

EXPANDING PRECISION

MEDICINE

The Path to Higher-Value Care

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The transformation of health care continues at a rapid pace, bringing both opportunities and challenges when it comes to providing improved clinical outcomes at lower cost.

While progress is clearly being made, as an industry we still have a way to go before we can consistently deliver high-value medicine. Despite the tidal wave of new medical insights and digital capabilities, many health care systems still struggle to reliably offer evidence-based care. Moreover, widespread unwarranted variations in clinical practice are driving higher costs and poorer quality.

At Siemens Healthineers, we believe health care is on the cusp of realizing the benefits of precision medicine—and this has already been demonstrated by many real-world examples from across the entire health care spectrum.

Programs for reducing unwarranted variations are already enhancing care and reducing costs and waste in some organizations. New developments in analysis and detection—genomics to imaging and radiomics—are enabling better, more accurate, precise diagnostics, and with greater safety and lower expense. This is also having an impact on prevention and earlier detection, giving patients a greater chance of a healthy future. Precision medicine is already making targeted treatments possible in certain clinical conditions. All of these advances, in combination with risk prediction tools and greater personalization of therapies, will guide future medical decision making to improve clinical outcomes and avoid iatrogenic harm.

We believe personalized therapeutics will continue to make significant progress. Even today, the use of image-guided, robot-assisted, minimally invasive procedures is allowing radiation therapy and surgical treatments to be performed more safely and effectively and with faster recovery. Precision care is also impacting implants, ensuring these devices and the corresponding procedures are tailored to the needs of individuals.

In addition, the use of artificial intelligence to drive automation, analyze vast amounts of data, and optimize operations is growing rapidly—and its potential remains largely untapped.

Current and future advances in diagnostics and personalized therapies, in conjunction with powerful artificial intelligence, are the key elements to expanding precision medicine—enabling consistent delivery of high value care.



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EXPANDING PRECISION MEDICINE

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Health care providers around the globe are facing a one-two punch of increasing financial pressure and expanding medical challenges due to a wide variety of factors, including growing, aging populations and the rising cost of new pharmaceuticals and other advanced therapies. The Precision Medicine Initiative was and remains an important response to these challenges as it seeks to make medical care more precise. Now, by expanding the concept of precision medicine to include precision diagnosis and individualized therapy, health care leaders have an opportunity to simultaneously improve patient outcomes even more and mitigate the seemingly relentless cost pressures weighing on their organizations.

EXECUTIVE SUMMARY

Health care executives around the world face enormous and growing challenges as they seek to provide favorable medical outcomes for growing and aging populations—while also trying to manage the ever-escalating costs of delivering health care and responding to malpractice claims.

For some time, “precision medicine” has been seen as at least a partial solution to these problems. Although it can mean slightly different things to different people, it generally refers to tailoring patient care according to the patient’s genetic characteristics. It seeks to classify patients into groups with similar genetic makeup and, as a consequence, similar susceptibility to certain diseases or illnesses and similar responses to certain treatments.

While this narrow genetic model has sound underpinnings, it ultimately may be too limiting. By expanding its scope, health care CEOs have an opportunity not only to help their organizations deliver improved patient outcomes—delivering the right treatment to the right patient at the right time—but also to mitigate some of the terrific cost pressures hospitals and medical facilities around the globe contend with on a daily basis. Many of the tools to start doing this are already here.

EXPANDING THE
SCOPE OF PRECISION
MEDICINE CAN DELIVER
IMPROVED PATIENT
OUTCOMES AND MITIGATE
COST PRESSURES.

Expanding the precision medicine mandate will require that the medical community embrace, at scale, four pillars of care. These can be grouped into two broad categories, precision diagnosis and individualized therapy, as follows:

Precision Diagnosis

PILLAR 1

IMPROVE DIAGNOSTIC ACCURACY

Improve the accuracy of each diagnosis by treating diagnosis not as a singular event but rather as a precise and systematic process enabled by integrated imaging and laboratory results. Speed, quantification, and accuracy are critical because the diagnosis determines the subsequent path of care for each patient. Leverage technology to allow diagnoses to be made, in many cases, at the initial point of care.

PILLAR 2

REDUCE UNWARRANTED VARIATIONS IN DIAGNOSIS

Tightly align training, systems, and protocols throughout the medical community to ensure more consistent care and diagnosis, eliminating variations related to the type of imaging or testing performed, who performed it, or who read the results. The goal is to provide consistent medicine, based on evidence, for the specific medical condition of the patient.

