INSIDE STANFORD MEDICINE

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Software developed at Stanford can measure a surgeon's technical skill.

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More primary care doctors equals longer lives

By Beth Duff-Brown

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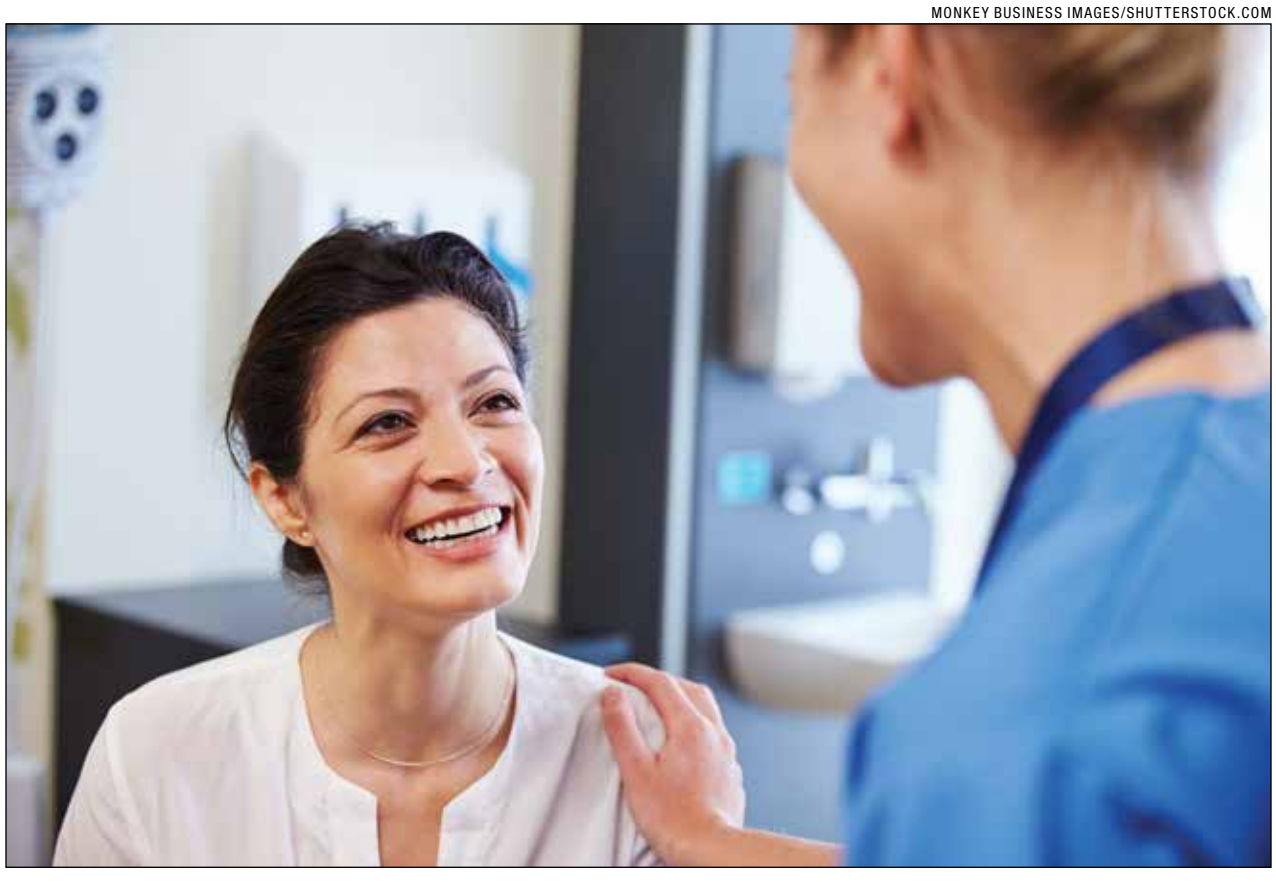

Life expectancy grows when there are more primary care physicians in the field, yet their numbers are shrinking, a new study reports.

New research shows us just how important primary care physicians are in prolonging our lives.

Every 10 additional primary care physicians per 100,000 people in the United States was associated with a 51.5-day increase in life expectancy during the decade from 2005 to 2015, according to a study led by researchers at the Stanford School of Medicine and Harvard Medical School.

By comparison, the researchers found that an increase of 10 specialists per 100,000 corresponded to only a 19.2-day increase.

"Greater primary care physician supply was associated with improved population mortality, suggesting that observed decreases in PCP supply may have important consequences for population health," the study said.

Nationwide, the researchers found that the number of primary care physicians has increased. However, disproportionate losses of primary care physicians in rural areas and overall population growth has led to a decrease in the density of PCPs per 100,000 people from 46.6 to 41.4 per in that same decade. Rural populations were particularly hard hit.

"Primary care physicians serve as the primary point of contact for most of the population and often perform preventive care, cancer screening and early diagnosis," said Sanjay Basu, MD, PhD, assistant professor of medicine and of health research and policy at Stanford.

The researchers' finding were published Feb. 18 in *JAMA Internal Medicine*. Basu, a core faculty member at Stanford Health Policy, is the lead author. The senior author is Russell Phillips, MD, professor of global health and social medicine at Harvard.

Dramatic shortfall in near future

The Association of American Medical Colleges estimates the United States will see a dramatic shortfall of primary care physicians by 2030.

"Many believe that a well-functioning health care system requires a solid foundation of primary care," the study said. "Yet, persistent payment disparities between primary care and procedural specialties continue to erode the U.S. PCP workforce."

The researchers say that a lack of health care policies aimed at increasing primary care physician supply, compounded by market forces, have reduced the number of primary care physicians relative to higher-income specialties, such as cardiology and orthopedic surgery.

"There are few incentives to go into primary care among U.S. medical school graduates," Basu said. "Pay tends to be lower, burnout rates higher and prestige lower."

The researchers set out to identify the extent to which the number of primary care physicians might impact mortality — and to encourage policymakers to consider the importance of encouraging more medical students to become primary care physicians.

They defined primary care physicians as nonfederally employed physicians younger than 75 years old who are not hospital residents and whose major professional activity is outpatient care in general practice, family medicine, general internal medicine and general pediatrics in every U.S. county and the District of Columbia.

The primary care physician counts were obtained from the American Medical Association Physician Masterfile for the years 2005, 2010 and 2015, and population counts came from the U.S. Census Bureau.

Five major causes of death See DOCTORS, page 7

Opioid deaths jump fourfold in 20 years; epidemic shifts to eastern states, study finds

By Beth Duff-Brown

Opioid-related deaths nationwide jumped fourfold in the last two decades, and the epidemic has made major inroads in the eastern states, according to a new study by researchers at the School of Medicine, Harvard University and the University of Toronto.

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Synthetic opioid deaths now outnumber heroin deaths, suggesting that synthetics have contaminated the production process of other illegal drugs, like cocaine.

"Although opioid-related mortality has been stereotyped as a rural, low-income phenomenon concentrated among Appalachian or midwestern states, it has spread rapidly, particularly among the eastern states," the study said.

The researchers found the highest rates of opioid-related deaths occurred in eight states: Connecticut, Illinois, Indiana, Massachusetts, Maryland, Maine, New Hampshire and Ohio. Two states, Florida and Pennsylvania, had opioid-related mortality rates that were doubling every two years. The mortality rate from opioids has increased the fastest in the District of Columbia, more than tripling every year since 2013, the researchers found.

The study's findings were published Feb. 22 See OPIOID, page 7

Modest decrease seen in burnout among physicians, researchers say

By Tracie White

The epidemic level of physicians reporting burnout dropped modestly in 2017, according to a study by researchers at the School of Medicine, the Mayo Clinic and the American Medical Association.

"Physicians remain at increased risk for burnout relative to workers in other fields, but there is some good news," said Tait Shanafelt, MD, director of Stanford's WellMD Center and a national leader in the movement to improve physician well-being. "For the first time, we're seeing improvement in the prevalence of burnout symptoms in physicians nationally."

Burnout decreased and satisfaction with work-life integration improved between 2014 and 2017, according to the study. Still, levels of burnout remain markedly higher than in other fields. About 44 percent of physicians reported at least one symptom of burnout, and only about 43 percent reported satisfaction with their work-life integration, which was less than in 2011.

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Tait Shanafelt, a co-author of the study, is a leader in the movement to improve physician well-being.

