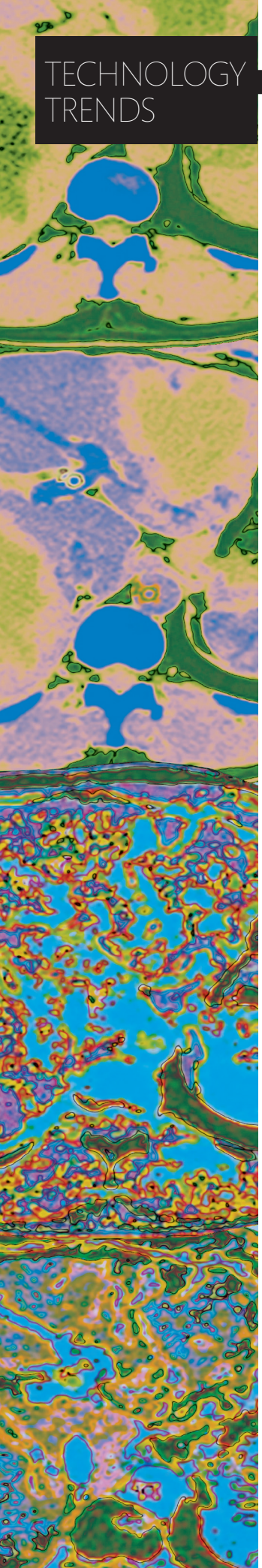

Precision Imaging: An important component of precision health care

Mary Beth Massat

Precision health and personalized medicine are the holy grails of health care. And while the two terms seem similar, the success of one actually leads to achievement of the other: realizing personalized medicine will bring about precision health for individuals *and* the population as a whole.

Precision health is defined as an approach to medicine that addresses genetic, environmental, and societal factors, in addition to a person's current health status. When former U.S. President Barack Obama introduced his Precision Medicine Initiative, it was to "pioneer a new model of patient-powered research that promises to accelerate biomedical discoveries and provide clinicians with new tools, knowledge, and therapies to select which treatments will work best for which patients."[1]

And while "precision medicine" may be more familiar to most people, clinicians increasingly prefer the term "precision health." Lloyd Minor, MD, Dean of the Stanford University School of Medicine, recently wrote,[2] "The vision would be to go beyond Precision Medicine: instead of a frantic race to cure disease after the fact, we can increasingly focus on preventing disease before it strikes." Indeed, Stanford launched its Precision Health and Integrated Diagnostics Center in 2017 to support researchers and embrace the fundamental shift to more proactive and personalized care that can enable people to lead healthy lives.

Other leading healthcare institutions, including the University of Michigan, Indiana University, University of Chicago, and others are also embracing the concept.

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According to Jonathan S. Lewin, MD, FACR, President, CEO and Chairman of the Board for Emory Healthcare, Emory University established the Predictive Health Institute in 2005 as part of its strategic plan to focus on maintaining health rather than treating disease. The institute is now also affiliated with the Georgia Institute of Technology, merging medicine with data management.

"There are multiple different sources of information in medicine, and we are looking at the impact of data sources on population health—including understanding the phenome and genome of the individual on their health and in preventing disease," Dr. Lewin says, describing the focus of the institute.

Emory is also participating in the National Institutes of Health *All of Us* Research Program, which aims to accelerate discovery by establishing three genome centers nationwide to collect genomic data from 1 million or more participants. Other than Emory, the Southeast enrollment center includes the University of Miami and the University of Florida. Besides providing biomedical researchers with access to anonymized genomic data, the program will provide genetic results back to participants who wish to receive this data.

In 2018, Emory University and Sharecare launched the Emory Healthcare Innovation Hub to identify unmet user needs and to develop, test, and implement solutions that put the patient at the center of care delivery. As part of this vision, the Emory Healthcare Innovation Hub recently announced its newest strategic partners—Cerner, Konica Minolta Healthcare, Novo Nordisk, Philips and Stryker.

Announcing the partnerships, Scott D. Boden, MD, vice president of business inno-

vation for Emory Healthcare and chief medical/quality officer for Emory University Orthopaedics & Spine Hospital, pointed to Emory Healthcare's collaboration with Konica Minolta Healthcare and Ambry Genetics to validate development of cancer screening tools, genetic testing modules, and closed-loop reports to aid early detection of cancer risk.

