Episode 44—Jay Pandit: How biosensors are enabling a new era in medicine

Lauren (00:08):

Hello, listeners. I'm your host Lauren Fish and a warm welcome back to another episode of Science Changing Life. This episode is airing during a special time in Scripps research history. We're celebrating our hundred year anniversary this year after our founder Ellen Browning Scripps, established the institute in 1924. Things have changed quite a bit over the last century, and today's discussion is certainly evident of that. We'll be talking about how wearable technologies are changing the face of science and healthcare as we know it today. Joining us is Dr. Jay Pandit, director of Digital Medicine here at Scripps Research and Co-host Drew Duglan. Jay starts off by telling us how his wide ranging experiences led him into the healthcare world, all with the intent to make a change.

Jay (00:52):

I was born in India, raised in Kenya, Africa for about 16 years, and then came out here in the United States in 1999. It's been more than a couple of decades. That journey really defined my interest and passion in science because I kept searching for an identity for myself. And I think in searching for an identity, I got interested in finding out how people interact, how people are made by their journeys, how they interact with different cultures, with themselves and with different systems. I was always interested in how does one person take that sort of interaction and turn it into who they are. And because that was the case, it first started with this interest or love for anthropology and really understanding how people and cultures interact with each other. And then the interest in biology came up because of an extensive family history of cardiovascular disease, whereby on my father's side, there was almost every single male above the age in the last three generations that had some sort of a cardiovascular event, like a heart attack or a stroke before the age of 50.

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And I said, okay, interesting. So as I'm learning more about people, I'm also learning more that people inside internally, there's an entire world that's happening within, and yet we also need to work with the world outside to define who we are. So there's so much going on, and I fell in love with that complexity when I got my undergraduate education and I came out, I actually majored in biology and minored in anthropology, cultural and social anthropology because I wanted to kind of mix these two. And I said, the first thing I want to do if I become a care provider or a cardiologist or a doctor at the time I was thinking going to medical school was to make medicine relatable because it's still this esoteric thing that a lot of people at the time, and this was way back in the early two thousands, where people still felt like, Hey, if I have to go to the doctor, I'm going to have to relinquish control.

(02:43):

To me, that felt like it's not fair. You should be able to go into the doctor and have a symbiotic relationship with that person who's going to make clinical decisions for your care. And I'd seen this in the care of my patients, of my parents and my relatives. And so I said, okay, I think I can make a change here. And then as I started looking at how people interact with the medical system, I realized, okay, there's so much that's antiquated that really we can work on. There are a lot of things that people do in their real lives that medicine really just doesn't take seriously. Wearables being one of them. And I think that's kind of how all this came together into this career in digital health always with this whole concept of how do you make medicine more personal and more relatable.

Drew (03:29):

Yeah, it's an amazing human-centric approach, and it almost makes the case for all sort of physician scientists having that somewhat of a background, whether it's anthropology or psychology, behavioral economics. It seems like that would be a real asset in the medical training.

Jay (03:45):

Absolutely, and I will say that I think having practiced for over a decade now, initially internal medicine and now cardiologist, I think I became a much better doctor after I got diagnosed with brain cancer myself. And this was back in 2016. For six months, I had to go through speech therapy, spent a lot of time in silence looking at the interactions and how patients and doctors interacted with each other, how physicians would come and talk to me. And I just realized there was this sense of you really do have to relinquish some control, and unless you've experienced that uncertainty that not knowing what's going to happen with my prognosis, especially when I have a syndrome that doesn't necessarily have good prognostic data, unless you've experienced that, you can't really put yourself in the patient's shoes.

Jay (04:39):

I get MRIs every three to four months still because there's always a risk of recurrence, and it's one of those diseases that never goes away. It's always going to come back. You just don't know what time and when. But yes, I am in a much better shape now, chemotherapy, radiation, and all that is done. It was an active recovery process for about two to three years, and then after this, we're just in surveillance right now.

Drew (05:03):

Sure. Wow. Yeah, must've really put that idea of personalized medicine in perspective. And so how was it that you, either from a personal point of view or professionally, how did you sort of get involved in the study of biosensors and wearable technologies?