Individualized Therapy

PILLAR 3

PERSONALIZE CARE WHEN IT MATTERS

Move beyond treating patients based on which genetic subgroups they fall into and treat them instead as distinct individuals, taking full advantage of our understanding of each patient's unique genetic and metabolic makeup—along with the images and lab test results collected over the course of a patient's treatment. This enables earlier intervention in cases involving patients who do not respond to treatment.

PILLAR 4

UTILIZE ADVANCED THERAPIES

Take advantage of robotics and advanced imaging technology to make greater use of minimally invasive procedures, especially where imaging can be deployed in real time to guide the procedure and thereby optimize its effectiveness, minimize errors, and reduce costs.

By committing to expanding the concept of precision medicine in this fashion, health care providers have a real opportunity to resolve their biggest challenges.

INTRODUCTION

Why Medicine Needs to Become More Precise

Although medical advances have extended lives and improved the quality of patients' lives, actual medical practice too often remains inconsistent and imprecise. Unwarranted variations in medical care—differences in treatment that are not medically justified—put a significant number of people at unnecessary risk and add to the cost of medical care. Consider angioplasties for coronary heart disease, in which doctors insert a catheter into an artery to diagnose and remove blockages, often followed by the placement of a stent to keep the artery open. A study by *U.S. News & World Report* found that the percentage of Medicare beneficiaries undergoing the procedure in the U.S. was as much as 4.5 times higher in some parts of the country than others, suggesting that not all such procedures are explained by medical need.¹ That's bad for patients, given that angioplasty, like most other invasive medical procedures, carries risks.

It's bad for costs, too. When patients receive ineffective or unnecessary treatment, or when

effective treatment is delayed, not only is their health compromised but their use of health care services increases. A 2013 article in *Translational Psychiatry* found that patients with depression or anxiety who were treated with a suboptimal medication had 69% more total health care visits than those who received an optimal medication. These patients also had more than three times as many sick days and a fourfold increase in disability claims. Similar bad outcomes and increased costs can result from the delayed diagnosis or misdiagnosis of pneumonia, flu, hepatitis, and many other common maladies.

Such problems aren't confined to conventional courses of therapy. Harvard Business School professor Clayton M. Christensen and venture capitalist Spencer Nam, a senior research fellow at the Clayton Christensen Institute, a nonpartisan think tank, argue that poor diagnostic capabilities cause large numbers of people to pass through clinical trials for drugs aimed at diseases they don't even have, leading efficacy outcomes to top out around 35%. While the cost of developing new drugs is certainly high—more than \$1 billion per

compound—they write, “the cost of wasted drugs might be even greater.” Put another way, the cost to the health care system of providing drugs that are wasted due to an incorrect diagnosis may be even greater than the cost of developing drugs.

What Can Be Done: The Four Pillars of Expanding Precision Medicine

The precision medicine initiative is widely viewed as a way to improve health care by diagnosing and treating patients based on their genetic characteristics. But some in the medical community believe that definition to be too narrow. “While precision medicine can be seen by some people as genomics-guided treatment, I think this definition is too limiting,” says Dr. Larry Chu, a Stanford professor who advised President Barack Obama on the Precision Medicine Initiative announced in 2015. “It is indeed a much broader definition than that. I think precision medicine means precisely diagnosing conditions, then integrating all relevant patient data and insights to guide care to the best outcomes. It is about providing the right treatment to the right patient at the right time.”

Expanding precision medicine to this degree, and empowering its adoption at scale around the world, will require that health care providers everywhere embrace four key pillars of care that can be grouped into two broad categories: precision diagnosis and individualized therapy.

Precision diagnosis involves making medical diagnoses more accurate (pillar 1), and eliminating unwarranted variations due to factors that should play no role in a diagnosis—the location of diagnostic testing, for example, or the experience of the person conducting the test or analyzing its results (pillar 2).

Individualized therapy begins by tailoring treatment to the patient by taking into account their unique phenotypic and genetic makeup and characteristics (pillar 3), and leveraging the latest technologies, including imaging technologies, to maximize the effectiveness of their treatment, minimize mistakes, and reduce costs (pillar 4).

Some of the tools and resources to do this are already available, and others are being developed. Part of this is due to the advent of big data.