"Emory's model of innovation is founded on the idea that industry and healthcare providers, together, can solve problems faster than either alone," says David Widmann, president and CEO of Konica Minolta Healthcare. "Konica Minolta has a deep history of bringing innovation to health care. We have a shared vision that imaging and genomics, along with rapid access to an individual's complete medical record, will enable clinicians to deliver healthcare in a very different way that propels the future of personalized medicine."

While genetics is an important component of precision health, there is another important facet: precision diagnostics.

"Precision diagnostics is trying to enable the acquisition of more systematic, transparent, and standardized data that can be applied broadly to populations of people with specific abnormalities, diseases and health challenges," says Chip Truwit, Chief Medical Officer of Diagnostic Imaging at Philips Healthcare and formerly the Chief of Radiology and Chief Innovation Officer at Hennepin Healthcare (Minneapolis, MN). "It is only when we add onto the diagnostics that we can move to therapeutics, which gets us to precision medicine."

At Hennepin Healthcare, an integrated public healthcare system, Dr. Truwit's primary focus was to move care upstream. "Precision health lends itself not just to diagnosis and treatment, but to prevention and prediction," he says. "If we focus on preventive measures, we have to attack the problem through the lens of what we can accomplish."

In a public health system, that may be as basic as getting residents to understand the need to see a doctor before a health situation becomes an acute or chronic issue. On the flip side, it may be as basic as acknowledging that getting to the physician may be harder than many might expect. Dr. Truwit believes that precision health has to address the environmental and societal challenges that often face patients in in public health systems.

"The ZIP code many people live in is a primary determinant of their health," says Dr. Truwit. "Many patients are focused on far greater issues than what genetic footprint they carry."

Referencing the National Cancer Moonshot initiative launched by President Obama in 2016 with $1 billion in funding to accelerate the development of new cancer detection and treatments, Dr. Truwit adds, "We need to make the moonshot available to everyone."

Precision imaging

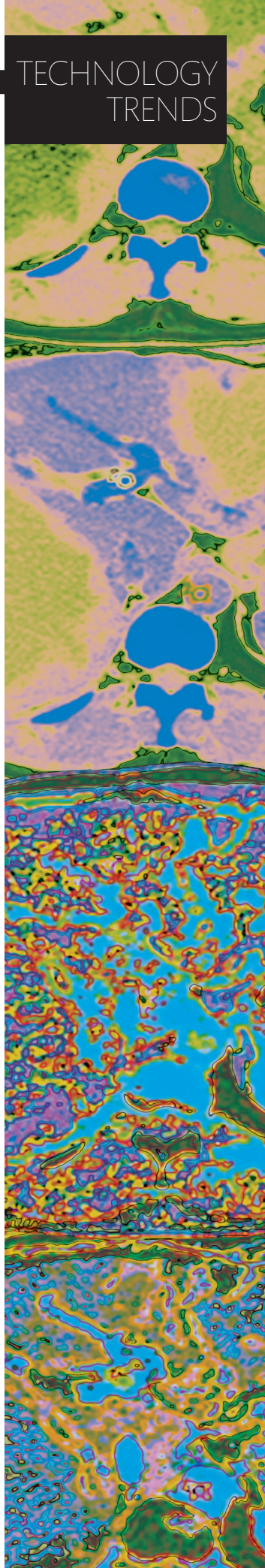
To achieve precision health, precision imaging will become an integral component. Supriya Gupta, MD, a radiologist with OnRad, Inc., which provides services to Amita Health in Kankakee, IL, and surrounding communities, co-authored a paper that examined the role of imaging in precision medicine.