Jay (05:20):

Right, and this happened before, even before my brain cancer diagnosis and my initial seizure that all that happened in 2016, but I was always one, having gone to Stanford undergrad, there was always this exposure to a startup era in electrical engineering, et cetera, the venture capitalist space. This was the time when activity trackers were growing. And then I went to UCSF for medical school and residency, and then there again, lot of industry academic partnerships happening. And then I went to Northwestern for cardiology. And there again, I was always shocked by the fact that there were so many people in the consumer space utilizing wearables and sensors collecting these biometrics that I am being trained to use in making clinical decisions, but we don't take them seriously because they're not either FDA or FDA A approved or CE marked or because there's just no good pathway for us to utilize that data and trust it.

(06:24):

And every day we were seeing a new heart rate measurement, wrist wearable coming out. Then there was the pulse oximetry measurements that are coming out. Then there's new devices coming out that are measuring continuous temperature. And at that point, I was seeing patients towards the end of my training in cardiology, I was seeing patients in clinic where I could clearly see one in five patients with white coat hypertension. They'd come in, they'd have a completely different measurement from what their home blood pressure logs showed. And I got frustrated. I was like, why are we not looking at a wearable for blood pressure? Now, first, taking a deep dive in, I realized that people had tried, it was one of the hardest things to do to get a wearable blood pressure. The other vital signs were much easier acquired through optical sensors, but blood pressure is much tougher.

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And so that's what I did. I said, okay, this is going to be my research project. In the third year of cardiology fellowship, you are supposed to be focusing on research output. And at that point, I said, Hey, building a device, testing a device, validating a device is research. You have to do deep dive and see why many companies, many other folks failed in trying to build this because naturally it made sense. You're collecting vital signs. Why can we use this vital signs? So let's first actually make sure that we get a good gamut. We covered the entire gamut of vital signs. And so we came up with an approach of collecting blood pressure through LED sensors and the thumbs. And so that was my first foray in. After doing a deep dive, I figured out, okay, getting a heart rate from using an LED sensor, it's actually very easy.

(08:04):

You can buy off the shelf LED sensors and just put them next to your finger. And that was considered novel 10 years ago, but now it's so easy to do. And so at that point, we built out a prototype. We actually founded a company, and that was my foray into biodesign and entrepreneurship. And so we went out and raised some funding, applied for an SBIR grant, which was all an education of its own for me. And I realized that that education is important to understand when you're actually looking at how to integrate these devices and sensors into clinical care, because you know what the incentives are when you're actually just when you're building a device and taking it from zero to one, at that point, the incentives are completely different. All you want to do is make sure that it's non-inferior to what exists so you can push it out and start selling it.

(08:56):

But that in itself is a problem because on the other end, we can't just apply it generally to everybody because the data that we get is not going to be generalizable. You're going to have trained your device on a smaller, less representative dataset of people. And so at that point, it's nice to be able to understand both incentives because we need to test the device on a larger population to see if it actually works. And so that's where my foray began. Okay. We were at a point, I kind of understood the electronics that went into this, understood the human factors that went into actually making a device that's practical and useful, and I got that education at that point.

Drew (09:36):

Yeah, that's an amazing firsthand experience and actually building one of these devices. And so before we get into some of these different wearables, I guess could you just give us a summary of what are the most common vital signs we take and what kind of information can they give us?

Jay (09:52):

So I would say that the very first foray into this was with heart rate monitoring, which is done typically through an LED sensor. And heart rate is a vital sign that we typically measure. The common four vital signs that we talk of are heart rate, blood pressure, a breathing rate or respiratory rate, and then temperature. And then if you add on a fifth, sometimes it's oxygenation. And that's the most common thing that we measure. When you can walk into the clinic, it's the first thing that gets done. A medical assistant or a nurse or somebody who's going to come in and take those vital signs while you wait to get an opinion from the physician. What's surprising about that is that that's one single snapshot, and based on that one single snapshot and that moment in time, we have to make these clinical decisions about what's happening in your life outside when in reality the real data or the more accurate data is what's coming through the wearables. And so those are the four vital signs. And I think that the absolute numbers can be very deceiving. It's just the partial picture of what the actual complete picture is. And if you can start getting those vital signs and looking at the delta in those vital signs in each individual, that's when you're actually personalizing medicine.

Drew (11:04):

Yeah, it's incredible that you get such a comprehensive long-term data with this continuous monitoring. And I presume as well, it must be great for the patient because they don't want to go into a doctor's office as much and they want more telemedicine. It's presumably less invasive too than some of these historical ways of taking these measurements. And so in terms of the actual technologies themselves, I mean, a lot of people are very familiar with the basic sort of wrist wearable fitness tracker, whatever devices, people like best. And you've got the rings now as well to track those kinds of things. But what are some of the latest developments in these technologies that you're excited about and how are they being used now in clinical research, either broadly and by your team?

