

Future of Health Technology Symposium

Presentation by:

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Astro Teller:

This is exciting to get to talk to you. A number of the people you'll be hearing from today like BodyMedia are working on the future of health technologies but the CDC is at the forefront of using those technologies, understanding how they can really impact people; that's your expertise, and sharing those ideas and finding those intersection points is as interesting for us as it is for you. With that said, there's a joke, you've probably heard it but I'm going to remind you of it because it's painful and it's true about health care. So the police officer finds this man crawling around on the ground late at night outside and he says, "Sir are you okay?" The guy says, "I'm fine, don't worry about it, I lost my keys." "Well, I'll get down on the ground, I'll help you look for your keys." "Oh, don't worry about it, it won't help, I lost my keys over in the bushes." "Well, why aren't you looking for your keys over in the bushes then?" "There's a lamp post right here, I can see much better here."

No one meant to do this and I mean no disrespect when I say that but that's what body monitoring has been in health care for the last 60 or 70 years. And until we get really comfy with that idea we're not going to get to the next step. Here's the problem. Body monitoring has started with two seemingly very reasonable suppositions but you have to break them in order to do what I'm going to tell you and I think I can convince you is what's really most important to be done. The first assumption is that you have to get the best information you can get. Doesn't seem like such a bad assumption. But the world is a very confusing place. Most of the noise that you see in sensors when you try to do body monitoring isn't the kind of "psssh" like static noise. It's noise like it's a signal, you just don't know what it means because people are out there in the real world jogging and brushing their teeth and having sex and playing with their dog and a thousand other things and you don't know what it is. And all these signals are coming through your sensors and you just don't know what it means. You, the medical device that you make, don't know what it means. And that's a big problem. The way this has traditionally been solved is make them come to a controlled environment and act in a controlled way. Remove all the confusing real world annoyances and you can get good data. Unfortunately, you get good data on a very artificial situation. The second assumption is that the medical world says, look there are two parts, two sides. You make a model which is testable, whether or not it is actually predicted or how predicted it is, and you make a description of the mechanism of the human body that underlies or attaches to this model.

Actually the first of those two things is required for science. It's the definition of science. The second is totally extraneous. Personally, as a scientist, I share the interest in understanding how the human body works, but that's not actually required in order for it to be good science. And the requirement that we understand the human body and why the human body produces particular signals with respect to body monitoring has constrained us to part of the body monitoring world and not allowed us to look at other spaces.

So let's not worry about the technology for a second. What would be the best case scenario if we could see the other 99% of people's lives, right, the physical and the mental states of these people minute by minute, the other 99, maybe 99.9% of their lives when they're not in clinical environments, when they're actually living their real lives because we all know this is the issue of the light, the lamppost and looking in the bushes. The bulk of health care costs, I'm teaching it to you guys – hardly! You guys are the ones who taught it to us, come from people's lifestyles, their choices, and secondarily from their genetics. But the number one thing that causes health care costs are how people live. It's determined out there, not sitting here in the doctor's office, and we have no visibility to that. And when you don't measure something, you will not manage it. So we shouldn't be that surprised that we don't manage the real underlying cause of health care's costs because we're not measuring anything about it. So the physical and mental states of people in real time and over long periods of time, that's what we want. That's not a technology statement, that's just kind of a fantasy, wouldn't that be great if we had it. So what would it take to actually get that kind of information? First, you'd have to see their bodies in some way, and fundamentally there are two big buckets of ways you could go with that. The first is you could instrument the world. You could put sensors under people's beds and in their couches and laser range finders in the corners of every building and room. I'm not sure if you instrumented this room how you would sort out who's sitting in which chair, but there are people who are certainly trying to solve the problem this way and there are probably niche markets in which that is going to make sense because people don't move around very much. But for the bulk of humanity I don't think that's the solution and the only alternative has its own set of problems, which is you have to instrument the person instead of instrumenting the world, and unless you're going to put it inside of them, which again we can do for people who we're ripping open anyway; if we're going to put an ICD inside them, might as well throw a couple extra sensors in. But for most people that's not practical and it means it's going to be on the outside of their bodies, at least for the next 10-20 years. So is that good? Actually no, disasters occur. You just took people from a state which they didn't really know anything about their bodies and their caregivers really didn't know anything about what was going on with them, the other 99% of their lives. Now if you just do that first thing, you've turned on a fire hose. No one can drink from that. You have hundreds of thousands of times as much data as anyone has ever seen about anybody. Health care professionals can't use that. The patients don't know what to do with that. So you have to process the information. You have to take that flood of data that you conceive from people many, many times a second and distill it into nuggets of information; these little droplets which are actionable which are really powerful and can change how health care professionals help people or how people help themselves. And then even if you do

that, even if you make really important new statements about people, you have to show that information to the right people in the right ways, in the right time, and especially once you start looking in the real world and you acknowledge that lifestyle change is what it's all about, you enter the really scary world of behavior modification which is harder than open heart surgery. That's why we spend all our time doing open heart surgery and have made so little progress on the behavior modification front. So doing that third thing is critically important and getting it right if you expect to make any progress.

