CHAPTER 3

"The Name Game" by Shirley Ellis

Come on everybody, I say now let's play a game /
I betcha I can make a rhyme out of anybody's name.

One of the culture shocks I experienced when moving from a health system to the technology world was the name game of initials describing the new world of digital healthcare. RPA, RPM, AI, NLP—it's a word salad of health information technology. The trends these initials represent have received unprecedented investment and show incredible potential, but have not yet resulted in measurable improvements in population health or health disparities. In areas such as remote patient monitoring, however, these words connote real promise.

No area better defines the maxim that we tend to overestimate technology in the short term and underestimate its potential in the long term. None of today's devices are life-changing, just as the initial iPhones were mostly cool phones. But moving from sick care to health assurance for all will require humans and technology to come together to create a future of "healthcare at any address." When that happens, the resulting devices will change the lives of millions.

Because of the pandemic and new reimbursement rules, remote patient monitoring (RPM) has surged along with telehealth over the past few years. In many cases, RPM has been combined with virtual visits and health coaching. Meanwhile, artificial intelligence (AI) now informs some advanced RPM applications. As these technologies come together, they promise to reduce the amount of time that physicians need to care for each patient while improving the quality of care. To the extent that they prevent avoidable hospitalizations, decrease the need for office visits, and enable most healthcare to be provided at home, the combination of RPM, telehealth, and AI can also reduce costs.

RPM is divided into two overlapping categories: mobile health, a.k.a. mHealth, and home monitoring. For several years after the advent of the smartphone, mHealth was the more glamorous branch of RPM. Mobile health apps proliferated, and by 2015 there were 165,000 apps on the US market. However, two-thirds of these apps just provided information on medical conditions. The majority of the others focused on fitness and wellness and were sold to healthy people who wanted to track their exercise, diet, or sleep patterns. Fairly few apps were designed to help people with chronic conditions such as diabetes or hypertension (Terry 2018). Fewer still were meant to help the underserved population better care for themselves and their families.

There was little effort to evaluate mHealth apps for either physicians or consumers. Doctors who wanted to prescribe them had little to go on; the early adopters tended to suggest apps they'd used themselves, or they just advised patients to shop in the app stores. A few health systems such as Ochsner and the Cleveland Clinic had their own app stores.

Consumers who downloaded these apps usually didn't stick with them for long. One reason is that most apps had no way for consumers to send data to their physicians. They could look at the data themselves, and the app might tell them what it meant, but it didn't really connect with their healthcare. What consumer marketers call "stickiness"—something that gets someone to tap on the app every day—was missing.

Meanwhile, the VA health system was showing the value of RPM. Besides reducing readmissions, a primary reason for the VA to use RPM was to keep veterans who required long-term care at home. As early as 2013, the VA had used remote monitoring for 119,000 veterans, more than one-third of whom had avoided institutionalization (Terry 2013). A 2021 VA pilot program found that veterans who actively shared vital signs weekly through an RPM platform had "a 75% decrease in emergency room visits and hospitalizations post-intervention, compared to pre-intervention" (McMillian 2021).

Some private health systems began using RPM with recently discharged patients, mainly those who had congestive heart failure, to prevent readmissions. But despite the cost savings the VA had achieved, only a handful of large organizations such as Kaiser Permanente, Partners Health Care, and Geisinger Health fully embraced remote monitoring. The biggest reason: Outside of healthcare organizations that took financial risk, providers were not being reimbursed for using RPM data in patient care. The core principle that it's hard to get someone to do something when their salary depends on them not doing it restricted RPM to those few systems that functioned as both payer and provider, such as Kaiser and University of Pittsburgh Medical Center (UPMC).

CMS REIMBURSEMENTS FOR RPM

Math is a wonderful thing, especially when it comes to reimbursement in healthcare. So when the country's largest payer, the Centers for Medicare & Medicaid Services (CMS), first began reimbursing physicians for RPM services provided to seniors with chronic conditions, both the implementation of RPM solutions by healthcare systems and the venture capital necessary to fuel research and development expanded greatly.