The quantity, quality, and relevance of patient information that’s being collected today—and the promise of more tomorrow—will be increasingly critical to improving precision in medical diagnosis and treatment. In time, by applying deep learning and other artificial intelligence techniques to big data, the medical community will have a much-improved opportunity to:

- Determine optimal therapeutics based on an individual’s phenotype, disease subtype, or tumor signature, so that the most effective therapy is administered without delay.
- Identify disease subtypes and determine which drugs work best for each.
- Use predictive analytics to identify risk of disease onset or progression, creating an opportunity to intervene earlier and more effectively and perhaps prevent the disease from progressing.
- Reveal new uses for existing compounds.

The power of these opportunities derives in the end, of course, from data, and specifically from its curation and actionable analysis. Some of this data resides in the growing storehouse of patient information captured in still relatively new electronic medical records. Using this resource, Dr. Atul Butte, director of the Institute for Computational Health Sciences at the University of San Francisco, has already begun to create a database of clinical data across the entire University of California health system to start learning more about what’s working and what’s not in health care. Meanwhile, the National Institutes of Health’s All of Us Research Program, originally launched as the Precision Medicine Initiative by President Barack Obama in 2015, is seeking to gather data—considering individual differences in lifestyle, environment, and biology—from a million American volunteers. The goal for the 10-year project is to accelerate research that will enable the individualized prevention and treatment of disease. Recruiting of volunteers began in March 2018. Meanwhile, a number of U.S. companies in the health care industry, including biotech firm Regeneron and health care providers Geisinger and Kaiser Permanente, have opted to undertake similar initiatives on their own. Europe is home to still more such undertakings, such as the U.K. Biobank study to understand more about the role of imaging, genetics, and the environment in the development of disease, and the Study of Health in Pomerania (SHIP) in Germany.

Big data initiatives such as these—and the technology that’s now available to analyze big data—are giving medical researchers today the ability to uncover connections and patterns in data that would not be obvious if data sets

THE POWER OF THESE OPPORTUNITIES DERIVES FROM DATA, AND SPECIFICALLY FROM ITS CURATION AND ACTIONABLE ANALYSIS.

were smaller and studied by human brainpower alone. “Medicine can now look to piles of data to identify what molecular or genetic signatures lie underneath a person’s condition or constellation of symptoms,” says Susan Dentzer, president and CEO of the Network for Excellence in Healthcare Innovation and a former Robert Wood Johnson Fellow. She notes, by way of example, that there is now an increasing suspicion that type 2 diabetes is not one type of disease, but a collection of different subtypes. Knowing this allows doctors to address different subtypes in specific ways to improve the effectiveness of treatment and to reduce costs by avoiding complications.

Artificial intelligence offers the promise of making medical care more precise and more scientific, too, in part by further enabling rules-based diagnosis and treatment planning. The hope is that in the near future, diseases will be precisely diagnosed based on the integration of all relevant patient data and insights at the point of decision. Provision of care will be rules-based, and therapy will be tailored to every individual based on their unique characteristics or the unique characteristics of their disease—again, resulting in the right treatment for the right patient at the right time.

Let’s take a closer look at how CEOs of health care organizations can leverage the four pillars of care to expand precision medicine, and to address the twin challenges of improving patient outcomes while managing costs.

PILLAR 1

Improve Diagnostic Accuracy

Delivering the right treatment at the right time requires an accurate diagnosis. Making that diagnosis—traditionally a combination of art, intuition, and exclusion of differential conditions—can be a long and complex undertaking, during which the patient waits for the initiation of an effective treatment plan. Mistakes along the way are not uncommon. In its 2015 report “Improving Diagnosis in Health Care,” the National Institute of Medicine found that diagnostic errors affected 5% of U.S. adults who received outpatient care the prior year, contributed to about 10% of patient deaths,

and accounted for as many as 17% of adverse events in hospitals. They imposed additional costs, too, in the form of malpractice claims.

In many ways, advances in diagnostic arts have trailed the overall pace of medical discovery as individual clinicians have been challenged to keep abreast of the latest findings on disease prevention and treatment while also striving to overcome ingrained clinical practices, cognitive biases, and the limits of the human mind. Beyond the more common and usual diseases, there are more than 6,000 rare diseases, helping to explain why no single physician is able to have a firm grasp on all of them (although a database can).

Another major complicating factor: Not all patients get the same result from the same treatment. Only 25% to 60% of individuals respond favorably to prescribed medication, for example. In fact, even when the same dose of a medicine is administered to two people of the same weight, drug levels in their plasma can vary more than a thousandfold. An unfavorable response to medication can range from a failure to respond, to bothersome side effects, to an adverse drug reaction (ADR). In the U.S., ADRs kill about 120,000 individuals per year, underlie approximately 5% of hospital admissions, and exact about \$30 billion annually in health care costs.