The study was published online Feb. 22 in *Mayo Clinic Proceedings*. Shanafelt, who is also a professor of hematology and the Jeanie and Stew Ritchie Professor, is the lead author. Lotte Dyrbye, MD, co-director of the Mayo Clinic physician well-being program, is the senior author. See BURNOUT, page 7

At new hospital, digital tools will augment patient experience

By Grace Hammerstrom

It's easy to see how the new Stanford Hospital will look now that the exterior is complete; the interiors are built out; and the furniture, equipment and art are being installed. Less visible but equally important is how the new hospital will feel to patients when it opens in the fall of 2019.

Multiple teams throughout the hospital have helped create a digitally driven patient experience that matches the majestic façade of the new structure, said Alpa Vyas, vice president of patient experience for Stanford Health Care. "The service and the culture we create inside must complement and enhance the physical environment," she said.

From the moment patients and family members come through the doors of the new Stanford Hospital, a compassionate team of caregivers and staff will shepherd them through their health care journey. Digital tools developed specifically for the new space will also assist them: Teams at Stanford are designing a patient experience that will take advantage of smartphone technology to guide them through their inpatient visit.

Digital companion

Stanford's MyHealth app will act as the digital companion for patients at the new Stanford Hospital, said Aditya Bhasin, vice president of software for Stanford Health Care. Patients can check in using MyHealth and speed up the admitting process before their scheduled surgery or inpatient stay. The app will also remind them about appointments and provide step-by-step directions to locations within the building. For example, the app can guide patients from the parking garage to the laboratory to the infusion treatment area and back again.

"Navigating a large medical campus can be confusing," said Vyas, noting that it's especially difficult for patients who are already consumed by anxiety or worry about their health or the health of a loved one. The way-finding capability within MyHealth is one way of quelling that stress and improving the experience, she said.

More than 500,000 people are using MyHealth for their outpatient care at Stanford Health Care; the software team is now enhancing the app for patients staying at Stanford Hospital.

For those inpatients, health information will show up on their MyHealth account before, during and after a hospital stay. "We want the technology to be a digital companion for our patients, helping them transition from the outpatient clinic to the inpatient setting and back home once they're discharged," Bhasin said. "We are building location awareness and health information content into our digital platform. As a result, we will know where patients are in their journey, and provide them with relevant information throughout their continuum of care."

The patient room

Every room in the new Stanford Hospital will be private and equipped with a 55-inch television screen, an iPad and a bedside remote. Using a keypad, patients can select movies, on-demand TV, music, relaxation videos, white noise, spiritual content and patient education information; they can also stream their own content into the entertainment system.

"The system was initially developed for the hospitality industry, so the user interface is extremely intuitive and easy to navigate," said Briana Lawson, project manager for the interactive patient experience. "Patients will be able to have an entertainment experience that's closer to what they have at home."

Additional family space has been designed into every patient room, with plug-ins for electronic devices and storage for personal belongings. Patients will also be able to control the temperature of their room as well as the lighting and window blinds — all without getting out of bed.

"We understand that people feel very vulnerable as patients in a hospital bed," Vyas said. "When designing the patient rooms, we looked at some of the small things we can put back into the hands of our patients to give them a sense of control over their environment."

STEVE FISCH

Rajiv Ramdeo and Alpa Vyas in a room at the new Stanford Hospital, where patients and family members will be shepherded through their health care journey with the help of a variety of technologies.

Enhanced communication

Every patient at Stanford Hospital is cared for by a team of doctors, nurses, therapists, case workers and support staff who must work together to coordinate services and manage a patient's return to health. Improving caregivers' ability to communicate and collaborate easily —in a way that protects patient privacy — was a priority, especially as the caregivers move into the larger space of the new hospital, Vyas said.

Stanford has implemented a secure messaging platform that allows care teams to communicate about a patient's personal health information in a protected environment, said Troy Foster, senior manager for network infrastructure. "It provides seamless communication between all members of a treatment team via phone call or text," he said. It also eliminates a lot of searching for team members when a question arises. The system runs on iPhones and is being used by more than 3,500 physicians and 2,000 nursing and ancillary staff. On an average day, 30,000 text messages and 6,000 calls are transmitted through the messaging platform.

"It's a faster way for care teams to collaborate on patient care," said Ann-Marie Yap, executive director of technology. "It really increases our efficiency."

"From a patient experience perspective, we are looking at how technology can help automate processes so team members have more time to focus on patient care," Vyas said. Care teams and staff are currently testing and refining many of these new capabilities in the existing hospital before they are implemented in the new hospital. "We want to get people comfortable with using all the new technology before we move into the new space so they can be ready to care for our patients," she said. **ISM**

New antibiotics are desperately needed: Machine learning could help

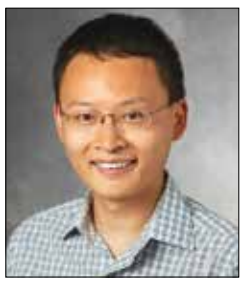
By Hanae Armitage

As the threat of antibiotic resistance looms, microbiologists aren't the only ones thinking up new solutions. James Zou, PhD, assistant professor of biomedical data science at Stanford, has applied machine learning to create an algorithm that generates thousands of entirely new virtual DNA sequences with the intent of one day creating antimicrobial proteins.

The algorithm, called Feedback GAN, essentially acts as a mass producer of different DNA snippets. And while these sequence attempts are somewhat random, the algorithm isn't working blindly. It's basing the new possible peptides, or small groups of amino acids, on previous research that lays out the DNA sequences most likely to align with antimicrobial properties.

For now, these templates, which don't exist in nature, are theoretical, generated on a computer. But in the face of rising concerns about microbe resistance, Zou said it's critical to think about solutions that don't already exist.

"We chose to pursue antimicrobial proteins because it's a very important, high-impact problem that's also a relatively tractable problem for the algorithm," Zou said. "There are existing tools that we incorporate into our system that evaluate if a new sequence is likely to have the properties of a successful antimicrobial protein."



James Zou

Feedback GAN builds on that, working to incorporate just the right balance of random chance and precision.

A paper describing the algorithm was published online Feb. 11 in *Nature Machine Learning*. Anvita Gupta, a student in computer science, is the first author; Zou is the senior author.

Gupta and Zou's algorithm doesn't just churn out new combinations of DNA. It also actively refines itself, learning what works and what doesn't through a feedback loop: After the algorithm spits out a wide range of DNA sequences, it runs a trial-and-error learning process that sifts through the peptide suggestions. Based on their resemblance to other known antimicrobial peptides, the "good" ones get fed back into the algorithm to inform future DNA sequences generated from the code, and to get refined themselves.

"There's a built-in arbiter and, by having this feedback loop, the system learns to model newly generated sequences after those that are deemed likely to have antimicrobial properties," Zou said. "So the idea is both individual peptide sequences and the generation of the sequences get better and better."

Zou has also considered another core component of hypothetical proteins: protein folding. Proteins contort into very specific structures linked to their functions. An algorithm could create the perfect sequence, but unless it can fold up, it's useless — like the cogs of a clock strewn on a table.

Zou can tweak the algorithm so that instead of analyzing a propensity for antimicrobial properties, it determines the likelihood of correct folding.

"We can actually do these two things in parallel where we look at antimicrobial properties of one sequence and folding likelihood of another," said Zou. "We run both so that we're optimizing either the antimicrobial properties or its ability to fold."

Next, Zou hopes to merge the two variations of the algorithm to create peptide sequences that are optimized for both their microbe-killing abilities and their ability to fold into a genuine protein. **ISM**

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STANFORD MEDICINE

Medical residents' attention split between computers, patients

By Amy Jeter Hansen

It's no secret that doctors spend increasing amounts of time in front of computers rather than patients.

But what does this mean for medical trainees? That question is at the heart of a new study by Stanford researchers, who sifted through more than three years' worth of data in electronic health records, analyzing nearly 16 million interactions to find out how internal medicine residents at one hospital were spending their time.

Jonathan Chen

The study was published online Feb. 6 in *PLOS ONE*. The senior author is Jonathan Chen, MD, PhD, assistant professor of medicine. The lead author is former Stanford undergraduate student Jason Ku Wang.

The researchers discovered that the trainees spent an average of 5.38 hours — or nearly half of a 12-hour work day — in front of a screen. The findings correspond with what previous studies, conducted through observations and questionnaires, have found. But because their work analyzed computer records, the Stanford researchers could drill deeper.

"We were able to pinpoint more precisely what specific actions they were taking," Wang said, "so whether they were looking at a patient chart, or whether they were inputting new information — writing a note or ordering a lab test."