The initial CMS authorization in 2018 included the collection and interpretation of physiological data for at least 20 minutes per month (eHI 2018). In 2019, CMS added three new billing codes for RPM in chronic care. Coverage expanded further in 2020, allowing remote monitoring of patients with acute conditions such as COVID-19. In 2021, CMS proposed adding new codes for remote therapeutic monitoring that includes nonphysiologic data on medication adherence and mental status (Mecklai et al. 2021).

Private insurers are increasingly following CMS's lead. UnitedHealthcare, for example, now covers remote physiological monitoring services in its Medicare Advantage plans and some commercial plans (UnitedHealthcare 2022). In 2021, Humana rolled out a new program combining home health, RPM, and telehealth services (Wicklund 2021a). And in 2022, telehealth firm MDLIVE, which is owned by Cigna, introduced an RPM program for patients with chronic conditions (Torrence 2022).

Worldwide, the RPM market has exploded. In 2016, about 7 million patients globally were being remotely monitored (Mack 2017); by 2020, that number had ballooned to 45.6 million, according to Berg Insight (2021). The company projects that this number will jump to 115.7 million by 2026.

There are signs that RPM is growing rapidly in the United States as well, says Joseph Kvedar, MD, vice president of connected health partners at Mass General Brigham and professor of dermatology at Harvard Medical School. In an interview, Kvedar told me that "before the pandemic, remote monitoring was mostly confined to the VA and home care. Now lots of large physician practices are getting into the space." The reasons include improved reimbursement and hospitals' desire to avoid readmissions because of CMS penalties.

But fee-for-service coverage of remote monitoring is a clunky compromise, Kvedar argues. RPM will not achieve its full potential, he predicts, until value-based reimbursement makes it economically desirable to monitor and care for people between encounters with physicians.

"We're generally not set up to keep people healthy in their home," he points out. "We're set up to take care of them when they get sick. So, all those wonderful things that come from remote monitoring don't happen unless there's an economic reason for it to happen."

THE DEBATE OVER RPM BENEFITS

Since the VA's initial successes, a number of studies have shown positive outcomes from remotely monitoring certain kinds of patients. The Geisinger Health System found that telemonitoring reduced the readmission rate of congestive heart failure patients within 30 days by 44 percent (*Becker's Hospital Review* 2014). During the pandemic, Geisinger employed telemonitoring by giving patients an oximeter and thermometer to use at home. RPM patients provided daily updates on their subjective symptoms and objective pO2 (partial pressure of oxygen) and basal temperature. The combination of home monitoring and daily check-ins was a major component in reducing patient anxiety (Minemyer 2020). In another program, UPMC showed that 13 percent of monitored congestive heart failure patients were readmitted within 30 days, compared to 20 percent of those not enrolled in the RPM program (*Becker's Health IT* 2015b).

Systems that began RPM early, such as the VA, Geisinger, and UPMC, have taken those initial results as cause for expansion. In 2022, UPMC announced an app-like model with Vivify. Andrew Watson, MD, FACS, medical director of telemedicine at UPMC, described the system to NGPX (2020): "Patients simply open a box, then turn on a tablet or respond to a text message to access remote patient monitoring. The process has been streamlined to make it simple for them. Care is provided through survey questions, educational videos, scales, BP cuffs and pulse oximeters, and live video visits."

As described to NGPX, Vivify "provides a call center portal, equipment monitoring, reporting features, and integration with electronic health records (EHRs). It also offers BYOD (bring your own device) capabilities that allow patients to access the platform using their own personal devices." UPMC reported that the program reduced readmissions among Medicare enrollees by 76 percent, and patient satisfaction and compliance both exceeded 90 percent.

Ochsner Health System remotely monitors people with common chronic diseases such as hypertension, diabetes, and COPD. In 2021, Ochsner added health wellness coaching personalized to each patient and started selling its RPM service to payers across the country. By using RPM to cut health costs, Ochsner claims, health plans and businesses can see a return on investment of 3:1 for diabetes and 4:1 for hypertension (Wicklund 2021b).

On the other hand, Mayo Clinic Platform president John Halamka, MD, and Paul Cerrato (2021) have pointed out that only some remote monitoring devices are reliable, and few of these products are supported by randomized controlled trials. Some devices, such as those of Digital Diagnostics and AliveCor, have received FDA approval or clearance, but the vast majority have not. Studies have shown variable effects of RPM on outcomes (Mecklai et al. 2021).

