must be handled illustrates some of the governance issues raised by personalized medicine. There are new angles on privacy when genetic information makes it possible to identify patients directly from their tissue samples. And new ways of using data must conform to rules set by bodies like the extremely powerful US Centers for Medicare & Medicaid Services (CMS), while also complying with privacy laws that can vary by jurisdiction. Regulators are struggling to keep up. Dr. Seiler calls the proposed new version of US policies governing research on human subjects, known as the Common Rule, "one of the most convoluted sets of regulations I have ever read."

While institutions are addressing the issues at a high level, their ability to actually protect sensitive patient information and communicate the new realities to patients remains limited. Less than one-third of respondents say they are able to protect the identity of individual patients in personalized trials—a critical element in building confidence among participants.

Fig. 6: Privacy policies are changing, but execution is still catching up

Please rate your agreement with the following statements about privacy and security. *"Agree" and "Strongly agree" responses*



The ways the rules themselves are made must change, too. "We need both international and local regulatory systems that are applied pragmatically to evaluate personalized therapies, biomarkers, and linked diagnostics," says Dr. Reischl. "Our experience is that regulatory agencies are very much engaged, and regulations are starting to follow the emerging science. In order to accelerate innovation and ensure patients receive effective treatments in the timeliest, most efficient manner possible, we need to collaborate with regulators more effectively than ever before."

Culture and cooperation

Personalized medicine implicates and empowers the patient in new ways. There is an unprecedented level of patient involvement, reflecting the great value of personal data and increased interaction in all phases of the process. Creating a one-time consent mechanism that is sharable across institutions is critical to avoiding delays and complexity along the way. Yet the role of the patient in data sharing remains unsettled; in late February, President Obama addressed the uncertainty at a forum related to his Precision Medicine Initiative, saying, "I would like to think that if somebody does a test on me or my genes, that that's mine, but that's not always how we define these issues."

The huge amounts of data required to make personalized medicine a reality are more than any single institution can generate. "100,000 patients is a lot by some measures, but for Big Data, for genomics, and trying to detect specific mutations so you can bring a specific treatment to a patient, 100,000 is not enough. It's very small," says Dr. Sotomayor. The solution: "We need to share data; otherwise we are going to take decades to conquer cancer. I strongly believe that you need to share Big Data in order to make significant advances in the biology and the treatment of cancer patients."

"We need to share data; otherwise we are going to take decades to conquer cancer. You need to share Big Data in order to make significant advances."

Eduardo M. Sotomayor, MD, director of the George Washington University Cancer Center in Washington, DC

There are notable examples of successful data sharing, including programs like The Cancer Genome Atlas Project and the Oncology Research Information Exchange Network (ORIEN). But sharing is not always easy. "There is a lot of pushback from major institutions, because they say, 'well, our research scientists don't want to share their data,'" says Dr. Sotomayor. That could mean only certain types of data, say from a clinical angle, are shared. In fact, changing the culture around data sharing remains one of the most daunting challenges in personalized medicine.

IT and talent demands

Information technology is a critical component of personalized medicine. The volume of data to be shared means old mechanisms of capturing, storing, and analyzing it are no longer adequate. "What is extremely important is to have unified data collection. That's a major obstacle," says Dr. Sotomayor. "Right now we have silos. Each silo has its own data and each silo is using different software."