Jay (11:53):

Yeah, no, absolutely. So the form factors have just exploded. You've got rings, you've got wristbands, you've got chest patches, you've got necklaces, jewelry, apparel, earbuds, contact lenses, name it. Anything that you can actually apply a set of electronics on a miniaturized form of electronics on can be used to collect biometric data. You can largely group them as biophysical sensors versus biochemical sensors. And I think what's exciting initially is this, in the biophysical sensor space, you're collecting things like, I would say that from a raw signal standpoint, in a non-invasive way, there's only five or six different true electronic signals that you collect. The rest of it is just derivation, like photo discography, signals like optical signals, thermal signals on temperature. You can get modular signals on movement, you can get some. The other one that I'm thinking of is escaping me, but there's only four or five different signals that you can use to collect and make derivations on the data.

(12:58):

And then those are used to get things like heart rate, temperature movement, gait, oxygenation. That's what I mean by biophysical sensors or those are the biometrics that we're talking about. Then we've taken a step forward already in getting noninvasive approaches to get signals about what's going on in our blood, in our biofluids. So biofluid signatures like getting continuous glucose, getting blood alcohol levels, getting lactic acid levels, which kind of tells you whether or not you're an anaerobic, how much oxygenation you're going through. You've got electrolytes that you can measure, vitamin levels that you can measure. And so I think you can largely group these clinical wearable sensors into biophysical versus biochemical. The exciting component though now is that we're moving away from just trying to replace the physical exam, which is the four vital signs towards the concept of being able to do continuous imaging.

(13:59):

So a recent study out of UCSD just came out saying that we've got a chest patch that can do continuous ultrasound. And so I think that's the next level. It's a very nascent space right now, but I think that the whole goal here is doing all this in real world, and I think we've moved, we've kind of moved away from, not moved away, but necessarily evolved from just asking the question around is the data being collected by these sensors accurate anymore to what to do with the data? What should we do with the data? Because now we're getting oceans and oceans of data from these different research studies where they're being applied in episodic manner, in longitudinal ways that sit there. Most of the time they're evaluated in silo. So we're just looking at heart rate continuously. You can find different biometrics in heart rate or different digital signatures in heart rate because we've never done this before, but think about the fact that we have so many other modes of data with heart rate, temperature, electronic health record, et cetera. Nobody's putting all of this together because we're still working on that. We need to figure out how to harmonize that data and then turn it into clinically actionable output and make that real time, which is why large language models are so exciting because they've just come out because they have demonstrated the ability, the processing power to actually be able to harmonize this data and look at patterns that the human and that analytics just don't pick up.

Drew (15:36):

So presumably all of these studies have to be done with the provider of the device. So how do you see the data either being shared or sort of kept at an individual level to whoever's doing the study? Are there challenges there or is the community quite open about getting this data out on these large population studies?

Jay (15:58):

That's a great question, and I'll say that it's evolving. What my team does is we are pushing the boundaries of what you can collect with wearable sensors in the real world and providing and learning about how best to keep participants engaged, users engaged in data collection, how best to harmonize that data that we are collecting, and make sure that there's a return of information to the individual so that they remain engaged and pushing the boundaries on that and see how deep can we get in data collection using noninvasive sensors in the home. And so you're saying that in many situations, yes, we have to partner with the device manufacturers to get donation of devices in kind, but there are situations where we are the study sponsored by somebody who is looking at the field of diabetes, interested in the field of diabetes, and they're willing to just purchase these devices and we can utilize them in our study.

Drew (16:55):

Gosh, it's such a fascinating space and there's so much potential. I know even at Scripps Research, we've got studies on maternal health, sleep health, we've got continuous glucose monitoring and diet monitoring. And so looking wider to the other organizations, and even on the pharmaceutical side, do you see these being taken up in say, clinical trials now for different drugs to monitor responses?

Jay (17:22):

Absolutely. We went down, there's a whole field of, we call 'em digital biomarkers. That whole field of digital biomarkers had a lot of excitement. It was just they had early adoption and then suddenly it didn't get traction because it's very hard to get these digital biomarkers are regulatory approved, but now it's coming back because now we are matching the ability to actually process that data and analyze it and come up with patterns that we were not able to recognize, again, through human analytics, but a large language model potentially can. And then we need to test those models in cohorts going forward to be able to use them as silver standard outcomes in these studies. So if you have a drug, it makes sense. If you have a drug, I'm going to make this very simple. You have a drug that prevents heart attacks. You need so many people to get one primary outcome of a heart attack, and you might have to monitor them for 10 years at a time.