Kvedar attributes these varying results to differences in how the studies were conducted. Among the factors that might have influenced the results, he says, are "when a nurse or a doctor gets involved, who sees the data, what kind of data are they using, what kind of rules set is firing alerts, and how often they're communicating with the patients." For example, when Partners HealthCare (now Mass General Brigham) did RPM studies several years ago, "we had a 50 percent drop in heart failure and all-cause readmissions in the study groups. But an earlier study from Yale said RPM was ineffective." In that Yale study, "the intervention was that the patient weighed himself and then phoned the data into a robocall line. That's not a very sticky intervention; no wonder it didn't work. That's why there's so much difference between studies. The magic isn't in the scale or the blood pressure cuff, it's in how you use it."

Scales and blood pressure cuffs are just the "primordial ooze" of the potential for RPM, in much the same way that the iPod was the beginning of the digital revolution. The RPM devices most often prescribed by physicians today include equipment that tracks heart rate, blood glucose, oxygen saturation, and temperature. Patients with asthma or COPD are using remote spirometry devices. Patients with diabetes use glucometers to track their HbA1c and a pill bottle device to measure their medication adherence (Rosenthal 2020).

A more detailed explanation of the benefits that RPM can confer on patients and providers is presented in a report by eHI (2018, 1), which notes that RPM programs

> passively and continuously collect and transmit patient-generated health data (PGHD) from in-home medical devices to providers and care teams. PGHD, when compared to health data collected exclusively during in-person doctor's visits, more accurately and holistically reflects lifestyle choices, health history, symptoms, medication, treatment information, and biometric data such as heart rate, blood glucose, blood pressure, temperature, oxygen levels, and weight.
>
> . . . There are tools currently available that identify data trends, elevate critical data points, and help aggregate, summarize, and visualize PGHD in meaningful ways. Investing resources in these tools makes PGHD useful at the point of care, while encouraging health professionals to embrace the available data and utilize these tools to further benefit their patients.

Beyond these uses of monitoring data, RPM supports the expansion of telehealth into chronic care, which is one of the reasons telehealth service Teladoc acquired Livongo. It also explains MDLIVE's decision to launch an RPM program. By providing real-time data on a patient's vital signs and chronic conditions, curated monitoring data gives doctors much of the information they need to make patient care decisions without seeing the patient in person.

RPM INTERFACES AND WORKFLOW

To make monitoring data useful at the point of care, RPM services need to do two things: (1) connect monitoring devices seamlessly with a provider's EHRs and (2) provide a mechanism to screen the data for important information that triggers alerts or shows meaningful patterns.

Validic, a leading RPM service, says on its website (www.validic.com/how-it-works/) that it "integrates directly with your existing clinical workflows, augmenting the functionality of your embedded systems and services to make remote care more efficient and effective." Validic has also teamed up with Philips, the medical device maker, which has integrations with a number of EHRs and clinical systems (HIT Consultant 2016).

One solution gaining ground with health systems is the Stel Life Vitals Hub, which securely and directly connects Bluetooth vitals devices in the patient's home to the EHR system without complex setup, Wi-Fi, or mobile applications.

Qualcomm Life, another RPM service, has had a partnership with Cerner since 2015. Under this arrangement, it transmits data to the Cerner EHR system via Cerner's device connectivity platform CareAware (*Becker's Health IT* 2015a).

Vivify Health provides EHR integration along with a call center portal, equipment monitoring, and reporting features. Physicians log into the Vivify portal to monitor alerts, bio-parameters, and patient survey results and to conduct video visits with patients. At UPMC, provider documentation flows from the Vivify portal into UPMC's EHR system, which is Cerner in the system's hospitals and Epic on the ambulatory side (Siwicki 2018a).

Beth Israel Deaconess Medical Center uses Apple's HealthKit in its RPM program. After passing through the RPM software and the Apple Health app, the monitoring data goes into the hospital's core EHR system via a specially designed app (Comstock 2016).

So it appears that remote monitoring data from a variety of devices can be transmitted to major EHR systems. But once the data is there, how is it analyzed and organized to separate the signal from the noise? The RPM services say they have found ways to do this so that physicians aren't overwhelmed by the volume of data and turned off by the extra workload. The key to RPM is to be an early warning sign for people with chronic conditions, but that requires separating out actionable data so that the person at home can answer the Clash's question: "Should I Stay or Should I Go" to the doctor's office or hospital.

