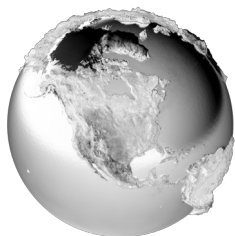


FORESIGHT



A FUTURIST EXPLORES THE
TRENDS TRANSFORMING TOMORROW

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THE HEART OF THE MATTER: THE FUTURE OF HEALTH CARE

In January of 2014, Illumina, a San Diego based company, announced that their high throughput genetic sequencing machine “HiSeq X Ten” had finally broken through the long sought after \$1,000 barrier to sequence a full human genome and could sequence up to five per day. To put this in some perspective, it helps to consider that the first human genome project was completed in 2001 for the sum of three billion dollars. The project has already had major implications for the health care industry and the way we prevent and treat disease. Alas, fast and inexpensive gene sequencing is just a small part of the incredible changes already occurring in the field of health care.

By the beginning of the next decade, in addition to the developments in genomics, genomic surgery, continued advances in information technology, biotechnology, nanotechnology, robotics, data mining, wearable technologies, artificial intelligence, sensors, social networking, and myriad other technologies will transform the face of modern medicine. What follows is a scenario involving one individual with a single ailment.

FUTURE SCENARIO

On October 21, 2020, Roger Martin, a sixty-seven-year-old, under-employed attorney, suffered a massive heart attack while tending to a small plot of land on an urban farm in a once thriving suburb of Atlanta. Had the event occurred ten years earlier, Roger, an early adopter of the “P4” (predictive, preventive, personalized, and participatory) mobile medicine, would not have made it to the hospital alive.

The first sign of impending danger came when sensors in Roger’s shirt detected an unusually high pulse. Unbeknownst to Roger, his shirt sent a wireless alert to his “PMD” (personal mobile device) so it could begin to more closely monitor his other vital signs. After noting his symptoms, it compared them, along with his medical history and genetic file, to its vast database of all known diseases and injuries. Among the possible causes were a number of serious conditions, so it also contacted his primary physician, who immediately contacted Roger via mobile video connection.

“How are you feeling, Roger?”

“Fine,” he replied, “maybe a little tired, but nothing out of the ordinary.”

Seeing that Roger looked a little pale, the doctor asked him if he had his permission to activate a mesh network of nanoscale diagnostic chips that had been placed inside Roger’s body following his first heart attack in 2017.

“What if it’s another false alarm?” asked Roger, who had been contacted by his doctor in response to a similar situation last year.

“I’m not 100 percent sure it isn’t,” replied his doctor. “The technology’s still far from perfect, but I don’t want to take a chance. Do you?”

“No, but are you sure the signals from those little nanobots won’t do more harm than good?” asked Roger, who was still ner-

vous about the chips' efficacy after hearing various reports from some news organizations hinting at the possibility that activated chips could be contributing to the recent rise in reported cancer cases.

"The rise in rates has nothing to do with the chips themselves," said the doctor, "and everything to do with our ability to detect cancer at an earlier stage. If you need further evidence," continued the doctor, "I suggest you query your personal assistant on your PMD. It'll confirm your worries are based on nothing more than an insidious urban myth. I can't believe it still persists in this day and age."

After gaining Roger's approval, moments later, the network of nanometer-sized circuits patrolling Roger's arteries was activated and began sampling his blood. Within seconds, the doctor was made aware that the level of C-reactive proteins in Roger's blood was abnormally high.

The doctor's voice took on a more serious tone. "Roger, I want you to sit down, stop whatever you're doing and take a deep breath." Roger did as instructed.

"Now, I want you to remain calm—and please know that I'm going to be with you the entire time—but there's a good chance you're on the verge of having a serious heart attack. The nearest hospital has been alerted, and an ambulance is already on its way."

"You're kidding, right? I'm just feeling a little tired. All I've been doing is working outside—getting some fresh air and exercise like you suggested."