(18:21):

Those trials cost millions of dollars. But if you can have a silver standard biomarker like a digital biomarker that shows early on the initial progression towards what's going to eventually turn into a heart attack, that lowers costs for studies so much more. And there's just a disagreement around whether these are valid or not, and especially in, and the pushback is, especially from regulatory authorities because we're talking about human lives and disease, and so there's actual real consequences. But the way to get around that question or that pushback is just more studies, more education around this opening up the proprietary barriers that exists. So we can actually put all this data together and we are leading the charge on this.

Drew (19:10):

Sure, yeah. I mean, gosh, if it can just bring down costs so dramatically, I mean the amount of potential innovation there is amazing. But I mean, I don't want to sound cynical in any way, but obviously you've got the whole insurance reimbursement side on the healthcare. So are there barriers there as well as bringing in these technologies to make things cheaper and more efficient?

Jay (19:31):

For the longest time, people have thought of reimbursement being the killer of innovation in clinical medicine, but unfortunately, it is the reality. It's the reality that we have to work with and live with. And in any way, if you think about it in a different way, it is just pushing us to de-risk this technology in the best way possible so that it's accepted by the payers. And it's just a question of building enough of the evidence that's there for how these technologies can affect positive clinical outcomes, how they can reduce negative clinical outcomes. And you keep building enough when you get to a point where it's undeniable. And that's already happened in the space of ambulatory electrocardiography with patch monitors that exist out there. In the past, people used to have to wear these wired monitors to monitor their electrical rhythm, to identify heart rhythms that are abnormal for 48 hours, which clearly affected their quality of life.

(20:29):

And now we have these beautiful monitors that are the size of a palm that are waterproofed. They sit there, it can be monitored for 14 days. When you're done, you just mail it off and it gets evaluated and it gets sent back to the provider that prescribed it. And that has clearly made it into the clinical practice realm. The next one that's coming up is continuous glucose monitoring. It's slowly making its way into the clinical practice realm because the data of evidence behind it is just so strong. We just need to keep doing this with other sensors.

Drew (20:58):

I had heard a while back when I was at a digital medicine conference, people were talking about, like you mentioned, the electrolytes and measuring lactate and glucose, not just wearable monitor in terms of a tracker or a device, but also tattoos. Is that a thing?

Jay (21:13):

Yeah, yeah. So we've had collaborators like Dr. John Rogers at Northwestern, Dr. Joseph Wang here at UCSD. Their lab groups have made significant advances in the field of flexible electronics, and they're very interested in their use in clinical medicine, in the clinical realm because if you've got a stretchable elastic tattoo, it's very unobtrusive to the lifestyle of the individual so that you can actually achieve passive continuous monitoring because that is the ultimate goal. The ultimate goal is that you want to be able to monitor the individual with their consent, obviously, but monitor them without intruding in their lifestyle so that you can actually see in reality what's going on. If somebody knows that their blood pressure is being measured, that in itself has an impact on their blood pressure. But if they don't know that they're being monitored, that's when you get the actual picture. And so I think that's a very exciting field.

Drew (22:07):

And another thing I saw come through, actually largely on the athletic side, but is the growth of the use of heart rate variability. So people will be familiar with the basic beat to beat of the heart, but can you actually talk about heart variability and what that actually means as a metric for health?

Jay (22:25):

Absolutely. So in the field of athletics, in athletics, I think that's a very known common indicator of good health versus poor performance and heart rate being one of the most commonly collected parameters. We are trying to look and see within the heart rate's measurement, what are other signatures or signals that we can use? So heart rate variability simply is what is the time between each beat over a certain interval, usually typically measured over 24 hours or so, and it is presented when we do these heart electrical rhythm monitoring with these patch monitors, it is presented as a parameter on those reports. But I can tell you as a physician, and having talked to so many different physicians, most of the times physicians don't even use it, but it's probably used more in training for athletics. And now we're starting to see that actually when trainers, when people training for marathons wear it and they're sick, the variability goes down that when they're actually training at an elite level and higher altitude, it goes up.