Kvedar isn't convinced that the current solutions are up to the job. "I know it's a very soluble problem, because it's being done in other industries. If a healthcare provider has a need for that kind of a product, someone will build it. But what we've seen to date hasn't been that effective. Probably the reason we don't see it is no one has been willing to pay for it. The data science exists to build those signal-to-noise dashboards. It's not new technology."

AI TO THE RESCUE

Could AI be the key to analyzing monitoring data and delivering insights to clinicians in real time? Some vendors claim that their AI-based products can discover correlations in remote monitoring data for patients with chronic conditions (Johnson 2018). Whether they can reliably predict or detect events of clinical significance is uncertain. But if the right kind of algorithm parsed the records of thousands of patients similar to the person a clinician was treating, it could theoretically assess what was going on with that patient at any point in time, based on the remote monitoring data.

AI tools are already being used to predict the likelihood of readmission, remission, and survival for patients with conditions such as blood cancer and brain cancer (Slabodkin 2017, 2018). They have also been used to predict the risk of individual cardiovascular events (Muise 2018). Machine learning algorithms can also predict the onset of sepsis, screen for diabetic retinopathy, and detect breast cancer from digital mammograms with a high degree of accuracy (Slabodkin 2019a; Muise 2018).

Some health systems have begun using AI tools to improve the outcomes of individual patients. UPMC has used predictive analytics to reduce hospitalizations and give discharged patients the diagnostic tools to manage their own conditions at home, so they don't need to see their doctor (Muise 2018). Intermountain has been at the forefront of using AI to assess patient disease risk and optimize care for a variety of conditions (Woolman 2020). And Northwell has applied AI to augment its postdischarge workflows, reducing readmissions by 24 percent. Its clinical AI tool stratifies patients for their risk of readmissions, identifies the clinical and nonclinical factors driving patient risk, and recommends targeted outreach and interventions to reduce that risk (Siwicki 2021).

Flagler Hospital in Saint Augustine, Florida, has used AI tools to improve the treatment of pneumonia and sepsis. A machine-learning program automatically revealed new, improved care pathways for these conditions after analyzing thousands of patient records from the hospital and identifying the common traits of those individuals with the best outcomes. Flagler was able to implement the new pneumonia pathway by changing the order sets in its EHRs. As a result, it reduced the readmission rate for pneumonia from 2.9 percent to 0.4 percent and saved $1,356 per patient (Siwicki 2018b).

AI's Rapid Growth

Nowhere has the word salad in healthcare tech been more prevalent than in the use of AI. Even its name is debated: Is it really artificial intelligence? I see AI as just an adjunct to the human being; a better name might be *augmented intelligence*. If it's operating in the background, rather than as a robot standing next to the human, we might use the term *ambient intelligence*. (Think unnoticed white noise vs. Jon Bon Jovi's "Blaze of Glory"). Those tech entrepreneurs who believe that the AI funding bubble of 2019–2021 is sustainable have yet to encounter an AI winter. Since 1984, the field has experienced several hype cycles, followed by disappointment and criticism, followed by funding cuts, followed by renewed interest years or decades later.

Healthcare in 2022 is clearly in an AI spring, despite decreased valuations among companies that are neither differentiated nor revenue sustainable. How long that blossom will remain depends on the ability to show that these techniques make a quantifiable difference in the conundrum of optimizing cost, access, quality, equity, and user experience that American healthcare now faces. Simply put, AI and machine learning will be a game changer in creating a healthier future, but just as spring gardening involves some pruning, several companies have been pruned down in this AI spring because they could not prove sustainable value.

AI has been spreading through the healthcare industry for the past several years. So far, it has gained more traction in administrative than in clinical applications, but the latter are catching up. According to a 2021 Accenture white paper, the top 10 AI applications in the 2020s will include robot-assisted surgery, virtual nursing assistants, administrative workflow assistance, fraud detection, dosage error reduction, connected machines, clinical trial participant identifier, preliminary diagnosis, automated image diagnosis, and cybersecurity.