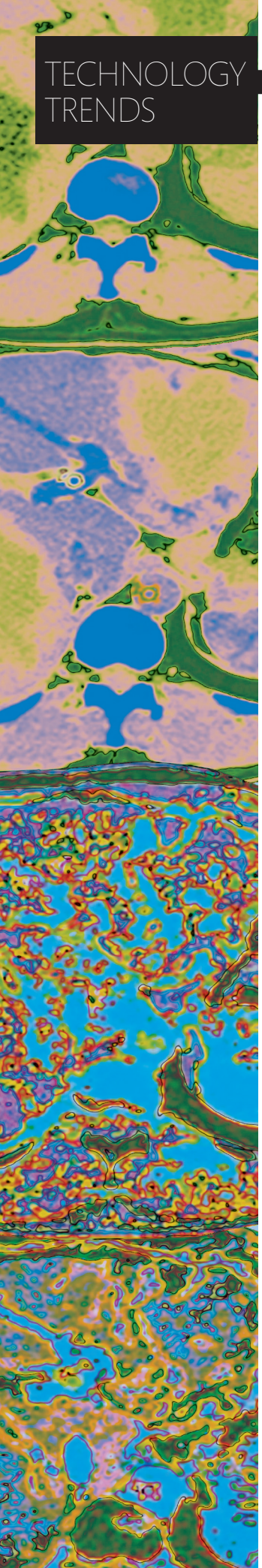
"Given the advances in medical imaging, it is very important that imaging run parallel with clinical care in each patient's workup," Dr. Gupta says. "Our paper emphasized how influential imaging is in clinical decision making. We can provide preventive and non-interventional approaches for managing patients with oncologic and non-oncologic diagnoses."

Image-guided interventions also can provide multiparametric morphologic and functional information. Dr. Lewin co-authored a paper with members of the International Society for Strategic Studies in Radiology that shared the proceedings of the 10th biannual symposium in August 2013.

The group urged radiology to embrace precision medicine by implementing quantitative imaging and establishing collaborations with industry and other medical disciplines. By linking basic molecular studies with phenotypic clinical manifestations, they wrote, biomedical imaging and image-guided interventions can facilitate accurate diagnosis and adequate response assessment.[3]

"The future state of radiology will no longer be just interpreting images, but creating the entire phenotypic picture of a patient," says Dr. Lewin. To get there, he believes artificial intelligence, including deep learning, will be required to sort through the vast amount of patient data that becomes available to radiologists.





This view embraces radiomics, or the extraction of large amounts of information from medical imaging using data-characterization algorithms. Beyond image acquisition and reconstruction, radiomics includes image segmentation, features extraction and qualification, analysis and model building to aid clinical decision making and outcome prediction.[4]

Dr. Truwit believes radiomics, along with new, sophisticated models of AI, will help bring together genetic data with anatomic, functional, and morphologic data in the diagnosis and prognosis of an individual's health or disease.

Radiogenomics involves linking imaging phenotypes to tumor genetic profiles. While the term initially referred to the prediction of radiotherapy-induced toxicity based on the genetic profile of a tumor, it is evolving to describe a broader picture of linking radiomics to biological parameters that include genetics, proteomics and metabolomics.[5]

Yet, there are multiple barriers to adding genomic data to the radiologist's armamentarium, says Dr. Gupta.

"Genomic data is not available to many clinicians," she says. "A huge limitation is that most people don't get genetic testing. It is only when a patient receives a diagnosis of cancer that they get genetic testing." Dr. Gupta adds that genomic databases are in short supply; the ones that do exist are currently available only by request or through special grants. "This significantly impedes data acquisition for everyday clinical management and small research studies," she says.

Reimbursement is another significant factor preventing people from seeking genetic profiling on a daily basis. Only recently, Dr. Gupta points out, have insurers begun covering genetic screening for patients who have a high-risk genomic profile, such as BRCA for breast cancer. Availability of data and reimbursement go hand-in-hand, she adds.

"The more that genomic data is studied and published, the easier it will be to build this into our clinical routine," she says. "We have imaging libraries, and if we can add genetic libraries in the future, then it will not only be easier to diagnose and treat [disease], but also to predict the disease and response to treatment."

Additional investment in research for biomarkers, radiotracers and imaging agents is also needed to realize precision health. As explained in the paper by Dr. Lewin, many radiotracers are in development, including biologics, that may help accurately determine the state of a disease in an individual.[3] However, companion biomarkers that can help with patient selection and identify those patients with the necessary biologics to treat and monitor disease is also needed to realize targeted imaging and precision health.[3]

In addition to the discovery and adoption of imaging biomarkers, Dr. Lewin believes work being done to standardize biomarkers so they can be more widely applied is be important. However, the regulatory and commercialization process must be accelerated to make this work.