To help make accurate diagnosis at an early stage of disease, physicians can take advantage of a wide range of advanced technologies that can yield higher-quality laboratory and imaging results than were previously available, which in turn can yield rich patient insights at the point of decision. They also can take a more global approach to diagnosing, drawing not just on their own medical training and experience but also on big data in appropriate settings. The opportunities to improve care this way are boundless. Here are just a few concrete examples:

Diagnose small lesions in the brain that previously might have gone undetected. New, higher-powered magnetic resonance imaging (MRI) scanners can deliver more than twice the magnetic field strength of traditional scanners,

Artificial intelligence offers the promise of making medical care more precise and more scientific, too, in part by further enabling **rules-based diagnosis** and treatment planning.

and as a result can provide higher-resolution images of the brain and other organs and tissues. This can support doctors as they uncover, among other things, smaller lesions on the brain that may be related to multiple sclerosis or contributing to seizures—lesions that in the past may have gone undiagnosed and so untreated. Dr. Meng Law, professor of radiology at the University of Southern California’s Keck School of Medicine, is using the first high-powered “7T” MRI scanner approved for clinical applications in the U.S.. Recently, it allowed doctors at USC to discover—and later remove—a small tumor in the pituitary gland of a 27-year-old woman with Cushing’s disease and multiple adverse symptoms, including weight gain, hair loss, and an inability to menstruate. The tumor had gone undetected by standard 1.5T and 3T MRI machines. (The “T” stands for Tesla, a unit of measure that quantifies the strength of a magnetic field.) “It changed her entire life,” Law says. “Having been able to see the small tumor at 7T, we were able to offer surgery, and now she’s cured.” Law adds that since the installation of the machine his department has “had inquiries from all over California, and elsewhere, asking whether they can send patients to us to have them scanned here.”*

Diagnose candidates for implantable defibrillators. Today, due to imprecise diagnoses, both too many and too few defibrillators are implanted. (Too many, because imprecise diagnoses mean that 80% or more of those who have them don’t benefit, and too few because many who don’t get them could benefit.) This could be resolved with more precise selection of patients at risk for sudden cardiac arrest using diagnostic algorithms on blood tests and imaging—and by using other new digital analysis tools, including imaging and post-processing software. Antonio Berruezo, M.D., Ph.D., has seen this firsthand.

“In the Clinic Hospital, Barcelona, we implemented new clinical pathways resulting in more precise selection of patients at risk, by integrating an improved characterization of the patient using a combination of imaging and post-processing analysis,” Berruezo says. “This more precise diagnosis and additional individualization of treatment allowed us to expect an estimated 39% mortality reduction in patients who were under-protected due to misclassification by routine clinical protocol, and to expect a 70% reduction in the number of unneeded and expensive implantable devices.”

THERE ARE BIG STRIDES TO BE MADE IN DIAGNOSTICS BY QUANTIFYING THE RESULTS OF VISUAL IMAGES, INCLUDING CT, PET, AND MRI SCANS.

Remake radiology into a quantitative discipline supported by statistical methods and artificial intelligence, promising a whole new level of individualized diagnostics. The goal is to develop large amounts of quantitative data from medical images using data-characterization algorithms—part of what Stefan Oswald Schönberg, managing director of the Institute for Clinical Radiology and Nuclear Medicine at University Hospital Mannheim, Germany, calls a “mathematical revolution in radiology.” In lay terms, there are big strides to be made in diagnostics by quantifying the results of visual images, including CT, PET, and MRI scans. Quantifying images this way can help doctors reduce variations in diagnosis.

Rich insights drawn from imaging, including multiparametric MRI. Multiparametric MRI, or mpMRI, can save money in comparison to standard transrectal ultrasonography-guided biopsies. In the U.K., mpMRI scans are already being rolled out across the National Health Service (NHS), which is expected to dramatically reduce the incidence of unnecessary biopsies.

Expand the use of pharmacogenomics. Pharmacogenomics—the study of how a person’s genes affect drug response—has increased the precision of pharmaceutical treatment. “It allows the clinician to find the right therapy at the right dose for the right person, speeding the delivery of effective therapy and avoiding ADRs,” says David Parker, senior vice president of diagnostics solutions at Precision for Medicine, part of Precision Medicine Group. “It also boosts patient adherence to treatment. We know that patients often don’t take their medications as prescribed. But when a patient knows that a test indicates in advance that a drug will be effective, they’re more likely to believe it works, fill their prescription, find a way to pay for the drug, and so forth. And if it takes some time to show clinical effect, they’re more willing to stick with therapy.”