To that point, one of the most exciting and executable areas of AI is in clinical trial matching, especially getting more underserved populations involved in clinical trials. Deep Lens and Kyra combined to become Paradigm and use AI to create patient identification solutions that accelerate oncology clinical trial enrollment by connecting trial sponsors to community oncology practices at scale. As importantly, AI matching allows for more democratized utilization of potential lifesaving clinical trials to underserved populations who have been left out of more traditional trial matching.

Another exciting AI application is what Accenture calls a virtual nursing assistant—a kind of clinical decision support tool based on remote monitoring data. "When AI solutions remotely assess a patient's symptoms and deliver alerts to clinicians only when patient care is needed, it reduces unnecessary hospital visits," the company notes, adding that AI tools can also help people avoid unwarranted office visits (Accenture 2021, 4). Over the next few years, Accenture predicts, this function will expand from virtual triage to AI-based care recommendations to patients.

Hemant Taneja of investment firm General Catalyst sounds a note of caution about this rush into AI. Most of the digital health start-ups pitching him and his colleagues right now, he told me, claim they use AI in some way, but not many do. This is true of companies that have developed apps and services for population health management and of those that have created tools for use in the care of individual patients.

Taneja is much more likely to fund the former. When algorithms are applied to population health management, he says, they're seeking statistical correlations in data that might be used to improve the care of populations. Inaccuracies in some of that data are less likely to affect the outcome. But when AI is applied to the care of individuals, he says, the data must be highly accurate or it can harm patients. Taneja notes that the EHR data that these algorithms analyze may not be entirely correct, because billing considerations affect physician documentation (see chapter 4).

To use AI properly in digital health tools, Taneja says, you need to accumulate a lot of data pertaining to the outcomes of interest. That's why he won't invest in Silicon Valley start-ups that put AI first in their healthcare apps and services. Livongo, he says, avoided AI when it started and incorporated algorithms into its diabetes service only after it had built a large database.

AI Categories of Interest

The main AI categories in healthcare, besides robotic surgery, are natural language processing (NLP), predictive modeling, and prescriptive analytics. NLP and data mining will be explored in chapter 4 in the context of clinical decision support. From the viewpoint of interpreting remote monitoring data for patients, predictive modeling and its prescriptive cousin are more relevant—although more advanced NLP may someday play a role.

Predictive analytics is used to predict events and identify patterns, both in populations and in individuals. But it's really just a starting point to enact meaningful change. To apply predictive modeling to patient care, it's necessary to use prescriptive analytics that make specific recommendations to operationalize the data.

For example, Ochsner has used machine learning to predict the deterioration of patients in the hospital. The algorithm leverages more than 1 billion clinical data points to create a network capable of predicting deterioration outside of the ICU with 90 percent accuracy. Based on that model, the health system designed an intervention consisting of a response team and a notification process. This intervention has reduced adverse events outside the ICU by 44 percent (Slabodkin 2019b).

Supervised Versus Unsupervised Algorithms

Predictive analytics are typically based on algorithms that are trained through a "supervised learning" approach, in which the outcome is known ahead of time. That approach works fine when only certain kinds of data are being used, but the varieties of health data are increasing rapidly. For example, some health databases now encompass genomic data and social determinants of health, which include a dizzying number of variables. Moreover, individual responses to certain diseases and specific medications are very complex, and more is being learned about this all the time. So "unsupervised" algorithms that learn from experience are needed to accurately predict individual outcomes and responses to medical interventions (Hodach et al. 2016, 223).

The AI solution Flagler Hospital used to improve its clinical pathways, for instance, used unsupervised machine learning to identify common elements in the treatments of the pneumonia patients who had the best outcomes. The software did this by grouping patients who had been treated similarly and comparing those groups' outcomes, computing the direct variable costs, lengths of stay, readmission rates, and mortality rates for each of the cohorts. Comorbidities were also factored into the algorithm's calculations.

The Flagler team selected the cohort that had the shortest length of stay, the least readmissions, the lowest mortality rate, and the lowest cost. Then it used the algorithm to redesign its care pathway to reflect how that group of patients had been treated from the time they'd arrived in the ER until they were discharged. In some cases, the algorithm revealed relationships that the team would not have known to look for. For example, they found that the faster they started a pneumonia patient who also had COPD on nebulizer treatments, the shorter the stay, the lower the cost, and the lower the likelihood of readmission.