"Continuing to invest in the discovery of new imaging biomarkers through NIH, industry and foundation sources into radiology labs is critical so that radiology scientists can continue to move the field forward," Dr. Lewin says.

Such investment was part of former President Barack Obama's Precision Medicine Initiative.

"We are finally on the precipice of accelerating discovery and adoption, with the potential to use imaging characteristics of a tumor and understand the role of certain drugs in the disease process," Dr. Truwit says. "What is needed now is to finish flushing out the data across institutions, and to collaborate with the right people analyzing this information across data streams."

Artificial intelligence can help with this data mining, but Dr. Gupta stresses that unless the patient's genotype is known, many oncologists won't begin treatment until they have this information. While PET imaging has advanced with different, disease-specific biomarkers for prostate cancer and neuroendocrine tumors, she believes MR-based biomarkers and advanced PET/MR techniques are also promising.

"No other modality supersedes MRI when it comes to resolving soft-tissue structures," Dr. Gupta says. "More importantly, MR perfusion, diffusion tensor imaging and MR spectroscopy enhance the capacity of MRI to assess the tumor activity."

PET, MR and CT have all advanced individually, Dr. Gupta adds. "When they are used in combination, then imaging can provide more information about suspect pathology. If we add genomic markers, then we can better prognosticate and manage the patient in a more efficient way."

Contributions from industry

With imaging playing a central role in personalized medicine and precision health, companies like Philips are committed to pursuing precision diagnostics and making imaging equipment more accurate.

"We believe that precision diagnostics is an intelligent combination of different information that we combine for a single patient view, with the goal of achieving a first-time-right diagnosis," says Rob Cascella, Chief Business Leader, Philips.

Cascella cites the quadruple aims of enhancing health outcomes, improving the patient experience, reducing the cost of healthcare and improving the work life of healthcare workers as a guiding force in product development.

While higher performance gradients, excellent image quality and enhanced functionality are all important in MR imaging, Philips is also looking at ways to help reduce patient re-scans. Compressed sensing techniques are key to helping reduce scan times, which can minimize patient movement, a key factor in MR rescans.

Across precision diagnostics, Philips is looking at how to help clinicians make diagnoses without an intervention. Examples of this, says Cascella, include using MR and ultrasound to quantify liver disease, or using AI to accelerate image processing, correct for motion or improve image accuracy. Informatics also has an important role in delivering a consultative platform that can aggregate data—morphology, pathology, genomic and patient history—to help guide therapy.

Philips' IntelliSpace Oncology Platform aims to do just this and more. The platform includes care pathways from Dana Farber Cancer Institute that provide guidance similar to that offered by a tumor board.

"We are bringing this educational tool to our customers to help them create wisdom from data so they can be more precise and deliver the right treatment for the right patient at the right time," Cascella says. The oncology platform can compare discordances between Pi-RADS and Gleason scores across a larger universe of patient data, for example. With the growing volume of patient-specific information and increasing importance of quantitative data and analytics, AI can make interrogation of data more efficient, he adds.

Fujifilm Medical Systems U.S.A., Inc., is also embracing precision medicine in product development. Rick Banner, Senior Director of Marketing, points to software that helps identify various types of breast composition to enhance the visualization of lesions in the Fujifilm ASPIRE Cristalle mammography system with Digital Breast Tomosynthesis unit. Banner says the company launched the FCT Embrace, reportedly the first 85-cm bore 64- or 128-slice CT system optimized for oncology and radiology, to fulfill a need for sub-millimeter precision and high image quality in treatment planning.

"Our goal is to provide the best image quality so our customers can accurately define the gross tumor volume for radiation oncology treatment planning," Banner says. "The next step is to use deep learning auto-contouring systems for better precision consistency and standardization, which is another critical area of focus for Fujifilm."

Yet declining reimbursements or the lack of reimbursement for novel technologies and therapeutic agents pose major challenges to developing new systems. Banner says companies must be careful to address clinical needs at sustainable price points.

"We are at the intersection of data interpretation through deep learning and artificial intelligence, and analytics and precision medicine," Banner adds. "This will create a health system that can carry out personalized medicine in the context of clinical care and at the same time optimize the tools and information used to deliver improved patient outcomes."

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