(23:34):

And so when you start seeing this consistently in different people, different individuals, you could put together and say, oh, maybe we can use population level heart rate variability to see if there are hotspots for infectious disease in a certain area. And those are the kinds of questions that come to mind. Can we develop a surveillance network using wearables? And that's some of the research that we've been actively very involved in during, and that happened during covid. The goal being, can you identify individuals or hotspots with variations from people's vital signs and based on their reported outcomes or power or subjective outcomes, subjectively reported outcomes and how they're feeling, yeah, it's just going to expand from there. Can you find exacerbations in certain chronic diseases based on these wearable devices? The applications are endless at this point in my

Drew (24:30):

Mind. Right. And you had mentioned earlier the application of artificial intelligence, and everyone is familiar, I think at this point with chat GPT and some other similar programs. So when it comes to using this artificial intelligence with biosensors and wearables, where do you see the biggest sort of applications? Is it on just the data collection and streamlining side? Is it actually interpreting what it means or sort of implementing interventions down the road?

Jay (25:01):

I think that large language models and the idea of generative artificial intelligence is definitely going to change the way we practice medicine. That's one, that's a very general statement in specifically. Obviously, we're already seeing in repetitive task efficiency, like note taking, billing, generating, prior authorizations, things like that. It's a given that these things are going to become very streamlined. Now, the more exciting piece, which involves feeding data sets to a large language model, and when I say large language model chat, GPT is a large language model. GPT four, which is coming up now, is another large language model. We are going to be able to feed these data streams, and right now mostly those data streams are text. We turn text into text, then they're open eyes, Dali two, and then mid journey and all the other ones can turn text into image. We're going to get to a point where we can turn waveforms into text, and when we turn those waveforms into text, we'll be able to feed your biometrics into text. If you do biometrics into a large language model, and that large language model will tell you, Hey, by the way, you are different from yesterday because maybe you're starting to develop a upper respiratory infection.

Drew (26:29):

That metric signature and telling you where you're at, what you could do perhaps what's wrong, all of those things. Incredible. Well, I would be remiss if I didn't ask, do you have wearable devices? What's your favorite tracker or Oh,

Jay (26:48):

I absolutely, I mean, I sequentially go through, there are times when I have at least five at times, but I'm embarrassed to say today it's just the Fitbit that I have here. I've tried the watch, I've tried, I've tried whoop band, I've had patches on me. But I would say that what's interesting is there's, in my opinion, I think that we've got wrist wearables, we've got biosensors in wrist wearables, we've got chest patches in wrist wearables. I think that the ring form factor is a fantastic one, but at the end of the day, we run into the problem of continuously getting data beyond six months. Engagement is a piece that really has been a difficult challenge for us to overcome. You get great data when the person gets involved and knows that they're being monitored for the first three to four months, then things fall by the wayside.

(27:37):

It's just like app fatigue, popup fatigue, and everybody knows this. It's human behavior. But I think the ultimate vision is finding devices that melt into the person's lifestyle. And when we get to that point and we are, you've got your Amazon Echoes, your Google Homes, things like that, they can exist on their own. You're not constantly aware that you're wearing them and they can collect those sort of parameters. That's when you're getting true accurate data. And that doesn't mean that there is no space for wearable devices and sensors. I have great respect for the sensors and the ability of what they can capture, and I think that in certain short circumscribed periods of time, we can definitely use them to get clinically actionable insight. But to say that we're going to be able to do this for an indefinite period of time requires getting over that hurdle of data, missing this,

Drew (28:33):

Right. It's really got to blend into the lifestyle. Alright, well, I'll just end with my final roundup question. I'd like to throw all my guests, which is if you could give your one piece of advice or your wisdom to anyone in the realm of work, career progression, health, life, self-improvement, anything, what do you think it would be and why?

Jay (28:53):

Gosh, there's so many things there. I can throw so many different one-liners at you, but really I'll say what I tell my kids. I think be kind whenever you can and don't burn bridges if you can possibly avoid it, because you never know when people come back in your life to help you out. And always have a growth mindset. Always be willing to learn and stay humble because if anything, this whole chat GPT and GPT-4 world has taught us is that you can have a brain in the box. You don't have to be the smartest person in the room.

Lauren (29:35):

Many thanks to Jay for joining us and explaining how we can combine medicine and technology in ways that transform how we treat patients. To learn more about Jay's research and other Scripps research content during our centennial year, be sure to check out the show notes. A big thank you for tuning in with us today on another episode of Science Changing Life. Until next time.