The researchers found that chart review accounted for the largest proportion of computer activity by all residents, followed by note entry. That meant they were spending more time looking for information than adding new information — an insight that might be helpful for vendors and educators, Wang said.

"I know a lot of effort has been put into decreasing the amount of time physicians spend writing a note," he said. "Perhaps they could also look at improving EHR design so that information is easier to access."

The study also identified a behavioral difference between residents based on the clock: While night workers stopped their EHR activity promptly after their shift ended at 7 a.m., trainees working days tended to continue computer work up to 9 p.m. and beyond.

The variance might reflect understandable feelings of fatigue related to night work, Chen said, but it also could indicate that day-shift residents feel a different level of ownership than their counterparts when it comes to their patients — and that today's residents have a better means for bringing their work home.

"Doctors used to be done with work at work," he said, "but now they need to keep logging in, checking in, filling in that note or doing this other paperwork that still requires attention."

NEGATIVESPACE

Not all computer time for doctors is bad, Chen said, but much work needs to be done to ensure that hours in front of the screen translate to effective care.

Although he is a self-described "computer nerd," Chen said he still finds value in face-to-face patient interaction and even in paper charts. As a resident at a hospital without a digital record system, Chen said he spent more time in patients' rooms than at a computer console, and he discovered that his notes were more efficient when he had to use a pen. "You want to write as little as possible," Chen explained. "Just the relevant information."

Wang, who has plans to attend medical school next fall, said he was a bit concerned by what his own research showed.

"It's very alarming to see that almost 50 percent of your day will be spent on the computer rather than with a patient," he said. "That's definitely not what most of us go into medicine hoping for. But on the other hand, information, if it's high-quality, can be very useful and very promising: Precision medicine and personalized health care are rooted in having electronic health records that can make that data available. For me right now, it's very interesting because I think it's unclear whether the electronic health record as it's currently designed will prove to be more harmful or productive." **ISM**

Failure to take statins leads to higher mortality rates, according to new study

By Mandy Erickson

A lot of patients with arteries clogged by cholesterol aren't taking their statins, a new study by researchers at the School of Medicine has found. That boosts their risk of death, the study said.

More than a third of patients with cardiovascular disease who have been prescribed statins to reduce cholesterol failed to take them daily, according to a review of Veterans Affairs medical records. Women and nonwhites were least likely to take their prescriptions, as were the oldest and youngest patients.

"The takeaway for clinicians is not to become complacent about stable patients with cardiovascular disease," said Fatima Rodriguez, MD, assistant professor of medicine.

The study was published online Feb. 13 in *JAMA Cardiology*.

Rodriguez is the lead author. Paul Heidenreich, MD, professor of medicine, is the senior author.

The researchers examined the health records of 347,104 patients with atherosclerotic cardiovascular disease — caused by fatty deposits in their arteries — who had been prescribed statins. Statins are a group of drugs that lower cholesterol.

From the VA records, the researchers were able to ascertain how often the patients picked up their prescriptions over a span of nearly three years.

Almost a quarter of the patients died during that time, so the researchers were able to calculate patients' risk of dying based on how frequently they took their statins. They found that those who were taking them less than 70 percent of the time had a 20 percent increase in mortality compared with those taking them at least 90 percent of the time.

Even those who were pretty good — but not perfect — at picking up their prescriptions showed some increased mortality, Rodriguez said. "There is definitely a benefit to pushing adherence to 100 percent," she said.

Heidenreich said physicians can often do more to encourage their patients to take their medications daily.

"It's difficult to change behavior," he said, "but there are small interventions people can do. Just bringing it up and showing the patient that it matters to you as a provider probably has some effect. … In some cases, you'll be able to find a reason they're not taking it. … There may be a misconception or perhaps there is a cost issue."

JARMOLUK

He noted that most statins are available in generic form, however, so they are fairly inexpensive.

As to why patients fail to take the medication daily, Rodriguez said there appears to be a resistance to lifelong medications: "Patients are hesitant to take medications forever," she said. "They want to take it for a short amount of time."

She added that patients may also be reluctant because statins have gotten a lot of bad press, possibly because of controversy over whether patients with a lower risk of heart disease should take them. (Lower-risk patients were not included in the study; the researchers were looking at high-risk patients, for whom statins are not controversial, the researchers said.)

Rodriguez conjectured that women may not take statins regularly because they often underestimate their risk of heart disease. Older patients may lose track of their statins among all the other medications they are taking, and younger patients may not believe they are at risk of dying. It is unclear why nonwhites are less adherent, she said, though researchers are looking into it.

While some patients suffer side effects from statins, the researchers said they are few and don't explain the high numbers of patients who fail to take statins regularly. **ISM**

An art exhibit in white documents recovery, vulnerability and ritual

By Susan Coppa

In November of 2017, artist and physician Matthew Wetschler, MD, was bodysurfing at Ocean Beach in San Francisco when a wave drove him headfirst into the ocean floor, breaking his neck and leaving him partially paralyzed. He was spotted and dragged onto the beach before drowning. A vacationing nurse helped resuscitate him.

Wetschler was transported to Zuckerberg San Francisco General Hospital, where he was the first person in the United States to receive a post-experimental treatment focused on maintaining sufficient blood flow within the spinal cord.

That accident and the ensuing months of struggle to ultimately regain movement serve as the inspiration for Wetschler's new exhibit of paintings, Documenta, now on display at the School of Medicine's Li Ka Shing Center for Learning and Knowledge.

Wetschler, who completed a residency in emergency medicine at Stanford before the accident, created all of the works in the exhibit in the past year, and they are directly inspired by his accident and the recovery process. They are also exclusively a product of ritual. Wetschler, who still experiences loss of fine-motor coordination in his **See EXHIBIT, page 8**

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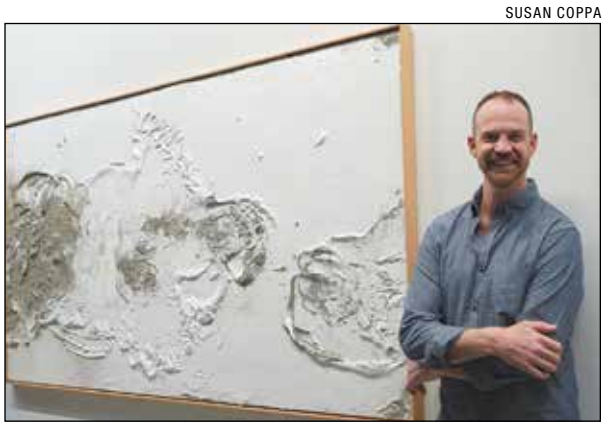


A bodysurfing accident and the ensuing months of struggle to regain movement were the inspiration for new exhibit of paintings by Matthew Wetschler at the Li Ka Shing Center

Young scientist helps design AI that measures surgical skill

By Ruthann Richter

Amy Jin loves hip-hop dance, the violin and English literature. But it's her passion for computer science that has made her a superstar in the exploding field of artificial intelligence.

Jin has been intrigued by AI since the sixth grade, when students at The Harker School in San Jose, California, chose research projects that challenged them to show how they'd use computer programs to tackle real-world problems.

But her passion for the subject was ignited when she was a high school freshman and she heard an IBM scientist describe how the Watson supercomputer could help extend human capabilities in medicine and other fields through artificial intelligence, the ability to teach machines to "think" and "see."

"That was really fascinating to me — that Watson could become like a second pair of eyes for a doctor," said the soft-spoken teen, now a freshman at Harvard. "I thought artificial intelligence was a really promising field, with so many cross-disciplinary connections."

Since then she's become part of a new generation of young science enthusiasts who are making waves in artificial intelligence, one of the hottest fields today in computer programming. The same technology behind the self-driving car, AI has the potential to change medical practice in myriad ways, from helping diagnose disease early to improving treatment and ensuring patient safety in the hospital and at home.

Over the past two years, Jin has worked with mentors at Stanford to produce a new software program that can measure a surgeon's technical skill. It works by "watching" a video of a surgery and tracking the movement and timing of instruments used during a procedure. The creation of the stunning piece of technology by Jin and researchers from Stanford's medical and engineering schools won the top research prize at a major international scientific symposium on artificial intelligence where Jin presented it in December of 2017.

Arnold Milstein, MD, PhD, director of Stanford Medicine's Clinical Excellence Research Center, predicts the approach will break new ground in objectively assessing clinicians' manual skills in diverse clinical activities.