Flipping the Paradigm

AI tools are also starting to be used in the care of patients at home. Ochsner, for example, has begun to apply machine learning to its remote monitoring of patients with chronic diseases. Instead of going to a doctor's office three or four times a year, these patients get regular virtual checkups using real-time analyses of monitoring data fed continuously to their care team. More than 6,500 patients were participating in this program in 2019, and some hypertensive individuals were seeing their blood pressure fall as a result (Slabodkin 2019b).

As the technology improves and consumers gain greater control of their own care, AI-based health advisers will provide recommendations directly to people, based on their monitoring data and other information about them. Livongo, Homeward, and other health assurance companies are already doing some of this, but more can be done.

For example, people at risk of developing type 2 diabetes can benefit from evidence-based interventions listed in the CDC's National Diabetes Prevention Program. The intervention can be delivered in person, via telehealth, or online. High-quality virtual diabetes prevention programs use technology that reaches people where they are so they can be educated about key risk factors. Virtual counseling, including sessions powered by conversational AI bots, have been shown to help people make meaningful behavior changes that drive better outcomes (Gabbay and Hu 2021).

Another type of preventive care involves warning people when they are showing signs of a worrisome health condition. Apple smartwatches, for example, are now able to detect atrial fibrillation when paired with a deep neural network. While the AI-enhanced smartwatch data is slightly less specific than that of an electrocardiogram device, its accuracy is considerably greater than that of self-reporting (Lovett 2018b).

People who use such apps still can't diagnose themselves without the help of a clinician. Accenture (2021) discusses AI tools making "preliminary diagnoses" that must be confirmed by a physician. But in at least one area, algorithms have pushed beyond that barrier. The FDA has recognized IDx-DR, created by Digital Diagnostics, as a "breakthrough device" able to accurately diagnose retinopathy without involving an ophthalmologist (Preston 2018). Google researchers have confirmed that a trained algorithm can detect retinopathy as well as a physician can (Lovett 2018a).

If the FDA approves this technology, patients could test themselves without having to visit an eye doctor. Considering how many people with diabetes are referred for retinopathy exams but don't get them, this could be a major advance.

A NEW RELATIONSHIP WITH PHYSICIANS

So where are we going in the world of virtual care? Will the healthcare version of Nicki Minaj's "Feeling Myself" be "Diagnosing Myself?" Will we return to the paradigm of mHealth apps, which people use to manage their health and wellness without connecting to their physicians?

I don't believe that's going to happen. Even with the advent of health assurance services that provide automated feedback on RPM data about how to optimize health and manage chronic conditions, people will still seek advice and help from their care teams. But the relationship between individuals and their physicians will change.

In *The Patient Will See You Now*, the prescient 2015 book by Eric Topol, MD, the founder and director of the Scripps Research Translational Institute envisions a future in which each person has all their own medical data and the computing power to process it, and most care is provided at home. Here's how he describes the result:

> The doctor will see you now via your smartphone screen without an hour of waiting, at any time, day or night. It might not be your primary care doctor, but it will likely be a reputable physician who is conducting part of his or her practice through secure video consults. And those consults will involve doing parts of the standard physical examination remotely. More importantly, they will incorporate sharing your data—the full gamut from sensors, images, labs, and genomic sequence, well beyond an electronic medical record. We're talking about lots of terabytes of data about you, . . . from the womb to the tomb, in your personal cloud, stored and ready for ferreting out the signals from the noise, even to prevent an illness before it happens. (Topol 2015, 8)

I view the future in a similar way. At least for people with chronic conditions, and perhaps also for relatively healthy people, remote monitoring will become more or less continuous. The data from this real-time, always-on digital physical will be available both to the person and their care team. This represents the dream and reality of healthcare at any address, or health assurance, as described in the book I wrote with Hemant Taneja in 2020. Most important, RPM changes the definition of a health system or a physician practice, because most care will be provided at home rather than in the office or the hospital. The concept of a once-a-year physical should go the way of bloodletting and leeches.

The New Annual Physical

The implications of healthcare at any address are enormous. Take the annual physical. Today, this appointment is primarily a data collection opportunity. Your physician takes your blood pressure, weighs you, takes your temperature, does an electrocardiogram, draws blood for lab tests, looks in some orifices and pokes a few others, and then has about five minutes to ask how you're doing.