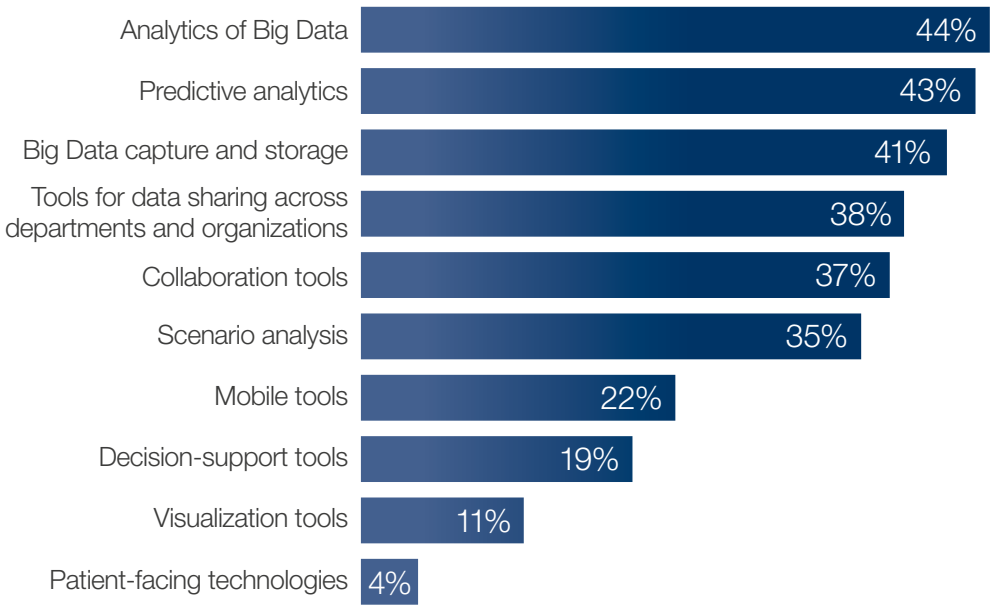
Getting multiple systems to work together is critical. For example, electronic medical records (EMR) may need to interact with databases of genetic information, creating an integration challenge that pushes IT departments to find solutions. Dr. Seiler has been working with IT staff as they create an enterprise data warehouse that allows easy extraction and sharing of valuable information with the biobank's customers.

But many organizations have more information than they can effectively use. A recent *New York Times* article told the story of a breast cancer patient who visited two North Carolina medical centers but found herself frustrated by their inability to determine which of the genetic factors identified were driving her illness, and which were incidental. And without the ability to make meaning from complex data sets, even potential breakthroughs do little to help patients—creating stress for people who need it least.

Big Data analysis is critical to the development of personalized medicine. Partners HealthCare is creating data-sharing and integration tools that pull information from its various hospitals and inform researchers as they attempt to solve big problems like heart disease and diabetes. Other healthcare organizations have a similar focus on analytics—Big Data analytics, capture, and storage are top areas of investment for the next two years. Tools that will take the process one step further—like data-sharing and collaboration technologies—are the next area of focus.

Fig. 7: Big Data drives personalized medicine

Which of the following technologies will receive the greatest level of investment over the next two years? *Select up to 3*



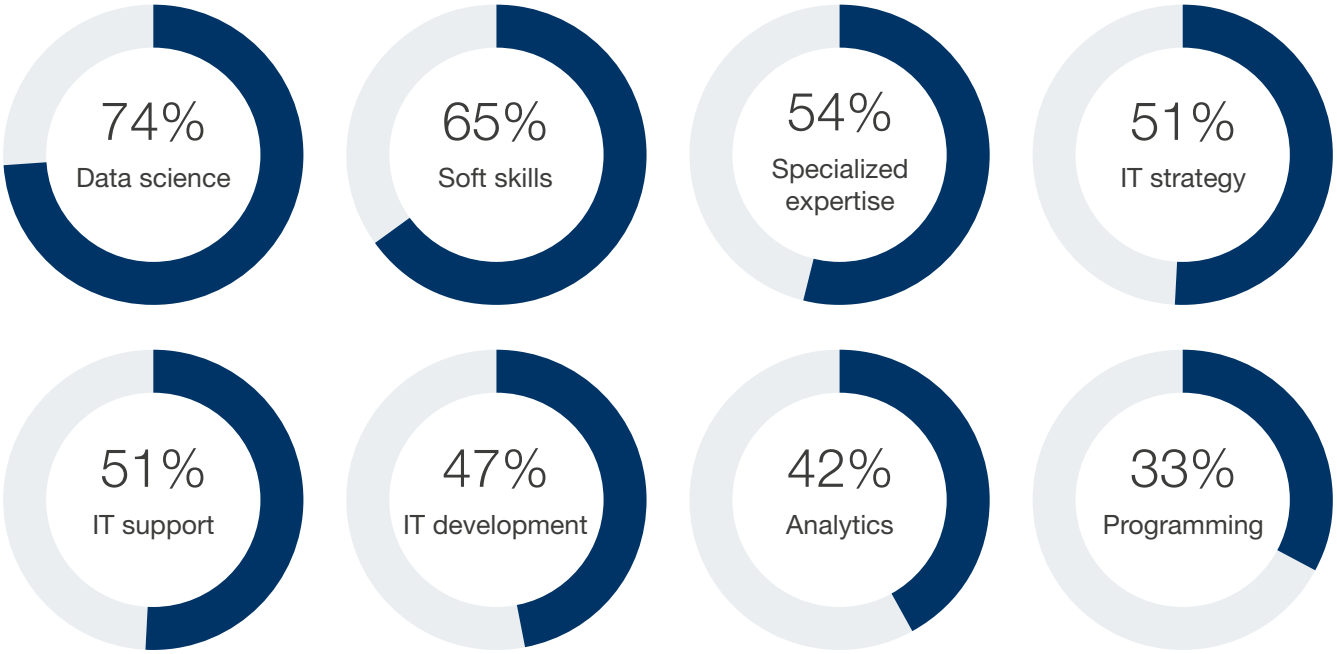
And the innovations keep on coming. Dr. Seiler cites the value of artificial intelligence (AI) applications, which can analyze huge volumes of disparate data quickly and cut diagnosis times dramatically. But she is concerned about cost. "It's very exciting, but extremely expensive," she says. "It involves an enormous amount of buy-in, both financially and also time-wise, to implement it, but the potential outcomes are phenomenal."