"This could make a big difference when manual skills matter," said Milstein, a co-author of a paper describing the work. "It provides a path for tailoring the duration of surgical training to how quickly residents learn. And it opens the way to a more objective approach to periodically certifying a surgeon's technical skill or alerting a surgeon when he or she needs a restorative break during a long procedure."

AI to ensure best practices

The project grew out of a six-year-old partnership between Milstein's group and researchers at the Stanford Artificial Intelligence Lab, led by Fei-Fei Li, PhD, professor of computer science at Stanford. The scientists are developing forms of AI to help ensure that best practices in health care are reliably applied. They initially focused on increasing staff adherence to patient safety protocols in intensive care units, improving hand hygiene in hospitals and monitoring frail seniors at home by assessing such things as how steady they are on their feet.

"Then one of the CERC fellows said, 'I think we should do this with surgical skills,'" Milstein said. "The American Board of Surgery has long sought an objective test of surgeons' technical skills."

Those hands-on skills are critical, said Stanford general surgery resident Jeff Jopling, MD, a former CERC scholar who proposed tracking surgical skills with computer technology. Jopling naturally gravitated to the project, as he had done graduate studies in Georgia in both engineering and medicine. He came to Stanford six years ago because he wanted to work with Milstein and Tom Krummel, MD, then chair of the Department of Surgery, to improve health care systems around the country.

Safety issues in health care became a focal point after the National Academy of Medicine issued its 1999 report on the high rate of deaths and disability that resulted from human errors in medicine. Afterward, clinicians tried to minimize preventable complications with solutions such as surgical safety checklists, a series of detailed steps for clinicians to follow to help avoid mistakes, Jopling said.

Then a 2013 study of 20 bariatric surgeons in Michigan highlighted a missing variable in the picture: surgeon proficiency. The study, published in *The New England Journal of Medicine,* showed that if a surgeon did well — as measured through blind ratings by peers of videos of surgeons' hand movements — so did the patient; if the surgeon faltered, the patient was more likely to suffer complications, undergo repeat operations and have emergency room visits.

"Until then, there had been so much focus on improving the system, but here it showed that people and their skills matter, too," said Jopling, one of the authors of the latest AI paper with Jin.

Yet, in the course of their training, surgeons are sometimes unable to get a good sense of how they are performing, he said.

"Even when I do the 1,000 operations for my training, I get very little feedback on most of those surgeries," Jopling said. "I was surprised by that as a trainee. I thought it would be like a sport or music, where you have a coach saying, 'Do this. Don't do this.' Exceptional teachers provide that, but not everyone does. Not everyone can explain what you are doing well or not doing well."

"This could make a big difference when manual skills matter."

While Jopling was mulling the new surgery project, Amy Jin was busy adjusting to the demands of high school. The second child of Chinese immigrants, both PhDs in physics, she had long been keen on computer science and was already a whiz at math, but she had never done any programming. So as a freshman she signed up for an AP computer science class and joined the school's Women in Science, Technology, Engineering and Math Club (she later became the club's president). There, she heard about an opportunity at the Stanford Artificial Intelligence Lab's Outreach Summer Program, which is designed to entice young women into science careers.

Hand-sanitizing initiative

In the program, she was paired with Serena Yeung, PhD, then an up-and-coming doctoral student, who mentored her. Yeung is also the daughter of Chinese immigrants, and the two shared a passion for science and a desire to help others. Yeung had long been interested in medicine — her father is a family physician — but as a Stanford undergraduate she realized she was an engineer at heart. She became immersed in AI, doing internships in the field at Facebook and Google. While searching for a doctoral project, she met Milstein and became captivated by the idea of using the technology to improve medical practice.

Yeung introduced Jin to one of the group's AI in medicine projects: a hand-sanitizing initiative designed to control the spread of infection, a significant problem among hospitalized patients. For the project, Yeung, Jopling and colleagues at CERC, the Department of Pediatrics and the AI lab received permission to install depth and thermal sensors outside a transplant unit at Lucile Packard Children's Hospital Stanford, where hand hygiene dispensers are located. They used AI to program

TIMOTHY ARCHIBALD

Amy Jin has worked with mentors at Stanford to produce a new software program that can measure a surgeon's technical skill.

the sensors to monitor personnel — shown only as outlines of human shapes to protect their privacy — as they passed by the dispensers.

Their algorithm was able to predict with more than 95 percent accuracy whether staff members were using proper hand hygiene, the researchers reported at the Machine Learning for Healthcare Conference in 2017. They are now using the algorithm to measure hand-hygiene compliance in other hospitals and see whether interventions, such as real-time alerts, can improve these practices, said Yeung, who is expected to join the Stanford faculty in the fall of 2019.

Jin was enthralled by her work on the project and was eager to learn and do more. Yeung figured the budding surgery project was the perfect new opportunity for her.

"We could scope it to a level that Amy could start with. Obviously, she surpassed all of our expectations," Yeung said, laughing. "It became much more than a high school project, which was great."

Jin fit in the work between a demanding school schedule, club meetings and orchestra and dance rehearsals. She audited a Stanford undergraduate course in computer vision to learn more about how to train computers to "see" and understand the visual world, with Yeung coaching her through. On her own, Jin dug up dozens of related studies in the medical and computer science literature, which she shared with the team.

Jopling took her under his wing to introduce her to the world of surgery. He showed her laparoscopic surgical techniques in the Goodman Surgical Education Center at Stanford Hospital.

The trio met every other week, and sometimes more often, at the Stanford Artificial Intelligence Lab, across the road from the university's medical center. The glass-walled laboratory is a hive of activity, as dozens of hoodie-wearing students peer intently at screens displaying colorful computer code and then discuss problems, often well into the night. The three researchers also frequently texted and emailed each other, as Jin was dependent on her mother to drive her to meetings.

The challenge of the project, which was officially launched in the summer of 2016, was to "teach" the computer to recognize and follow the path of surgical tools as the clinician guided them through the body. This is a form of object detection, a field that has been rapidly advancing in recent years, in part because of contributions from Li's lab.

Identifying data points

The method involves developing an algorithm that teaches the computer to learn as it is fed thousands of data points. With each bit of data, the computer gradually adjusts until it reaches a stage where it can form an accurate picture of the object — in this case, a surgical tool. The process is enabled by the growing ability of computers to rapidly digest vast amounts of data. Jin refined some of the techniques of object detection to apply it to surgery, Yeung said.

"The general idea was that if we are able to track and recognize instruments in videos, we would be better able to analyze tool usage patterns and movements," something that Jin said has been shown to be an effective building block for measuring and assessing a surgeon's skill.

For simplicity, the researchers focused on gallbladder-removal surgery because it is a common, standardized procedure that typically uses seven instruments at most, including clippers, graspers and scissors. They obtained 15 videos of procedures done at the University Hospital of Strasbourg and labeled some 2,500 individual frames, attaching a value to each one so the computer could build a visual picture of the tools and locate them within the surgical field. They used metrics to track the timing of tools — which instrument was used when, and for how long — and produced maps of the pathway of each tool. In addition, they created heat maps that showed how far the tools ranged within the surgical field, as better surgeons tend to handle instruments in a focused area.

"With that, we could gain a sense of a surgeon's performance overall," Jin said.