* The statements by HC professionals described herein are based on results that were achieved in their unique setting. Because there is no “typical” hospital or laboratory and many variables exist (e.g., hospital size, samples mix, case mix, level of IT and/or automation adoption) there can be no guarantee that other customers will achieve the same results.

EXPANDING PRECISION MEDICINE DEPENDS IN PART ON MAKING SURE THAT DIAGNOSES ARE ACCURATE.

Leverage the power of artificial intelligence.

Deep learning and other artificial intelligence technologies can improve diagnostic accuracy using vast sets of data that would be too unwieldy for humans. To cite just one example, physicians today can make greater use of artificial intelligence-aided phenotyping. Phenotyping uses imaging and other modalities to pinpoint biomarkers that define subgroups of patients or disease states, so that more efficacious therapies can be identified, prescribed, and delivered for diseases ranging from Alzheimer's to cancer.

In summary, more accurate and precise diagnosis of disease is necessary so that health care providers can prescribe the most effective therapy. An individual patient's own data, including diagnostic test results and medical history, combined with insights gleaned from multiple other patients, can inform health care providers in developing targeted treatment and prevention plans, benefiting patients and the health system alike.

PILLAR 2

Reduce Unwarranted Variations in Diagnosis

As we've just seen, expanding precision medicine depends in part on making sure that diagnoses are accurate. More than that, though, it requires that they be accurate each and every time—no matter

REMOVING UNWARRANTED VARIATIONS IN CARE AS WELL AS DIAGNOSIS

In addition to working to eliminate unwarranted variations in diagnosing illnesses, the medical community will also want to take measures to avoid unwarranted variations in care even after an accurate diagnosis is made. The Dartmouth Atlas identifies effective care as "evidence-based interventions for which the benefits so far exceed the harms that all patients in need should receive the service." It cites as an example the provision of lifesaving drugs following heart attacks. There is simply no excuse, it suggests, for "variations in the use of such treatments among eligible patients." It assails the "irrational distribution of valuable and expensive health care resources" by geographical region, and argues that "better planning of future growth in capacity can help build a more effective and affordable health care system."¹²

who is doing the testing and diagnostics, no matter how much experience they have, no matter where the testing is being done, and no matter who is reading the test.

Until now, this sort of consistency—this sort of precision—has been little more than a pipe dream:

- In the U.K., the 2017 diagnostic Atlas of Variation for England found a ninefold variation in the achievement of brain imaging for stroke patients within an hour of arrival at the hospital—resulting in a significant impact on their outcomes.
- In the U.S., the Dartmouth Atlas of Health Care has found a more than twofold variation in per capita Medicare spending across the country, with the differentiator identified not as the price of health care but its utilization.²
- At least three groups—the New England Healthcare Institute, management consultants McKinsey & Co., and media and information firm Thomson Reuters—have concluded that 30% of U.S. spending on health care is unnecessary.³

What's all this costing us? Suboptimal patient outcomes, for starters. In its 2009 Atlas of Variation, the U.K.'s NHS found "huge and unwarranted variation" in the access to, quality of, outcomes from, and value of health care in Great Britain. All this, it said, resulted in wasteful overuse of health care resources and incidents of harm to patients—even where the quality of care was high—as well as underuse of health care that led to failures to prevent disease and inequitable treatment of patients.⁴ In the U.S., the Advisory Board, a research and consulting organization, has concluded that unwarranted care variation exists within most of the country's provider organizations, representing "a \$20 million-\$30 million (per \$1 billion in revenue) actionable savings opportunity for a typical organization."⁵

It was in response to findings such as these that the U.K.'s NHS launched an initiative called "Right Care," led by professor Matthew Cripps, which seeks to reduce unwarranted variations in all British hospitals. Cripps identifies unwarranted variations in health care as "the things we do to our patients that can't be explained by demography, illness, or best practice evidence-based medicine." His Right Care initiative argues that eliminating those variations could lead to remarkable improvements in the cost and quality of care. For example:

- The Right Care initiative concluded in 2018 that early detection of chronic obstructive pulmonary disease (COPD) with accurate diagnosis, combined with optimal long-term care, could

identify 210,000 more COPD patients in the U.K., save £49 million, and save 1,400 more lives. These figures assume that each of the 211 clinical commissioning groups (CCGs) across the U.K. could begin operating as effectively as their five best-performing peers.⁶

- Right Care also concluded that with similar improvements the country could admit 3,800 more stroke patients to acute stroke units, save £51 million in emergency admissions, and save more than 600 lives.⁷

What's needed to eliminate unwarranted variations in diagnosis, though? Diagnostic consistency, many experts believe, is possible through standardization, adaptation to the patient, automation (powered, in some instances, by artificial intelligence), providing physicians with assistance in their decision making, and integrating technology into the diagnosis process. **FIGURE 1** Specifically, it requires changes to clinical practice and the adoption of specific technology enablers, such as sophisticated imaging tools that automatically adjust for the patient's unique characteristics, thereby allowing for the consistent delivery of high-quality images regardless of who the patient is. All this personalizes examinations by removing unwarranted variations.

We already have proof points on how this can work. Mercy Health in St. Louis, to cite just one example, was able to improve its patient outcomes on total knee replacement after analyzing a wide variety of data associated with the procedure,

THE RIGHT CARE INITIATIVE ARGUES THAT ELIMINATING VARIATIONS IN DIAGNOSIS COULD LEAD TO REMARKABLE IMPROVEMENTS IN THE COST AND QUALITY OF CARE.

including medications, surgical practices, implants, and adherence to defined pathways. A surprising finding was that patients with the shortest length of stay had all taken pregabalin, a drug generally prescribed for shingles. It turned out that several of its surgeons had seen in the medical literature that administering this agent prior to surgery would result in better pain management post-op, lessening the need for opioids and hastening the time it took for patients to become ambulatory again. After sharing this information with the rest of its surgeons, the hospital was able to refine its clinical pathway for the procedure, improving patient outcomes—including reducing length of stay—and saving more than \$1 million per year in direct costs.

PILLAR 3

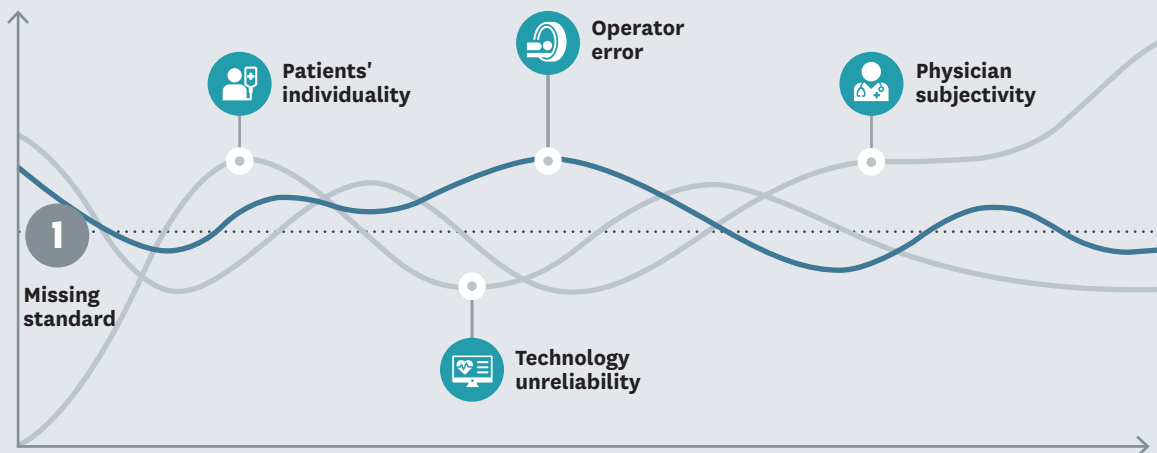
Personalize Care When It Matters

For optimal effectiveness, medical treatment must be tailored to the characteristics of both the patient and the disease. Today, this sort of customization is increasingly possible thanks to advances in

FIGURE 1

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MULTIPLE FACTORS CONTRIBUTE TO UNWARRANTED VARIATIONS IN CARE



FIVE STEPS TO DIAGNOSTIC CONSISTENCY

#1

Set Standards and Monitor Adherence

- Make variations transparent
- Decide on standards
- Make standards actionable and monitor adherence
- Innovate continuously to set new standards

#2

Adapt to Patient

- “Embrace human diversity”
- Control variation by adapting with technology to patient’s individuality