Let me tell you very briefly, I'm going to say something more specific about our company but I want to give you the sort of bigger picture because this is not just about our company, BodyMedia, but in a whole industry where a lot of health care is going. Modeling the lower level vital signs that you can see from people, modeling the data that radiates from the human body not by understanding why the human body makes those signals, just mathematically modeling how that data comes off of people relative to medical gold standard statements. You make the model and then you go test it. If you want to know for energy expenditure, you test that with metabolic carts or double labeled water. If you want to know about sleep, you would test that against polysomnography. If you wanted to know it for stress, you might look at cortisol as a silver standard for acute or chronic stress. Take your favorite thing that you want to know, maybe you can, maybe you can't predict, make an accurate statement about what's going to happen by looking at other lower level vital signs but you can try, and it turns out not because the people at BodyMedia are smarter than everybody else but because we just chose to relax this constraint about understanding the human body mechanism and focusing on a different way of looking at the problem by looking at the data modeling part of it, it turns out you can say some pretty interesting, pretty important things with very high accuracy.

So just to give you the intuition thought starter, this isn't how the math works. but I think it will give you the feeling. So imagine you're a motion monitor. You guys are all familiar with pedometers and accelerometers. So suppose there was one on my body and you see a bunch of jiggling, jiggle, jiggle, jiggle. So what does that mean? Am I jogging, am I in a moving vehicle, am I going up an escalator, am I in an airplane? Kind of hard to say actually. Surprisingly hard to say. Okay, suppose I'm not moving at all. If I'm just standing here or if I'm standing here holding 50 pounds, I'm motionless in both cases but I'm burning a lot more calories per minute, I'm expending more energy which is going to tell you a lot about my body's condition in those cases. If I'm walking up a steep hill with a backpack on, you're not going to see a lot of motion but I'm going to be sweating profusely with the heat pouring off my body, and this isn't just about motion, it's about any one thing about the world. This is back to the world is a very confusing place, remember that? So suppose my heart is going thump, thump, thump, really fast. So maybe a dog just barked at me, maybe I'm jogging, or maybe my wife winked at me. You don't really know. But if you could look at more than one thing about the body, you could start to disambiguate things. For example, if you could see the rate my body is producing and releasing excess heat, you would kind of expect all things being equal, it's more likely, this is statistical mathematical modeling, it is more likely if I'm producing

that excess heat under a condition that I'm physically active. And if you don't see that excess heat, all things being equal, it's going to be somewhat less likely that I'm physically active and more likely that I am, for example, in a moving vehicle. The world is sadly not nearly as simple as this and it takes a lot of modeling and a lot of data because there are a lot of exceptions and complexity to this. But conceptually you can model these things.

Now that's what people are doing; you can also see how much someone is doing. There are things like sleep, like energy expenditure, having a fever. You can say they have a fever or they don't but you can also say the amount of fever they have. And when you want to regress, a mathematical term for trying to say as precisely as possible what the right answer is, for example, energy expenditure, this is a picture of somebody – this pink line is a measure of motion of them walking up 12 flights of stairs, taking the elevator down, going around our office building twice and going up 12 flights of stairs again. Now it looks like it's actually more work to walk around the block but we all know that it's not. It's more work to walk up those 12 flights of stairs. If you could see that same issue, the production and release of heat, you would see that it's going to take, that you produce and release more heat, this blue curve, when you walk up the stairs. Now it's delayed in time; you're going to have to sort of integrate the area under the curve there. It's not trivial but you can kind of see how, wow, if we had both of those pieces of information and other ones, you could start to get at a statement - temperature like you could see from double labeled water or a kilometry room or an indirect kilometry cart more accurately than you could from either of these sensors by themselves.