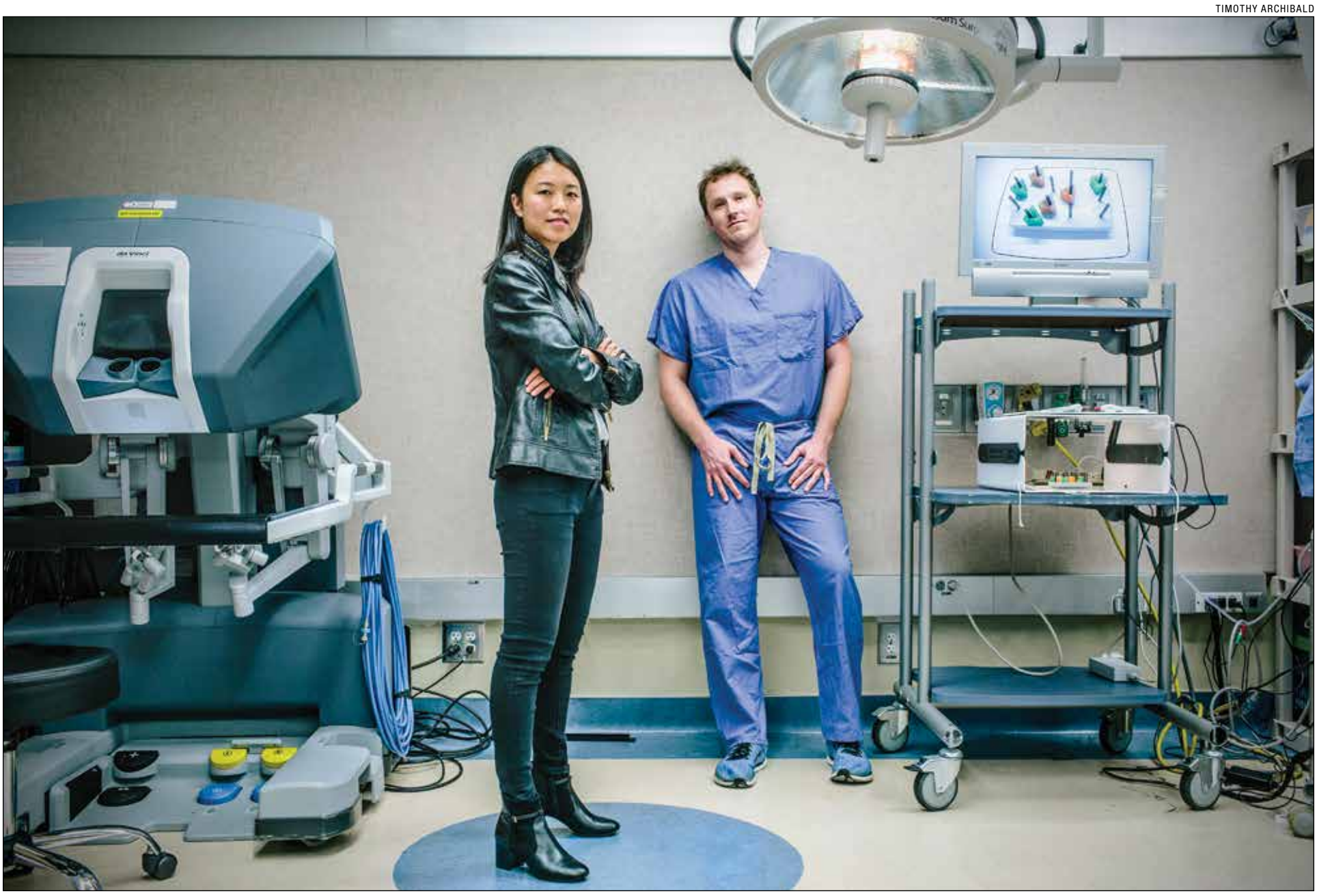
From the visuals and statistics, the researchers were able to gauge multiple aspects of the clinicians' performance, including their economy of motion, how often they switched back and forth between instruments, and their efficiency at each step of the procedure. They then asked three Stanford surgeons to watch the videos independently and rate the surgeons on a scale of 1 to 5, based on widely accepted criteria: their efficiency, their dexterity with both hands, their depth perception and their handling of the tissue.

"The insights into how the machine rated the different surgeries correlated with the surgeons' insights into how they rated the videos," Yeung said.

For instance, there is a critical step in a gallbladder-removal surgery in which the clinician has to clip and cut both the cystic artery, which supplies blood to the organ, and the cystic duct, which carries bile in and out of it. When done properly, this step prevents bleeding and leakage of bile during and after the procedure. If the clips are in the wrong place or come loose, the patient can suffer devastating complications, including damage to the bile duct.

A good surgeon does this efficiently, with economy of motion. In one case, a videotaped procedure showed the deft skill of the surgeon, with the clipper and grasper placed just right. Another video showed a surgeon struggling to put an extra clip in place, then

TIMOTHY ARCHIBALD



Serena Yeung, left, who is expected to join the Stanford faculty in the fall, and surgery resident Jeff Jopling worked with Jin when she was a high school student to design software for assessing surgical skill.

later taking some time to pry it loose. The computer detected the discrepancy in skill levels by viewing not only the placement and the pathway of the implements, but also the elapsed time of the procedure.

With the analysis in hand, the group submitted their results to the Workshop on Machine Learning for Health, part of the conference on Neural Information Processing Systems in December 2017 in Long Beach, California. The conference is one of the biggest AI meetings in the world, involving 7,000 researchers, graduate students and industry professionals. Yeung listed Jin as the first author of the paper, an extraordinarily generous move on her part considering doctoral candidates eager for publication credits typically claim this spot themselves, Milstein said.

In the workshop, the paper was selected from more than 120 submissions as one of 10 worthy of a spotlight talk. Jin, attending her first-ever conference, presented her work to the distinguished audience, and it was then published in the conference proceedings.

When the choice of best paper was announced, Jin was casually scrolling through her laptop, barely listening since she didn't expect she'd know the authors.

She was stunned when her name was called. "I was just kind of half there and was really surprised," she said. She immediately sent a text message to Yeung and Jopling, who said it was a surreal moment.

Jopling called Jin an "inspiration to all of us," and Yeung marveled that a high school student had both submitted a paper to the conference and won the top award.

So how did Jin do it? "It's definitely a combination of luck and opportunity, I guess," she said. And hard work? "Hard work, yeah, from everyone," she said, laughing.

Refining the tools

Jopling said the next step in the project is to amass as many as 1,000 videos recorded from several different surgeries. The Stanford researchers will collaborate with colleagues at the Utah-based Intermountain Healthcare, a 22-hospital system with a large surgical volume, to analyze the videos and refine the evaluation tool. The future work will take into consideration the complexity of surgical cases, as some gallbladder removals, for instance, may be quite straightforward, while others might be more challenging because of a patient's multiple medical problems, Jopling said.

He said the technology will be particularly helpful in surgical training, noting that it's labor-intensive for a surgeon to sit for hours and review the videotaped performance of a trainee. The automated system could do this for them, and could alert surgeons, in real time during a procedure, if they are starting to lose their edge, Milstein said.

"It's really important for the patient's outcome to know when those moments of fatigue and deterioration set in," he said. "Knowing when it's time for a lead surgeon to take a break and allow the assistant to take over is analogous to a baseball coach deciding when a dip in accuracy and pitching speed indicates that a pitcher needs relief."

Milstein has shared the work with Mary Hawn, MD, professor and chair of surgery at Stanford, who was also enthusiastic about presenting the model, once it's perfected, to the American Board of Surgery as a possible addition to current board certification exams.

However, not all surgeons are enthused about the idea of having a machine second-guess their skills, Jopling said.

"I had one surgeon tell me, 'When that day comes, that's the day I'm going to retire,'" he said. But, Jopling added, "There are always things you can work on and improve. It's like having a tennis coach that watches every single swing you take over the course of your career, but without blinking or getting tired. There is always something you can improve, but in surgery, you often don't get that feedback."

The AI technology could have broader applications in many aspects of medicine, Yeung noted. For instance, the group has been testing it to monitor the movements of patients in intensive care units — when, for example, they get in and out of bed or a chair — and to ensure that caregivers are following steps to keep patients safe. The technology is also being tested to monitor frail seniors at home, measuring their activities and mobility, and alerting others to a fall or other mishap that requires immediate attention.

"Clinicians, nurses and other health care providers are so overwhelmed now, and the problem is going to get worse as the baby boomer generation gets older," Yeung said. "I think AI has great potential to provide an untiring, constant awareness of what is happening, which can be used to assist health care providers and prevent cognitive overload."

But the work will go on at Stanford without Jin, who is now a freshman at Harvard, following the path of her brother, also a science whiz, who is a senior there. She said it was hard to say goodbye to her Stanford coaches after two years of intensive work, but she's excited — and a bit nervous — about what may come next. Although she has not settled on a major, it's no surprise that she's considering computer science. And that, Yeung said, could be a boon to the profession.

"It's great to have people like Amy who excel in computer science," Yeung said. "It's one of the problems AI is trying to address — that we don't have enough women in the field and the number decreases at every stage. So we hope Amy will continue in the field and be a good role model for others." ISM

Rockefeller's Titia de Lange to give annual McCormick Lecture on March 8

Cell biologist and geneticist Titia de Lange, PhD, will give the 2019 Katharine D. McCormick Distinguished Lecture at 4 p.m. March 8 at the Li Ka Shing Center for Learning and Knowledge.

The title of her talk is "Telomeres and the DNA damage response." The event is free and open to members of the Stanford community. A reception will follow. The deadline to register is March 7 at 7 p.m.