The data comes with no context over time—no sense, for instance, of what your heart rate or breathing rate is every day and whether it's showing troubling patterns. The data is connected to no other data about your life—nothing about what you eat, where you've been, how much stress you've been under. So, basically, the physician knows the state of your health only during the short time you're in the examination room, and has little time to talk to you because of the need to stay on schedule—and of course, collect all that data in the office.

An entirely new kind of "physical"—rich in data and deeply rooted in human empathy—will become the starting place for your health assurance. Some of this data will come from a comprehensive health record that will reflect everything that has been done for you by every provider you've come in contact with. In addition, the curated recent results and insights from your remote monitoring will be available. And there will also be information on other key parameters, including your genomic makeup, your personal and family history, and your social determinants of health. Think of a mix of Gloria Gaynor's "I Am What I Am" and Jaheim and Keyshia Cole's "I've Changed."

With the cost of genomic sequencing continuing to fall, in a few years genetic testing will be as routine as a blood test used to check cholesterol. However, people will have their umbilical cord DNA analyzed only once, because it will never change. It won't be long before everyone has their DNA tested at birth, making it part of each person's health record for life.

Privacy concerns around genomic data have become one of my primary areas of interest. Your genome tells doctors whether you have a predisposition for certain cancers or other diseases. It also provides clues about how to care for you, including what drugs are most likely to be effective for you. Your genetic data can even help you understand how fast you metabolize caffeine, which is important to know if you have insomnia. There are so many opportunities for commercialization and abuse, and the time to recognize the good, bad, and ugly is now.

If we knew that the social media revolution was not just a convenient way to communicate with others or to see your grandkids, but could also potentially affect elections and be used to spew hate, we would have put in some guardrails *before* implementation. Similarly, the genomic revolution—combined with continuous remote monitoring and, eventually, continuous blood analysis empowered by nanotechnology—opens up a new frontier for a healthier, more equitable society. Making sure that the unintended consequences of privacy issues, cybersecurity, commercial abuse, and racial inequities don't tarnish this potential will require (1) putting ethics into the equation at the beginning and (2) using technologies such as blockchain, deidentification, and tokenization to ensure that patients remain in control of not only their data but also the core of their being—their genomic makeup.

Another key source of data will be social determinants of health. These include social and economic factors as well as physical environmental factors, and account for 20 percent to 50 percent of health outcomes, as discussed in chapter 8 (Hodach et al. 2016). Some healthcare organizations use a range of apps to connect with community organizations that address components of social determinants, such as food insecurity and inadequate housing. In addition, they are turning to AI to accurately identify high-risk people with addressable social determinants and efficiently target interventions (Siwicki 2022).

When care teams have all this data at their fingertips, they'll be able to suggest appropriate interventions that will help people reduce their risk of developing or exacerbating chronic conditions. At the same time, automated health advisers will coach individuals about their health risks and opportunities to improve their health on a day-to-day basis.

As a result of these interventions, people will be healthier and better informed; thus, they'll need to visit doctors less often than they do now. When they do have a clinical encounter, it will be very different from today's routine interactions between doctors and patients. Instead of having to spend most of the visit investigating the person's physical condition and documenting it in an EHR, the physician will ask questions about recent trends in the individual's physiological data, find out more about their personal situation, and jointly prepare or adjust a treatment plan with the person.

It is beyond time for us to take advantage of these advancing technologies, not to just make the wealthy healthier, but also to move population health monitoring, social determinants, and predictive analytics from philosophic and academic exercises to the mainstream of clinical care and payment models.

Monitoring in the Background

Continuous health monitoring will not win many converts unless it can be done unobtrusively in the background. After all, most people don't want to regard themselves as patients unless they're very sick. One of the ways this can be accomplished is to develop improved wearable sensors, which will translate physical signs into data that can be transmitted via smartphones.

Wearables have been around for a decade or more. Ten years ago, Fitbit already existed, and so did AliveCor. A start-up named OMsignal was developing a compression undershirt with sensors that could reportedly capture electrocardiogram patterns, activity, breathing patterns, and emotive states (Dolan 2013).