So now I'm going to get a little more specific about our company so this doesn't seem like black magic. This is a set of things that BodyMedia makes commercially available today. These are not applications. I will show you applications of this technology in a moment but these are a specific set of things that can be said, are being said today with very high accuracy and the way that something gets into this list is because it is accurate enough to be clinically useful. That's different than saying it's better than the clinical products. So for example we're within about 10% of what you would get from a V02 machine. We can't get much closer than that because V02 machines turn out to have about 10% error between each other, between different V02 machines. But that's close enough that out in the real world it's so much easier to wear this thing which you can't even see here but it's right there on my arm. I just want to pass one around.

So some of these others, just to give you a sense, for example sleep; within a few percentage points of what you would get from polysomnography or that third one exercise type identification, knowing with 99% plus accuracy when somebody is walking, when they're jogging, when they're in a moving vehicle, this thing at the bottom, when they're doing some kind of resistance activity like moving furniture around their house, when they're on a bicycle, automatically journaling their lives minute by minute objectively, accurately. That's what this is. That doesn't tell you what the application is but does everyone understand that kind of Okay, so that could be used for a lot of stuff. We could do infant monitoring, we could do elder care, we could focus

on women's health, we could focus on the military. But where's the real problem? If the real problem is that lifestyle thing, and this should not be a shocker to anyone in the room, it's the metabolic syndrome, right? It's that constellation of problems driven largely by lifestyle which create primarily obesity, diabetes, and cardiovascular disease, close behind them COPD, obstructive sleep apnea. This is the problem in health care. And obviously it's not like we invented it, I think you guys did. So I won't bore you with stats; again, we might literally have gotten them from the CDC but I want to make a point here about the statistics which is that the clinical recommendations for each of these things is exactly the same. There are additional recommendations. A diabetic may be told, for example, that they should test their glucose whereas someone who is obese might still get told that actually; maybe someone with cardiovascular disease won't. But basically they need to be more physically active and to eat better, sleep better, less stress, but we haven't even gotten to telling them those things that turn out to be very important. The pathway that everyone goes through once they have obesity, diabetes, cardiovascular disease, is exactly the same. We start with the assessment and behavior therapy, diet and exercise. It doesn't work, and then we go through the pharmacotherapy and then that doesn't work and eventually we get surgery. And it gets more and more expensive and so we have the health plans, the insurance programs in this country have put all kinds of barriers in place to try to prevent people from stampeding up that – not necessarily because people don't need it but just because it's too expensive to let everybody through. I'm sure you guys are aware of that process. That, to put it slightly different, is "the" health care challenge. It's finding a way to actually make that work because all that's really happening right now is we tell people what they already know, that they're not doing something, and they say okay I'll do it and then they don't do it. Repeat. There are no solutions. There are solutions in pharmacotherapy; at least we have something to sell them, take this, eat it. Sometimes they won't eat it but sometimes they do; sometimes it helps. I mean there are miracle drugs like Lipitor that for particular groups of people have saved hundreds of thousands of lives. Surgery, obviously, it can work. It's surprisingly dangerous in many of these cases, lapbands, gastric bypass. I'm sure you guys are very familiar with that. So our mission essentially is make a solution using the technology that I was just telling you about. Make a solution for that bottom part of the pyramid. Something that people can actually use themselves to take real better care, actually change themselves, not pretend, not Weight Watchers, do it for 12 weeks and then forget like it ever happened. But actually make changes in their lives, and connect them to their caregivers in a way that the caregivers can be part of the cycle too without being onerous in the time required. What it takes for a solution to be successful is you have to have awareness driven, not just once but on a regular basis. That awareness then has to be followed up with adherence. There has to be something people need to do and they have to keep doing it. That is behavior modification is what you're driving towards. And the whole point of doing the behavior modification is going to lower health care costs. We just heard this morning that prevention is the answer. Yes, we all know prevention is the answer. The question is how are we going to make prevention something we can prescribe and actually expects some results from?

So very briefly, just to give you a sense of these solutions. One version of this is an assessment tool. You all know what a Holter monitor is, you've seen the little stickies that go in people's chest; they take this little walkman-looking thing home for a couple of days and come back to their cardiologist and the cardiologist sees their ECG strip. This is sold to clinicians in hospitals. It's a Holter monitor, only not for ECG but for lifestyle. Those things that you saw that BodyMedia can say about people every minute with high accuracy, this is like a strip for those things. And whether you're a cardiologist or an endocrinologist or bariatric surgeon, seeing that kind of information before an intervention, during an intervention, after an intervention, can help you to understand the person better, to do the intervention better, to learn which interventions work on which people, etc. The other side of the coin is actually making something, and this is the body bugg, the previous one called SenseWear is our clinical product. This one is a weight management solution sold to patients and users directly though they're almost always connected with some kind of nutritionist or health care coach, some weight loss coach of some kind. There are many tens of thousands of these in use right now out in the real world and it is wildly more successful than the alternatives. The little display device you see up there is a way – I'm wearing one right here – where you can get real time feedback but you can also take this as a display device as a health care professional and in more of a triage setting, even ICU's go around and test lots of different people to see how they're doing. So it acts in both ways.