As director of the Anderson Center for Cancer Research at Rockefeller University, de Lange is also the Leon Hess Professor.

Titia de Lange

At Rockefeller, de Lange has focused on understanding how telomeres ensure the ends of chromosomes are not identified as damaged DNA. She identified the telomere binding proteins involved in protecting the ends of DNA and cloned the first human telomeric protein. Her subsequent work helped to identify the six-subunit shelterin complex and determined how shelterin represses the DNA damage response. She also investigates how loss of telomere protection drives genome instability in cancer.

The lectureship is named for Katharine Dexter McCormick, who left a large bequest to the Stanford School of Medicine. She earned a bachelor's degree in biology from MIT in 1904. A suffragist and philanthropist, she is perhaps best known for funding research that led to the development of the first birth control pill. ISM

Stanford Biobank adds new services and off-site storage

By Kris Newby

The Stanford Biobank is rolling out new services that will enable researchers to better track, share and protect biological samples and the deidentified patient data associated with them.

KRIS NEWBY

Rohit Gupta, executive director of the Stanford Biobank, said a new biospecimen management system will make it easier for researchers to track and share biological samples and data.

The biobank has launched a new biospecimen management system that tracks the locations of barcoded samples and provides online links to corresponding patient health records, clinical notes and molecular data in the university's REDCap and EPIC information systems. All linked information related to a sample can be securely viewed by individual labs and shared with collaborators.

Before the project began, Rohit Gupta, the biobank's executive director, recognized that many researchers have troves of surplus biospecimens that could be used by others for follow-on studies if there was an easy way to facilitate sharing of both samples and data. To that end, Gupta's team developed BioCatalyst, a secure website that provides access to all the data associated with a given biological sample. In the second phase of this project, which will launch in 2020, BioCatalyst will provide researchers with integrated tools for managing, analyzing and visualizing molecular/-omics data.

The Stanford Biobank also provides faculty with on-site and off-site freezer storage. Labs that want to transition to this new system can use a preapproved consulting firm for help with moving the samples or advice on how to move them. The off-site storage facility, located in California's Central Valley, offers 24/7 temperature monitoring and fast distribution of samples back and forth to Stanford. The off-site storage not only reduces the risk of sample destruction due to earthquakes, power outages and fires, but it frees up expensive campus lab space for more researchers and equipment.

Gupta said the most important aspect of this new biospecimen management system is the potential for researchers worldwide to share disease and specimen data, reducing the total time and cost of collection and analysis.

One of the obstacles to sharing samples or data is obtaining patients' permission to use them in future studies. To facilitate this sharing, Gupta is collaborating with multiple departments at Stanford to launch an electronic consent platform that includes an explanatory video and online consent form in which patients have the option to allow their samples to be used in future studies.

The biobank currently houses the samples and data associated with almost 200 projects, including two large flu and chronic fatigue studies, a biorepository for the rare NGLY1 deficiency genetic defect, and patient data for the adult and pediatric transplantation group.

Gupta's team is also working on gaining accreditation as a College of American Pathologist biobank.

Researchers interested in using the Stanford Biobank should send an email to sbcrequest@stanford.edu. To promote the transition to this new system, the dean's office has agreed to provide financial incentives. ISM

New website connects researchers with data experts, other resources

By Kris Newby

The newly launched Stanford Data Science Resources website is a central portal from which data scientists can access advanced tools, data platforms and experts in diverse methodologies for conducting biomedical research.

At the heart of this website is a consultation-request form that quickly connects researchers with the experts, advice and resources needed for a given project. Requestors may submit a research question, a data need or a query on study design or methodology, and each will be matched with the appropriate Stanford research support team.

Experts are available from the Center for Population Health Sciences, Department of Biomedical Data Science, Research Informatics Center, Research Information Technologies group and Quantitative Sciences Unit. These specialists can provide advice in a variety of areas, including general project support, biostatistics, informatics, mobile technologies and research information technologies. The portal also provides researchers with an organized starting point for selecting secure electronic data capture applications and research management platforms.

On the data sets page, there are details on clinical information stored in the Stanford Research Repository, called STARR.

There's also an overview of population-level data sets, which enable Stanford researchers to better analyze factors such as poverty, inequality, climate change and forced migration on health and well-being. These data sources include the following:

- IBM MarketScan Research Database, which has person-specific clinical expenditures segmented into inpatient, outpatient, prescription drug and service categories for more than 150 million people.
- Optum Clinformatics Data Mart, which stores administrative health claims for more than 72 million members of a large, national managed-care company affiliated with Optum.
- The Health Inequality Project, which has data on the differences in life expectancy categorized by income, and identifies strategies to improve health outcomes for low-income Americans.
- Centers for Medicare and Medicaid Services, which allows researchers to evaluate geographic variations in the use and quality of health care services for the Medicare fee-for-service population in a 20 percent sample of the national Medicare population.
- The Integrated Public Use Microdata Series, which stores individual and household census records and which is a good source for research on social and economic changes.
- The "Born in Bradford" cohort study, which has data on 12,500 pregnant women from 2007 to 2010 and subsequent data on 13,500 offspring, all from a resource-poor town in the United Kingdom.

The website design team is soliciting feedback on how to improve the website. Please send any suggestions to Stacyann Forrester at sforrest@stanford.edu.

The development of this web portal was funded by a National Institutes of Health Clinical and Translational Science Award and the School of Medicine Dean's Office. ISM

Orthopaedic surgeon is recipient of prestigious award, $10 million grant

By Mandy Erickson

Constance Chu, MD, professor of orthopaedic surgery at the School of Medicine, has been named the recipient of a top award in her field and of the largest-ever research grant in her department — both related to her work on pre-osteoarthritis.

Constance Chu

The American Academy of Orthopaedic Surgeons will present her with a $20,000 Kappa Delta Award on March 14; she will invest a portion in future research and share the remainder with her team. The award recognizes her decades of work in defining pre-osteoarthritis and for developing a new MRI technique to diagnose it.

"It is really a huge honor," Chu said, adding that the award is sometimes referred to as the Nobel Prize in orthopaedic surgery. "Our work early on was viewed with some skepticism, but our persistence and teamwork have paid off."

> "Our persistence and teamwork have paid off."

In addition, the U.S. Department of Defense awarded Chu and her team a $10 million grant last fall, and this month approved a set of clinical trials to study ways to prevent osteoarthritis from occurring after an injury.

"We're on a path toward preventing and finding cures for osteoarthritis and reducing the number of people who are disabled from joint pain and who need metal and plastic replacements," she said. "That's the most meaningful to me and my team — to make a difference for patients."

Early in her medical career, Chu realized that while there was a condition known as pre-diabetes and that there were risk markers for heart disease, there were no equivalents for osteoarthritis.

Predicting osteoarthritis

About half of patients who suffer an ACL injury develop osteoarthritis 10 to 15 years later, when the joint-cushioning cartilage has worn away to the point that bone rubs against bone. Regular MRIs and X-rays can reveal the damage only after patients are painfully aware of the problem and it's too late to reverse the osteoarthritis.

But Chu and two colleagues at the University of Pittsburgh developed a new MRI technique that can diagnose pre-osteoarthritis. The technique generates a color map of the knee cartilage deep below the surface. Now, when a patient has suffered an ACL injury, it's possible to see just one year later if pre-osteoarthritis is developing, long before a patient has symptoms and early enough, perhaps, for the cartilage to heal.

"We now have the makings of an early warning system," Chu said.

The only current effective treatment for osteoarthritis is joint replacement once the symptoms grow severe enough to warrant surgery, but knowing that pre-osteoarthritis is developing opens up the possibility that osteoarthritis can be prevented.

With the grant, Chu is conducting five studies, including two clinical trials that will test new strategies to prevent osteoarthritis. In one trial, her research team will look at how patients walk after injury and whether improving their gait can prevent the condition from developing.

In another, they will test gene therapy in horses, who develop osteoarthritis similar to the way humans do. The researchers will also study preventive medications, stem cell therapies and the molecular changes that lead to the deterioration of cartilage.