None of these changes can be made effectively without the right talent. This includes high-end skilled workers, such as bio-informaticians, computational biologists, and biostatisticians. "I think institutions that have a strong presence in those areas are going to be able to deliver personalized care faster," says Dr. Sotomayor. "If someone asked me about job security, I would say, 'study computation systems or bioinformatics, because those guys are in demand.'"

But our survey shows the need for basic IT skills is strong, too. Well under half of respondents say they have the analytics skills they need, and only one-third have the necessary programmers.

Fig. 8: Worker bees wanted

To what extent does your organization have the talent and skills needed to develop and sustain personalized medicine research and practice? *"Mostly equipped" and "Fully equipped" responses*



Big-name, urban health systems may have access to the talent they need, but competition will be tougher for health systems and labs in less glamorous locations.

And while big-name, urban health systems—like Boston-based Partners—may have access to the talent they need, competition will be tougher for health systems and labs in less glamorous locations. Yet most organizations are not taking the necessary steps to fill these gaps; most strategies are minor or short term, with few taking action at the scale needed to reach the required talent pool.

Partners builds around personalized medicine

Partners Healthcare boasts one of the more impressive portfolios in American medicine, but the 12-hospital system (which includes big names like Massachusetts General Hospital and The Brigham and Women's Hospital) created a distinct entity to drive its precision-medicine agenda. "It's still relatively small," says Scott Weiss, MD, Scientific Director of Partners HealthCare Personalized Medicine, although with more than 100 employees at two locations, a group of core laboratories, and an annual grant budget of over $10 million, it is a substantial player in the emerging field.

The center leverages its relationship to Partners and its location in talent-rich Boston to meet critical technology needs. "IT is everything when it comes to personalized medicine, genetics, and genomics," says Dr. Weiss. The parent organization has more than 10,000 IT employees, many involved in a massive transition to a new electronic medical records system that will allow easier information-sharing among hospitals. A new research portal allows investigators to analyze patient samples from an in-house biobank, while another tool aggregates patient data from multiple hospitals; analytics that link these two resources allow Dr. Weiss' team, and all Partners investigators, to look into high-cost problems like diabetes management or heart failure.

But all that data presents a challenge. "We're drinking from the firehose," says Dr. Weiss. "There's only so much you can do every day." Privacy rules and other regulations add to the complexity of the work, especially as the system experiments with new ways to capitalize on patient data captured across its hospitals. "Our patients are concerned that they are going to be discriminated against on the basis of having some particular genetic constitution," says Dr. Weiss. Communication with these newly empowered patients is critical. "Telling them what we do to protect them, both clinically and from a research perspective, seems to help put their minds at ease."

Calls to action

The shift to personalized medicine is changing the healthcare experience. More than ever before, every aspect of disease prevention, diagnosis, and treatment depends on having the technology and scientific framework to tailor care to individual patients using clinical data and genomic information.

But getting personalized medicine right depends on more than just science and technology. Healthcare organizations must:

- Increase collaboration among physicians, researchers, and pharmaceuticals companies.
- Develop strategies to deal with cultural shifts around data sharing, whether among healthcare organizations or between patients and their doctors.
- Emphasize patient involvement throughout each step of the treatment process, as their data and feedback will be essential to individualized care.
- Prepare for regulatory changes and shifts in workforce skills.