"Just relax, Roger. Over the last few years, I've come to appreciate the system's ability to more quickly and accurately diagnose health-care-related issues than either I—or my patients—can. Plus, better to be safe than sorry, right?"

"Yeah, I guess," replied Roger pensively as his breath be-

came more labored. In an attempt to lighten the mood, he added, "I hate to think what this will do to my insurance rates."

By the time the ambulance had arrived, Roger was thankful to see it because he had begun to feel constricted in his chest. Then, only moments after being placed in the ambulance, Roger went into full cardiac arrest. The paramedics were prepared and followed the new protocol established by the American Medical Association in 2018. Normally, Roger would have been taken to Emory University hospital, but due to traffic congestion and the severity of his condition, the ambulance was rerouted by an intelligent traffic system to an outpatient clinic located just off the freeway. Once there, Roger was whisked away on a gurney to a "clean" room where he was anesthetized and prepped for surgery. Then, in a procedure that would have been all but unthinkable even five years earlier and which was approved just the previous year by the Food and Drug Administration for emergency situations, a robotic surgical device was wheeled into the room and positioned over Roger. With only a nurse and a young attending doctor in the room, a heart specialist located in Havana—connected via a secure, redundant fiber optic Internet connection—began guiding the thin, flexible arms of the device through the intricate surgical procedure using nothing but hand-gestures.

When the surgery was completed just twenty-three minutes later, all that was visible on Roger's chest was a Band-Aid-sized incision where the robotic arm had entered his chest cavity to insert a temporary stent.

Roger awoke a little later and was greeted by a split screen display showing the heart surgeon and his primary physician. "You're lucky to be alive," said his doctor. "I'd now like to introduce you to the person responsible for extending your life, Dr. Daniela Famosa. Under the recently passed International Health Services Act, she was able to perform your surgery from Cuba."

Roger smiled and nodded in her direction.

"During the operation," said Dr. Famosa, "I harvested some of your stem cells and, with your permission, I'd like to have them transferred to the Institute for Regenerative Medicine at Wake Forest University where they will grow you a new, fully compatible artery. If all goes according to plan it should be ready in two weeks and can be inserted the week before Thanksgiving. Based on your personal health record and history of patients with a similar health background to you, you should even be able to travel over the holidays if you want."

"You'll have to stay away from the eggnog this year," she added with a wink.

Later that afternoon, Roger was discussing his outpatient treatment with "Cindy"—a computer animated avatar program on his PMD that acted as his personal nurse. The avatar, which Roger liked to call his "cyber twin sister," was responsible for continuously monitoring his health status in addition to scanning the latest health care information in order to recommend and deliver Roger the best possible care.

"Based on your genetic profile and the presence of the following genes—SMAD3 and CXCL 12," said Cindy in a soothing and reassuring voice, "we know that the blood thinner warfarin—Type C3—will work best for you during this interim period. It's also recommended that you not take it with any of the other following drugs." His cyber twin went to list those drugs that Roger was to avoid, including the new antidepressant he had been prescribed. (In early 2020, the FDA was forced to pull the leading electronic brain stimulant treatment for depression after numerous patients in the first test group began losing feeling in their legs and feet.)

"I realize this is a lot of information for you to process right now. Don't worry," continued Cindy, "I'll remind you when to take your medication." In a tone that then offered just the slightest hint

of admonition, the avatar added, "When your heart is ready, we'll also do a better job of keeping you on track with your exercise regimen." Roger voiced his approval.

"Are there other questions I can answer for you?" queried Cindy.

"Well," said Roger, who, in spite of avatars' growing popularity the past few years, was still a little surprised with how natural it felt to be conversing with a virtual nurse, "could you tell me a little more about how the doctors are going to grow my new artery and install it?"

"Sure." Cindy promptly called forth the 3D digital scans of Roger's heart and showed him the blocked artery that had been color-highlighted for his convenience. The avatar went on to explain how plaque, fatty substances, cholesterol, cellular waste, and calcium had been slowly building up over time and this combination was the main culprit of his heart attack. The avatar then suggested viewing a simulation with his virtual reality goggles.