Diabetes, it's not just about weight management but just to use this as an example, diabetes education compliance is notoriously unsuccessful. There's a CPT code for it and you actually have to offer it as an insurance company, and really everyone knows that even if you have to offer it, there's no reduction in fasting glucose levels, your HBA1C's don't change afterwards. So why do we do it? Well, it's mandated. Oh, well. Wouldn't that be amazing though if you could actually give the diabetes nurse educator some basic information about what people are doing so that when they call up somebody on the phone or meet with them in person, instead of the conversation going like it normally does, are you doing everything you should be doing? Oh yeah, I'm doing that. Well, your levels are the same. Well, I don't know why. Okay. What if it was, I told you what to do and you're not doing it. Oh, I know. And then the next time, they're going to do it, at least a little bit more because they don't want to sit in front of that person, they don't want to be on the phone with that person and have them know that they're doing it. It's the same phenomena in rehab, right? People don't do what they're supposed to do at home, that's why you go into the rehab facility because it's the only way you're going to actually do your leg lifts. You just don't do them at home. But when somebody's watching even remotely, you will do them. It's an accountability issue. Accountability to yourself and to the health care professions. One of the things which is not obvious but it's tremendously important is that people will actually wear these kinds of products. Now to some extent I would like to believe that that's because we've done a very good job as a company in making products people will wear. But it's not really about the products, it's about the information. If this was a brick and you had to wear it on your forehead but you could fly, I'd wear it. I bet most of us would wear it, right? You can't make it cool enough if it doesn't do anything. If it made you sick or put a little "loser" sign on your forehead, nothing. No matter how small it was, no matter how sleek

or metallic looking or whatever would make it worth it. It's about the information. If the information makes people, the people who have to wear the product, if it makes them feel more human, if it connects them to their body, if it's actually helping them to make change, they will wear it. These are not people who are paid to wear this product, these are tens of thousands of people who pay their own money to have this product who have most of them no interaction or incredibly seldom interaction at their own choosing with a health care professional, and they're wearing it 15 hours a day. Watches barely make it 15 hours a day. My wedding ring makes it more than 15 hours a day, my glasses might make it 15 hours a day. There are no medical devices except the ones we sew inside people that make it 15 hours a day. Very exciting and it tells you something about how desperate people are for real solutions if you can get it to them.

Corollary to this is that it's not just the technophilic people. There's this myth out there that people who are 60, they don't have computers, they don't like technology, there is some trend, fewer people who are 60, not actually that many less have computers, have internet access. But when it comes to wearing something and understanding about their bodies they have so much more of a reason to care about their bodies because whether they take care of themselves or not is going to make an impact in their bodies now. The 25-year-old doesn't care, he's not going to die for 40 years for what he's doing to his body, but the 60-year-old could die within five. It becomes a lot more interesting to take care of yourself.

We now have 80,000 hours a day of minute-by-minute data coming from many tens of thousands of people. So our business is offering these solutions to people but as a side effect of our business we are gathering an enormous amount of data. We now have 1.3 billion minutes of what people do when they get up in the morning, how long their commutes are, how much they fidget while they're at their desks and whether that's related to how well they sleep at night; and 50 other things like that that are all just sitting there in our database. So not just about BodyMedia but I think one of the tremendously exciting things about this field is that we are starting to understand the world not in these snapshots that we take very briefly once a quarter once a year but every minute and to see the world at that next level of detail is totally going to change how we care for people, and the solutions that we can make for them.

So just to give you a sense, again expanding out a little bit from BodyMedia; some of the things that I think you'll see coming in this area include smaller devices. Certainly ours will be out later this year. New application areas, everything from ICU's to various kinds of disease management, wellness, corporate wellness is going to be a huge one because of how the costs are shifting toward the corporations and then from the corporations to their employees. Aggregate views of this kind of data, mining this data for new statements about the human body and understanding new care pathways not by looking at we intervened and then six months later here's what happened but by watching minute by minute what happens. So I'd be happy to take questions later. I think this is a tremendously exciting part of where the field of health care technology is going and I encourage you all to look into it. Thank you.

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