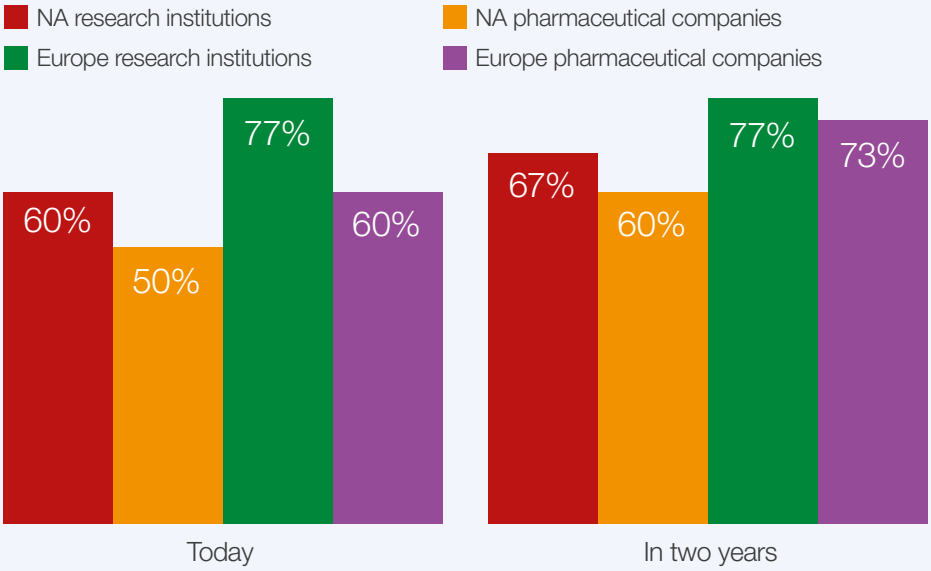
Regional and sector variations

Enthusiasm for personalized medicine is strong among research institutions and pharmaceuticals companies across our surveyed geography, but European institutions tend to be ahead of their North American peers in the development and commercialization of personalized medicine.

European respondents are more likely to say personalized medicine is having an impact on their organizations, both today (68%, vs. 55% of North Americans) and in two years (75% vs. 63%). They are also more likely to say personalized medicine programs at their organization are having a positive impact on patient or project volume.

Fig. 9: Personalized medicine an area of emphasis in Europe

To what extent will personalized medicine have an impact on your organization, today and in two years? *"Significant impact" and "Very significant impact" responses*



European institutions are more likely to have developed specific strategies to deal with the changes associated with this shift to personalized medicine. Both research institutions and pharmaceuticals companies are more likely than their peers in North America to say they have changed privacy policies to match the increasingly personalized nature of research and treatment. European institutions are better prepared for local and regional regulation: research organizations in Europe are more likely to have a strategy to address changing regulatory standards; European pharma companies are more likely to have engaged with their legal teams to address these changes.

However, North American respondents are at least as advanced as European institutions when it comes to the use of technology, advanced scientific frameworks, and culture. North Americans, for example, are more confident in their strategy and culture's ability to support data sharing (62% vs. 43% of Europeans)—something that will be essential to the further development of personalized medicine in the years ahead.

OXFORD
Abbey House, 121 St Aldates
Oxford, OX1 1HB, UK
Tel: +44 1865 268900

LONDON
Broadwall House, 21 Broadwall
London, SE1 9PL, UK
Tel: +44 207 803 1400

BELFAST
Lagan House, Sackville Street
Lisburn, BT27 4AB, UK
Tel: +44 2892 635400

NEW YORK
5 Hanover Square, 19th Floor
New York, NY 10004, USA
Tel: +1 (646) 786 1879

PHILADELPHIA
303 Lancaster Avenue, Suite 2e
Wayne, PA 19087, USA
Tel: +1 (610) 995 9600

CHICAGO
980 N. Michigan Avenue, Suite 1412
Chicago, IL 60611, USA
Tel: +1 (312) 214 3545

LOS ANGELES
2110 Main Street
Santa Monica, CA 90405, USA
Tel: +1 (310) 310 4596

SINGAPORE
Singapore Land Tower, 37th Floor
50 Raffles Place
Singapore 048623
Tel: +65 6829 7068

PARIS
9 rue Huysmans
75006 Paris, France
Tel: +33 1 45 49 60 85

SYDNEY
Level 4, 95 Pitt Street
Sydney, 2000
Australia
+61 (0)2 8249 8286

email: mailbox@oxfordeconomics.com

www.oxfordeconomics.com

SAP®

OXFORD ECONOMICS