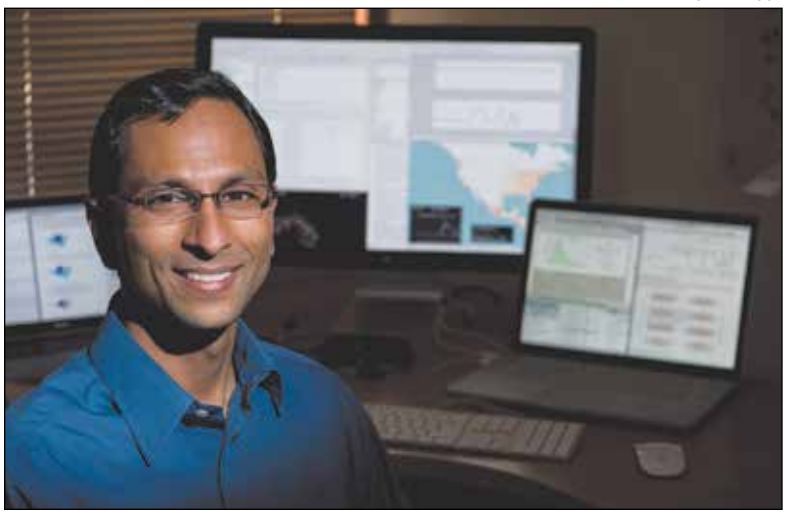
"Some patients are able to heal on their own after injury," Chu said, "while others aren't. These trials will help us determine how we can help those who need it." ISM

Doctors

continued from page 1

were considered: cardiovascular disease, cancer, infectious disease, respiratory disease and substance abuse or violence (such as death from alcohol and drug use, self-harm and interpersonal violence).

STEVE FISCH



Sanjay Basu laments that despite the clear correlation between better health and primary care, the number of primary care physicians is likely to continue to decline.

Bottom line

The association of PCP density with life expectancy was approximately one-fifth the magnitude of the association of poverty with life expectancy, and approximately two-thirds the magnitude of the association of tobacco with life expectancy.

Breaking that down to cause-specific mortality, the researchers found an increase of 10 PCPs per 100,000 people was associated with a 0.9 percent reduction in cardiovascular mortality, a 1 percent reduction in cancer mortality and a 1.4 percent decline in respiratory mortality.

"The surprising result was how much PCP supply has declined despite so much emphasis on primary care over the last decade," Basu said. "I think the problem comes down to money. We pay less for prevention than treatment — and the former is where primary care lives."

Basu believes another key benefit of the study is the methodology that was used.

"We tried to test whether this is just an 'association' at the area level, or more likely to be a causal connection," he said. "We looked at people who moved between ZIP codes and compared how their survival changed when moving to higher-PCP ZIP codes versus lower, controlling for other individual and area characteristics."

They found that those people who moved to ZIP codes with more primary care physicians had substantially higher survival rates, as much as 114.2 days per decade for every 10 additional primary care physicians per 100,000 people.

Basu laments that despite the clear correlation between better health and primary care, the number of primary care physicians is likely to continue to decline.

"The passionate students who care about population health really want to go into primary care," Basu said. "But they also have serious education debts and are looking at the paychecks for fields like dermatology, ophthalmology or urology. They don't actually find those fields compelling, but the pay disparity is often just too much for them to take a low-level primary care job instead."

Other Harvard researchers and researchers at the University of North Carolina-Chapel Hill and the American Board of Family Medicine Center also contributed to the study.

The research was supported by the National Institutes of Health.

Stanford's departments of Medicine and of Health Research and Policy also supported the work. **ISM**

Burnout

continued from page 1

Shanafelt first conducted studies on physician well-being almost two decades ago. Over the years, research uncovered evidence of growing distress and cynicism among physicians due, in part, to spending more time on clerical work at the expense of time spent with patients. Increasing workloads and regulations contributed to high levels of emotional exhaustion and job dissatisfaction. Physicians were leaving their jobs, and their suicide levels were markedly higher than those of other professionals. Still, the studies weren't being taken seriously enough, Shanafelt said.

"Anytime a study came out on physician burnout, people would say, 'Well that's true for all workers. Everybody is stressed out; doctors are no different,'" he said. "There was a need for an ongoing, nationwide study that would compare physicians with other workers in the United States."

"Physicians remain at increased risk for burnout relative to workers in other fields."

Third in series of national studies

In 2011, while he was at the Mayo Clinic, Shanafelt joined forces with other researchers and the American Medical Association to publish the first of what would be an ongoing series of national studies to measures changes in burnout levels among physicians at three-year intervals. This is the third study in the series; the previous two were conducted in 2011 and 2014. The studies have found that symptoms of burnout are markedly more common in physicians than in workers in other professions, even after adjusting for work hours and other characteristics.

To conduct the current study, researchers sent surveys to a nationwide sampling of physicians and workers in other fields. Among physicians, 5,445, or about 17 percent, completed the survey. Of these, 43.9 percent reported at least one symptom of burnout in 2017, compared with 54.4 percent in 2014 and 45.8 percent in 2011. Symptoms of burnout among workers in other fields remained the same — about 28 percent.

The improvement from 2014 to 2017 in symptoms indicating burnout were not seen among physicians in all specialties, the study reported. Levels among certain specialties, including general surgery and obstetrics and gynecology, failed to show any significant reduction in 2017. Also, the proportion of physicians screening positive for depression showed a modest but steady increase in the three studies: 38.2 percent in 2011, 39.8 percent in 2014 and 41.7 percent in 2017.

The researchers could only speculate about what may have contributed to the decrease in the burnout level in 2017. One possibility is that a large number of burned-out physicians left the workforce, so they were no longer included in the study. Another possibility is that 2014 may have been a particularly challenging time for physicians due to consolidation of hospitals and medical groups, a number of new regulatory factors, and increased administrative burdens. But Shanafelt is hopeful that growing national efforts by government agencies, professional organizations and medical institutions to improve working conditions for physicians may be making a difference.

PR IMAGE FACTORY/SHUTTERSTOCK.COM

"Over the last couple of years, we have begun to think about the well-being of health care professionals through the lens of the system and practice environment rather than through the lens of personal resilience. There are now large-scale national efforts, as well as efforts at the institutional level in many organizations, to reduce physician burnout and promote physician well-being," Shanafelt said. "We can't say for certain, but it's looking like those efforts may be starting to make a difference."

Mickey Trockel, MD, PhD, clinical associate professor of psychiatry and behavioral sciences at Stanford, was a co-author of the study.

Funding for the study was provided by the Stanford WellMD Center, the AMA and the Mayo Clinic Department of Medicine Program on Physician Well-Being.

Stanford's Department of Medicine also supported the work. **ISM**

Opioid

continued from page 1

in *JAMA Network Open*. Mathew Kiang, ScD, a postdoctoral scholar at Stanford, is the lead author. The senior author is Monica Alexander, PhD, assistant professor of sociology and statistical sciences at the University of Toronto.

'More potent than they expected'

Synthetic opioid deaths now outnumber heroin deaths, which suggests synthetics, such as as fentanyl, have contaminated the production process of other illegal drugs, like cocaine and methamphetamines, and is no longer limited to heroin, Kiang said.

"People aren't aware their drugs are laced and more potent than they expected, putting them at higher risk of overdose," Kiang said.

The research, which is based on data from the National Center for Health Statistics and the U.S. Census, suggests the opioid epidemic has evolved as three waves, based on the types of opioids associated with mortality:

- The first wave of opioid-related deaths, from the 1990s until about 2010, was associated with prescription painkillers.
- The second wave, from 2010 until recently, was associated with a large increase in heroin-related deaths.
- The third and current wave, which began around 2013, involves a rapid increase in deaths associated with illicitly manufactured synthetic opioids, such as tramadol and fentanyl.

Mathew Kiang

"The evolution has also seen a wider range of populations being affected, with the spread of the epidemic from rural to urban areas and considerable increases in opioid-related mortality observed in the black population," the study says.

The Centers for Disease Control and Prevention reports that African-Americans experienced the largest increase in opioid overdose deaths among any racial group from 2016 to 2017, with a 26 percent surge.

"The identification and characterization of opioid 'hot spots' — in terms of both high mortality rates and increasing trends in mortality — may allow for better-targeted policies that address the current state of the epidemic and the needs of the population," the researchers wrote.

States are trying to combat the epidemic by enacting policies, such as restricting the supply of prescription painkillers and expanding treatment and access to the overdose-reversing drug naloxone.

"Treating opioid use disorder should be our top priority to curb the problem," Kiang said. "Similarly, we have the ability to counteract the effects of an overdose. These lifesaving drugs should be easily accessible and widely available."

Another Stanford co-author of the work was Sanjay Basu, MD, PhD, assistant professor of medicine and of health research and policy.

The study was supported by the National Institutes of Health.

