FACULTY INTERVIEWS

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What does digital health mean to you or how would you describe it to others? There are a lot of different definitions out there.

I think of it broadly to mean any way of making healthcare better by leveraging digital technologies. Simply put, it's the use of commonly available digital devices to make healthcare better.

As far as digital health is concerned, are the lines blurred as far as how the field is developing? Is it fairly clear to you what digital health is and isn't?

I would say the lines are somewhat blurred because I don't think anybody can accurately predict how all of this is going to evolve. I think we can look at other enterprises that have been changed by application of technology, like banking or finance, and see how human interactions change with application of digital tools. However, for healthcare this needs to be both more efficient and personalized.

Have you always been at the forefront of technology or has that been more of a recent development? If you try to trace back your entry point into the digital health space, what does that look like?

I'm not a person who has always stayed up to date on the latest technology. I've learned to do that out of necessity because of my research interests. It wasn't for a love of technology that I decided to enter digital health. It was because I saw a big problem in orthopedic and neurologic clinical care and research that can be solved through digital health tools. More specifically, early in my career, as a clinician and as a budding researcher, I became quickly frustrated with the subjectivity of the science that underpinned the treatment of people with back pain and all other kinds of orthopedics and neurologic problems. The science was built largely on outcomes from questionnaires provided to patients, our knowledge base is largely subjective. This is quite different than research and clinical care in cardiac disease or cancer, where the outcomes measures are mostly quantitative and objective. Comparing progress in these areas shows vast differences. In a few decades, cardiac care and cancer

care have progressed dramatically through multiple iterations built on precise measurement of outcomes. There just has not been an ability to do this for back pain treatment, which was my primary clinical focus. The same applies to nearly all orthopedic and neurologic diseases. When I got my first iPhone I had the "aha moment" that led me to the digital health space. I thought wait a minute, this is a thing that can help us quantify the things that we care about in our research, and that the people I treat in my clinic care about. We can do it in a way that can provide objective and quantifiable measurements like those that have allowed cardiac and cancer care to advance over time. So that's what led me to first ask the question, "How can I use my iPhone to measure human function or human performance in the real-world, which is the primary measurement that researchers and clinicians look for from treatment of orthopedic problems, including low back pain? How can we use these common digital devices in order to measure the things we care about in a quantifiable way rather than in a subjective way?"

So, the "aha moment" came when you first got the iPhone for personal use?

Yes. I'm a physiatrist, also called a physical medicine and rehabilitation (PM&R) doctor, and physiatrists focus on human function. Just like a dermatologist cares about the skin, just like an orthopedist cares about the bones. We care about human function. So, I understood that an iPhone had potential to measure function in a way that was not previously possible.

What year was that? (When you got your first iPhone?)

Late 2007. This was also six months before I got a phone call from one of my former mentors at Stanford. I had trained at Stanford then took a job at the University of Michigan in 2002. I was there in 2007 when these thoughts were moving around in my head. Having done some background research I found that nobody appeared to be looking at using iPhones in this way, so I started to imagine how I would go about developing a research program focused on this opportunity. Around this time I got a call from one of my former mentors at Stanford who asked if I was interested in coming back to Stanford to help rebuild the PM&R program here at Stanford. So when I came to interview for the position, I made sure to talk to some people who were involved in research using similar digital tools. It was then clear to me that Stanford was the right place for me to develop my research ideas and I moved back to Stanford in 2008.

How does digital health contribute to your motivation to keep learning or growing and to look for new technologies that can improve those outcomes? How would you describe how digital health enables that as opposed to maybe more traditional means of providing healthcare?

Specifically to the problem I'm trying to solve, it gives us a tool where we can measure what people are doing in their daily lives, in their normal lives, and see the impact of disease on their daily lives and changes that occur due treatment. Whether we recommend physical therapy or whether we recommend surgery, whether we just recommend changes in habits, we can actually measure how people respond. We can base decisions on each individual's history since these devices can provide a historical record. It sounds fairly easy, but as it turns out the types of things I need to look at from the device are more nuanced than what the devices currently provide.

For instance, I can't just look at a person's step count or the number of exercise minutes. Those things aren't sufficient to provide the granularity of information that's needed to be meaningful for somebody with low back pain. What the people in my lab are working on is developing the algorithms that can provide the type of information we need. Ultimately the companies that make smartphones, smart watches, and other personal devices can include our algorithms to routinely measure things that have greater health implications. Our work on this is hypothesis driven. We know from clinical insights that there are certain data streams provided by the digital devices that are more likely to provide fruit and we interrogate those data streams or features or information streams that prove meaningful when compared to currently used research tools.

In terms of just your own digital health work, what would you say that you're most proud of? (A project or an initiative)

I am most proud of our work to redefine how researchers can use physical activity monitoring in populations with pain and mobility limitations. Prior to this work, physical activity monitoring had only been looked at as a means of measuring a person's energy expenditure. That's important for fitness research or work on diseases where energy expenditure impacts health, but it has very little to do with changes in behavior caused by back pain or knee arthritis. We defined the parameters that are meaningful in looking at the influence of pain on a person's physical behavior. That was an important innovation that allowed us to objectively quantify human function as it relates to pain and to learn more about orthopedics disease.