"I thought that contraption was only good for playing games with my grandson," replied Roger with a laugh.

Once Cindy recognized that Roger understood the cause of his heart attack—which she determined by using facial recognition technology to scan his physical reaction to the information that was being presented—she went on to show him how his new artery would be grown. Cindy called up a short video tutorial produced by the Institute of Regenerative Medicine demonstrating how a small scaffold would first be constructed using bio-compatible material and a 3D printer, and how that scaffold was then seeded with Roger's own stem cells and cultured until an artery replacement of precise proportions was grown. "There's virtually no chance your body will reject the new part," said Cindy. The avatar explained other treatment options to Roger along with the costs and benefits of each procedure. "I'm happy to ar-

range a conversation with a doctor if you have any additional questions, but I recommend the replacement surgery.”

Roger asked Cindy a few questions regarding his insurance coverage and what costs he would be responsible for, but once satisfied with those answers Roger indicated he didn't have any additional questions. The avatar then began preparing him for outpatient services.

“The first thing we'll need to do is outfit you with a new line of sensor-embedded clothing. Your current wearable bands are pretty good in terms of monitoring your vital signs, but as an extra precaution we'll want to keep extra close tabs on you during your recovery period.”

Continuing, Cindy said, “I have also taken the liberty of putting together a list of friends and colleagues who have either had heart attacks or have lived with someone who has had one.”

Knowing that Roger was the type of person who responded better to scientific information, Cindy added, “Past heart attack patients who have joined health networks are 37 percent less likely to suffer a repeat heart attack within the next five years. They also experience an increase in life expectancy of 2.8 years over those who don't.”

To make the point more vivid, Cindy displayed the information using a visually compelling chart on one of the nearby screens. She added, “A good way to use your network is to enroll in Healthy Hearts, your insurance provider's new game to encourage an active and healthy lifestyle. It's possible your rates could go down in the future if you score above the eighty-fifth percentile.”

Two months after his successful artery replacement surgery, Roger received a small scale 3D model of a human heart when he refilled his personally tailored heart medication prescription. It was a discount offer from a new biotech company that had

only recently begun growing and marketing human hearts. Roger activated the computer chip inside the model, which then displayed a holographic advertisement on this PMD. The ad read: "It's not too soon to begin thinking about your next heart. You can never know when you'll need it, but it sure 'beats' the alternative."

Roger then called up Cindy and asked her what the odds were that he would need a new heart by the year 2030.

"If you continue to follow the recommended therapy and exercise, 42 percent," replied Cindy. "Just as an FYI, due to your projected increase in life expectancy, the odds of you contracting prostate cancer have also increased. But don't worry, I'll keep a close eye on all the indicators and notify you if any action is necessary."

"Thanks." Roger turned back to his PMD and directed his personal assistant to revise his monthly budget so that he could afford his new heart when the time came as well as live comfortably for the few additional years that had just been added to his life.

— BONUS QUESTIONS —

Right now, it's highly unlikely that you have had your personal genome sequenced. What do you think the chance will be that you've had it sequenced by 2020?

Do you wear a personal monitoring device such as a FitBit or a Jawbone Up?

How do you feel about health care apps, such as those powered by IBM's Watson, providing your initial diagnosis?

Right now, robotic assistants, such as the Da Vinci machine, are helping surgeons perform complicated surgeries on their patients. How would you feel if the robot performed the surgery all by itself?

Do you think we will ever cure cancer, or will it continue to adapt to our advancements?

If genomic surgery could be performed on an embryo to prevent a genetic disease would you select that option? Do you believe insurance companies should be required to pay for such a surgery?

How do you feel about having a set of "backup" organs grown from small samples of your cells and stored in case you ever need them?

When planning for or thinking about retirement, what age are you expecting to live to? Given the rapid pace of advancement in medical technology, do you think that your expected longevity could change and require a new retirement plan?