#3

Automate Workflow of Operator

- Remove human variations
- Automate test preparation
- Guide test execution



#4

Assist Decision Making of Physician

- Reduce subjectivity in decision making
- Assist operational decisions
- Assist clinical decisions



#5

Integration and Surveillance of Technology

- Utilize IT integration
- Manage fleets of equipment



genomics, proteomics, and metabolomics—and to the advent of big data and the tools to process it. Big data and modern data analytics systems can extract insights from massive amounts of diagnostic, treatment, and outcomes data—as well as data from the patient’s own medical history—that physicians could seldom uncover on their own. This is allowing medicine to come closer to the goal of delivering the ultimate in high-value, patient-centered care by enabling the right treatment to be given to the right patient at the right time. It is empowering patients, who, when they know their treatment has been chosen with precision, are more likely to engage in and comply with their treatment plan.

Blood transfusions represent an early example of personalized care; patients have long received different blood supplies depending upon their blood type. Now, it’s possible to individualize a wide range of additional therapies thanks to innovative technologies driven, in some instances, by the application of artificial intelligence. Examples include:

Radiation therapy planning. High-quality imaging technologies paired with advanced software now allow every radiation patient to receive a personalized radiation therapy plan based on their own anatomic and functional imaging profile.

Pharmaceutical therapies targeted using genetic markers. Women with breast cancers, to cite just one example, can now be tested for the presence of the growth-promoting protein HER2/neu (also known simply as HER2). Doctors know that HER2-positive cancers are more likely to benefit from treatment with drugs that target that protein.⁸

Companion diagnostics. Companion diagnostics are tests designed to show which patients could be helped by a particular drug and which are unlikely to be helped or even harmed. For example, a given drug might help people with specific gene mutations, but not those without it. In the U.S., the Food and Drug Administration now requires a companion diagnostic test for drugs designed to work on a specific genetic or biological target that is typically present in only some people.⁹ As early example also the previously mentioned testing for HER2 can serve: the breast cancer drug Herceptin can shut down the HER2 protein and help stop the spread of cancer cells.¹⁰

Radiomics. Radiomics refers to injecting quantitative discipline into radiology using statistical methods and artificial intelligence. Consider tumor clusters, which often share a high level of genetic heterogeneity with various tumor cell lines that can vary in their aggressiveness and their response to treatment. Their composition can be a decisive factor in the success of treatment. Radiomics, observes Stefan Oswald Schönberg, can give doctors a precise image of these clusters through quantitative analyses of imaging information, along with artificial intelligence-based interpretations of clinical, genetic, and imaging data. This allows doctors to tailor treatment more precisely to individual patients.¹¹

Liquid biopsy. In oncology, liquid biopsy and further genomic analysis now allows for identifying the genomic makeup of circulating DNA or cancer cells, which can help in identifying the right treatment for the patient—including cases where a tumor biopsy is not feasible.

Surgeries empowered by image guidance allow for a higher rate of accuracy, as the surgeon benefits from both **better visualization** and **greater magnification** of the patient’s organs.

All of these examples of personalized care have already entered, to varying degrees, the realm of clinical practice. The need now is to develop them at scale. They need to be embraced across the health care community.

PILLAR 4

Utilize Advanced Therapies

Medical science regularly delivers astonishing advances that further our understanding of disease and its treatment. Among the most important for expanding precision medicine are advances in image-guided therapy that allow physicians to perform minimally invasive surgeries and other procedures rather than traditional open surgeries.

Compared with traditional surgeries, minimally invasive surgeries empowered by image guidance allow for a higher rate of accuracy, as the surgeon benefits from both better visualization and greater magnification of the patient’s organs. The resulting