One of our publications that received a good amount of press and that provided an important insight was a study that used our new methods to demonstrate, for the first time, that physical activity is one of the important mechanisms that links obesity to low back pain. Researchers had looked at this question in the past, but only using the traditional self-reporting. By using objective and quantifiable measures we were able to show that habitual physical activity has a strong influence on the link between obesity and back pain. (Outstanding Paper: Medical and Interventional Science- Does Physical Activity Influence the Relationship Between Low Back Pain and Obesity? Matthew Smuck, MD; Ming-Chih Kao, PhD, MD; Nikhraj Brar, MD; Agnes Martinez-Ith; Jongwoo Choi; Christy Tomkins-Lane, PhD)

Do you think that outcomes will really be improved or is PM&R and orthopedic still behind the curve as far as actually improving outcomes or the standard of care?

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Outcomes will definitely be improved over time with these types of tools, not just in things like PM&R and orthopedics that need better objective outcomes, but even in things where outcomes are already objectively measured. These tools can impact many fields that currently rely largely on subjective information from questionnaires such as PM&R, orthopedics, psychiatry, and neurology. Some physicians I know fear that AI and these digital tools will replace doctors. I disagree. I think what will happen is that these tools will allow doctors to spend more time doing the things that we are uniquely trained to do.

How do you filter through the technologies that could potentially be beneficial? Is it hard to find the ones that have actual clinical efficacy or provide a benefit?

I probably approach it like the average doctor, and that is I'm not trying not to be an early adopter of these things. I wait until I see what others have experienced before making decisions. Since most physicians practice in larger systems now, instead of independently, we do not have as much control over these things as you might think. We largely use the tools provided by our institutions.

What is it about Stanford that allows for digital health initiatives, projects or ideas to flourish? What makes Stanford different, where these opportunities can really be successful?

When I arrived at Stanford, I knew about good clinical research, but I didn't really know how to approach translational research. So, one of the first people I met with once I arrived on campus was Bill Haskell, who is the director of the Stanford Prevention Center. The Prevention Center was one of the international

leaders in physical activity research, and I spent some time talking to Bill about my ideas. And he was very generous with his time and also generous with some of his resources, and assigned one of his post-docs to work with me in carrying out some of the very first studies that I performed in this space. Bill has remained a mentor to me over time, even after his retirement.

From there I gathered a little bit of momentum, I started working with more people around campus and with students from different labs. Most notably, Scott Delp in Bioengineering has been very helpful. Scott established the Mobilize Center with NIH funding and got me involved with his team. Our efforts are very complementary and his insights always help make my work better. I also worked with Nigam Shah in bioinformatics to help one of his PhD candidates through his doctoral thesis on knee osteoarthritis and physical activity monitoring. These types of connections happen very naturally at Stanford through different research events and meet-ups on campus. I don't even remember how I first got linked up with Scott Delp. I think it was through the recommendation of a colleague to meet with him. Scott was very generous with his time, agreed to meet with me and saw a lot of potential and the things I was talking about which allowed us to work together. I remember I got introduced to Nigam Shah through a student who was working with me on research. He was presenting at one of the Bio-X meetings when one of the students from Nigam Shah's lab noticed his work and then brought Nigam over to talk. From there we set up a meeting, and that's how that whole collaboration started. Stanford is a very unique environment. One of the reasons I came here with the digital health idea in mind is I knew that it would be a much more fruitful environment, not just because of proximity to Silicon Valley, which has also proven useful in some interesting ways, but also because of the different types of researchers and the interdisciplinary collaborative nature of Stanford.

What do you envision are the next developments or trends over the next 5-10 years in digital health? Is there anything that specifically excites you? How do you see the field developing?

Well, video visits are already happening, and have expanded dramatically with COVID-19. This will likely trend further upward in the future. I think that barriers for people having contact with their healthcare providers are going to start to go away which will facilitate better communication. What I mean is, as you know, scheduling an appointment is a very onerous task currently and it doesn't need to be that way. I think digital tools are going to create new scheduling systems and video visits will facilitate a better, more efficient use of the health system for the patients in particular, because a digital visit can be just as useful for the clinician as an in-clinic visit. It doesn't really make a difference in many circumstances. Alongside that, I see a lot of opportunity for these new data streams to inform the clinical system: like physical behaviors and how that might influence orthopedics care. All of this can be pumped into the EMR to provide information to the clinician when needed. We currently see very little of this information, almost none it from a digital health perspective, but I think that's going to change in the next five to ten years. That type of information

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is going to come in and inform the clinical decision making. Another thing I see happening over the next five to ten years is better use of these digital tools, not just from the things that I'm looking at, but the way that people are leveraging information from the digital tools around heart health, around mental health, and so forth. All of that is going to become very important because the health policy makers want to move the health system away from our current fee for service model and towards a value-based model of health care delivery. When that happens we will need to have systems in place to measure outcomes at scale. This is because value-based healthcare is based on outcomes over costs. The costs of care are easier to calculate while the outcomes are challenging. If we rely on patients to provide answers about their health by filling out questionnaires each time they interact with the health system, the system will fall apart due to the overwhelming responder burden placed onto the patients. If you've been to the doctor in the last couple years, you probably received a questionnaire after that visit. Hopefully you are healthy and don't get those questionnaires very often, but imagine the more typical person that comes to a physician with four or five diseases. Now imagine receiving questionnaires for each of these conditions each time you interact with the health system, not just to follow up from the most recent encounter but also from the one six weeks ago, and the one six months ago. You can see how that system falls apart. Having

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