Stanford's departments of Medicine and of Health Research and Policy also supported the study. **ISM**

PEOPLE

Rare pulmonary defect prompts parents' search for answers

By Stacy Rollo

Carter Johnson came into the world on Jan. 9, 2018. According to his parents, Kelly and Malcolm Johnson, he was perfect in every way. But it wasn't long before red flags went up, and one of the couple's happiest days became shadowed with worry and fear.

Something wasn't quite right. Carter's color was off and he was turning gray, prompting the care team at his local hospital in Maryland to whisk him to the neonatal intensive care unit for tests. When their efforts failed to provide answers, the family was sent to a regional hospital for further examination. That's when they discovered there was no blood flow to Carter's right lung. He was diagnosed with a rare condition called absent right pulmonary artery.

Time was of the essence. Typically, this condition is associated with multiple congenital heart defects, prompting additional echocardiograms, more tests and a rapid search for answers. In Carter's case, his doctors determined that the uncommon malformation was isolated. But risks were high, as Carter's test results revealed pulmonary hypertension, and other complications could be imminent. Carter needed help.

Searching for the best treatment

Kelly and Malcolm were told by the regional hospital that the best course of treatment for Carter's condition was surgery but that he was not a candidate. This prompted his parents to start a nationwide search. Malcolm went into research mode and delved into pages of medical journals. He also sought second and third opinions from the nation's leading children's hospitals. All the results of his research pointed to the same treatment plan of placing a shunt to initiate blood flow to the right lung. This plan would require repeat surgeries throughout Carter's life to up-size the shunt as he grew. One night, Malcolm was on his laptop and came across the Pulmonary Artery Reconstruction program at Lucile Packard Children's Hospital Stanford. He shook Kelly awake and told her, "I think I found it."

"I'm stubborn by nature," he said, laughing. "I just felt there was something else for Carter."

The next day, Kelly and Malcolm were on the phone with Jennifer Shek, a nurse practitioner in cardiothoracic surgery at Stanford Children's Health. She told them Carter was a promising candidate for the program. The surgical team was led by Frank Hanley, MD, professor of cardiothoracic surgery and chief of pediatric cardiac surgery, and Doff McElhinney, MD, professor of cardiothoracic surgery and of pediatrics. Stanford Children's Health has been recognized worldwide for using innovative approaches to surgical management of complex pulmonary artery procedures. The team revealed that Carter did, in fact, have a pulmonary artery, but it was in the wrong place. The doctors diagnosed Carter with discontinuous pulmonary artery resulting from a ductal origin. Their unique surgical approach to Carter's case would restore his lung without requiring any long-term treatments. Kelly and Malcolm could barely believe their ears.

JOHNSON FAMILY

Carter Johnson had two surgeries at Packard Children's Hospital.

Exceeding all expectations

Any parent who's had to watch their child be taken away for surgery will tell you it's one of the toughest things you can go through. But Kelly and Malcolm said the care they received at Packard Children's helped them get through Carter's surgery. "Everyone exceeded our expectations. We didn't have one negative interaction," Kelly said. "We received constant updates on Carter's status, and we really felt empowered in how we played a role in his care."

Carter had two repairs in all. In his first surgery, a shunt was implanted to establish blood flow to his right lung. The second surgery, which happened five months later, in November 2018, was the final artery construction in which Hanley removed the shunt and connected the grown pulmonary artery. During the five months between the two surgeries, Carter's pulmonary artery grew to normal size, surpassing the doctors' expectations.

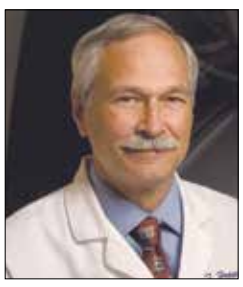
Today, Carter is back home in Maryland and doing well. His hometown medical care team — from his pediatrician to his cardiologist — have communicated frequently with the Stanford team to ensure the boy's care is fully coordinated.

"Dr. Hanley and his team have delivered on their promise that Carter will live a normal life," Kelly said. "Dr. Hanley told us Carter will be repaired and he will run, play baseball and have no restrictions. As parents, that was our greatest hope." ISM

OF NOTE

reports on significant honors and awards for faculty, staff and students

Karl Deisseroth



Richard Hoppe

Mark Nicolls

KARL DEISSEROTH, MD, PhD, the D.H. Chen Professor and professor of bioengineering and of psychiatry and behavioral sciences, was elected to the National Academy of Engineering. He was honored for pioneering molecular and optical tools for discovery and control of neuronal signals affecting behavior in health and disease.

RICHARD HOPPE, MD, the Henry S. Kaplan-Harry Lebeson Professor in Cancer Biology and professor of radiation oncology, will receive the inaugural American Radium Society Gold Medal Award in recognition of his exemplary professionalism, leadership, contributions to the field of medicine and service to the society.

MARK NICOLLS, MD, the Stanford University Professor in Pulmonary and Critical Care Medicine, was awarded a $2.3 million R01 grant from the National Institutes of Health. The four-year grant will support his study of the role of inflammation in lymphedema, a chronic condition caused by lymphatic obstruction that leads to disfigured and swollen extremities.

TERESA NICOLSON, PhD, was appointed professor of otolaryngology-head and neck surgery, effective Jan. 1. Her research aims to understand the molecular basis of hearing and balance, with a focus on studying the function of deafness genes and developmental aspects of sensory hair-cell activity and synapse formation.

DAVID OUYANG, MD, cardiology fellow, has been awarded the American College of Cardiology/Merck Research Fellowship in Cardiovascular Disease and Cardiometabolic Disorders Award. The $70,000 award will support his study of big data analysis and machine learning in cardiovascular imaging.

MANALI PATEL, MD, assistant professor of oncology, and **LISA GOLDMAN ROSAS**, PhD, assistant professor of health research and policy and of medicine, are among five principal investigators leading a new project funded by a $3 million California Initiative to Advance Precision Medicine grant from the Governor's Office of Planning and Research. The grant supports proof-of-principle demonstration projects for patient populations suffering from cancer health disparities, with the aim of improving access, care and outcomes through collaboration between academic, community, nonprofit and private partners. Their project is focused on Monterey County.

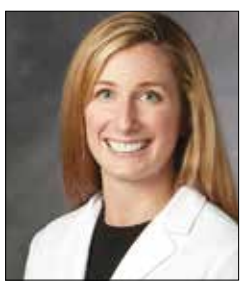
CORINNA ZYGOURAKIS, MD, was appointed assistant professor of neurosurgery, effective Jan 1. She specializes in the comprehensive surgical care of the adult spine, including revision surgery, and treats complex spine disorders, such as spinal deformity and spinal tumors. Her research examines health care costs, quality of neurosurgical care and spine surgery outcomes. ISM

Teresa Nicolson

David Ouyang

Manali Patel

Lisa Goldman Rosas



Corinna Zygourakis

Exhibit

continued from page 3

hands, began each piece with a ritual of repetition that used positioning and stress to create weakness in his hands and arms. Then he painted.

What arrived on the canvas was a direct product of that physical vulnerability in brush strokes and movement. Wetschler views the ritual itself as the art; he said he felt color would detract from the viewer's comprehension of the ritual.

The location of the exhibition in the School of Medicine also becomes part of the viewer experience.

"There is something cyclical about showing [at the School of Medicine]," he said. "This is an expression of my own healing in the place I learned to become a healer. It becomes a statement of how that is an active process for all of us. Sometimes we are the healer, and sometimes we need to be healed."

The first time Wetschler returned to the site of his accident, he brought a canvas, but he did not start painting immediately. Instead, he drew a large circle in the sand, walked the 200-foot perimeter as a ritual, then went into the frigid ocean. He repeated this circle-walk and ocean dip 13 times to induce hypothermia and weakness, but surprisingly, he found his final laps were his strongest. He then hurled his body, sand and all, onto a paint-covered canvas. The work in the exhibit titled *Reentry* is the result.

"My accident was a manifestation of an individual encountering the chaos of world and his own frailty," he said. "We aren't in control. Things can change at any moment. In emergency medicine, we are exposed to people's vulnerabilities. That requires a certain constitution to face every day and still remain emotionally whole. … The antidote is adopting the perspective that crazy things can happen, and we will always rise to the challenge. Hopefully I'm living proof that even if we break ourselves in some way, we can still move forward. Within us is a deep well of capacity we underestimate. There is strength in acknowledging vulnerability and still persisting."

Wetschler said he plans to return to practicing emergency medicine this month. ISM