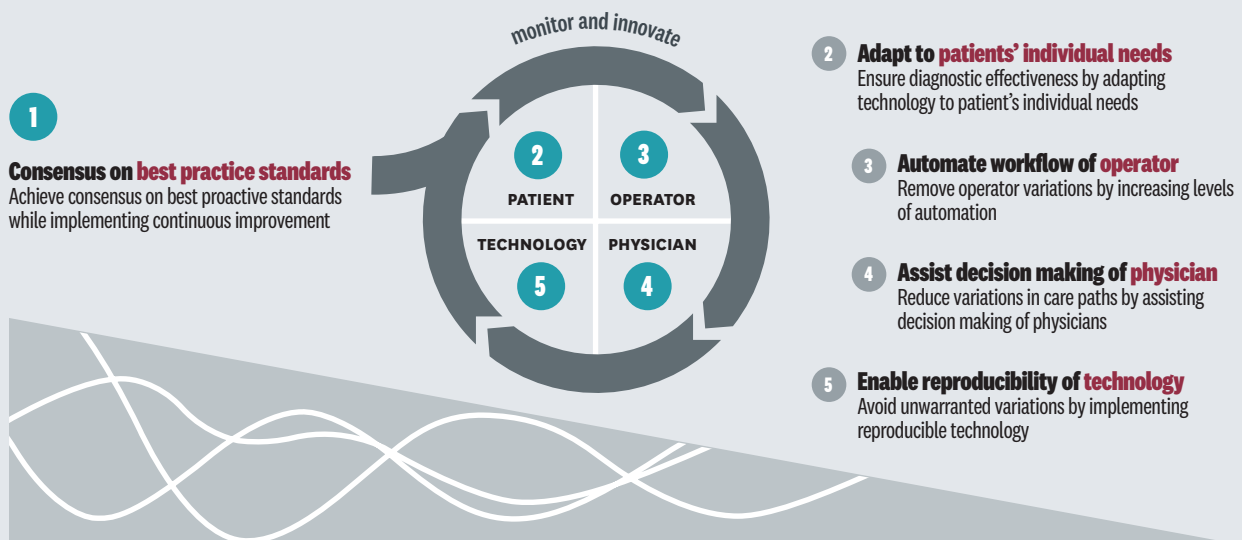
improvements in accuracy can lead, in turn, to shorter hospital stays and less post-operative pain and discomfort for the patient.

Doctors today can utilize individual or combined images from a mix of technologies, including ultrasound imaging, magnetic resonance imaging, preoperative CT scans, and endoscopic cameras. In using interventional radiology to treat liver cancer, for example, computed tomography and angiography systems can combine high-resolution images to permit more precise procedures and improve patient outcomes.

Elsewhere, real-time images are being used in a wide variety of applications in cardiovascular care, oncology, and orthopedics procedures (e.g., stereotactic surgery and radiosurgery); vascular procedures (e.g., balloon angioplasty/stents for endovascular aneurysm repair); and the surgical removal of tissue (e.g., radiofrequency ablation).

SIEMENS HEALTHINEERS PERSPECTIVE

BEST PRACTICE STANDARDS FOR CONTINUOUS IMPROVEMENT



**“PRECISELY UNDERSTANDING THE CAUSES
AND PROGRESSION OF A DISEASE
IS THE FASTEST AND THE MOST ECONOMICAL
WAY TO DELIVER MORE EFFECTIVE AND
INDIVIDUALIZED THERAPIES TO EACH PERSON.”
CLAYTON M. CHRISTENSEN AND SPENCER NAM**



Robotics also play a role in this area. In a common application, a doctor inserts a high-definition 3D camera or other imaging device into the patient's body using a control console in the operating room. The imaging equipment is held, moved, and precisely placed and readjusted by robotics as the doctor manipulates it, along with a small array of miniaturized surgical tools, with the master controls. Images of the affected part of the body are then available for immediate review and use in the OR. In this way, the doctor is able to perform surgery that is far more precise than anything he or she could do relying on the human eye alone.

RESEARCH HAS SHOWN THAT ELIMINATING UNWARRANTED VARIATIONS IN MEDICAL CARE CAN REDUCE THE COST OF PATIENT MANAGEMENT BY AT LEAST 35%.

Conclusion

Medicine must inevitably become more precise. The benefits to health care providers and patients, in the form of better outcomes and reduced costs, are simply too great to pass up. As are the benefits to health care organizations. Research suggests that eliminating unwarranted variations in medical care can reduce the cost of patient management by at least 35%.

The first step in expanding precision medicine is to improve the diagnostic accuracy. As Harvard's Christensen and venture capitalist Nam have written, "Precisely understanding the causes and progression of a disease is the fastest and the most economical way to deliver more effective and individualized therapies to each person."

Still, that's just one of four pillars of care necessary to expand precision in medicine sufficiently to reach its full potential. The others are reducing unwarranted variations in diagnosis (making diagnoses and overall patient care more consistent), personalizing care when it matters, and utilizing advanced therapies.

CEOs of health care institutions, who are under increasing pressure to improve patient outcomes and simultaneously reduce costs, have every incentive to embrace these four pillars of care and expand precision medicine not only within their own organizations but also throughout the health care community.

ENDNOTES

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