Since then, the concept of wearable sensors has been dramatically upgraded. At Jefferson Health, for instance, we worked with an Australian company to codevelop a carbonized hemp wearable called Hemp Black, with sensors that help people stay connected with their health, track their steps, record their heart rates, and more. Michael Savarie, a Jefferson graduate and the sustainability enterprise catalyst for Hemp Black, told me in an e-mail, "There's a space that needs to be filled, and currently that space is being filled with clunky wires going into fabric." But Hemp Black has technology that could eliminate clunky, uncomfortable wires.

Sensor-laden clothing hasn't caught on yet, but in 2019 Current Health received FDA clearance for an upper-arm wearable monitor for home use in post-acute care. Paired with a dedicated tablet, educational content, medication reminders, and support for virtual visits, the wearable can monitor skin temperature, pulse rate, oxygen saturation, and movement (Muoio 2019a). Also in 2019, the FDA cleared an upgraded version of AliveCor's wearable six-lead electrocardiogram device, which is part of a cardiology service (Muoio 2019b). In February 2020, AliveCor rolled out a credit card-size electrocardiogram with a single lead that can be carried in a wallet (Lovett 2022a). Another company hatched in Philadelphia, Stel Life, is leading the wearable revolution that John Sculley predicted in the foreword with Bluetooth-enabled sensors that seamlessly and securely connect a variety of health devices to EHRs.

Apple leads the health wearables market with its Apple Watch, Beats, and AirPod products. I've already mentioned Apple's pilot for using the smartwatch to detect atrial fibrillation. Apple also makes 100 types of data available through the iPhone, Apple Watch, and third-party apps. People whose doctors use one of six leading EHRs will soon be able to send them tracked data on heart rate, sleep hours, exercise minutes, steps, and falls through Apple Health (Kaiser Health News 2021; Moeller 2020).

Fitbit, acquired by Google in 2021, sells a widely used wristband that tracks exercise. It also has a smartwatch that can measure blood oxygen, skin temperature, heart rhythm, heart rate, sleep patterns, and stress, as well as activity. Amazon has also entered the wearables race with its Halo wristband for health and fitness tracking (Moeller 2020).

The next stage in background monitoring will likely involve the Internet of Things. Smart speakers like Alexa and home control systems like Nest may serve as access points for low-power wearables and ambient sensors. They could also enable intelligent personal assistant capabilities such as medication reminders and exercise monitoring (Moeller 2020).

Meanwhile, the caricature of someone walking around with several devices stuck to their body is being replaced with almost imperceptible continuous monitoring techniques that don't require you to add or wear anything. These approaches use micro sensors attached to things you use in your daily life, much the way your car sends continuous signals about its own status. Rod Stewart's "You Wear It Well" may soon describe your health status, rather than your attire.

A pair of start-ups have beat the tech giants to the punch in the Internet of Things. Eight Sleep, which started out as a mattress that can heat or cool to your body's wishes, can now measure an increasing amount of healthcare data automatically. Casana, a smart-toilet maker, describes itself on the company home page as "the future of in-home health monitoring, where you least expect it!" Its "heart seat" seeks to capture reliable data during the three hours and nine minutes a week the average adult sits on the toilet—twice as much time as they spend exercising (Lee 2017). Olamide's song "Sitting on the Throne" might have a very different connotation someday.

Wearables are moving from the ring and watch to your everyday life. The cofounder of Jawbone, Hosain Rahman, is working with All.health to develop a comprehensive preventive and proactive healthcare platform that combines clinical-grade sensors, machine learning, patient histories, insurance claims data, and other information to provide real-time at-risk screening for several disease conditions. And *Digital Medicine*, of which Kvedar is the editor, has published an article about a remote device called Wellvii that can monitor 11 health parameters using medical grade sensors and algorithms which allow you to capture blood pressure variability, heart rate, heart rate variability, respiration rate, and SpO2 in 90 seconds (Polanco et al. 2019). The device provides an intuitive dashboard around balance, stress, vitality, and trends so you can "boost your health IQ" (wellvii.com).

No area of RPM and AI health data analysis will have a more rapid trajectory than advances in this direct-to-consumer area. What exists today will soon look like a first-generation iPod next to the wearables of the near future.

REDUCED SPENDING WHILE ENDING DISPARITIES

In a world of health assurance, consumers will stay healthier, manage conditions better, see doctors less often, get fewer tests, buy fewer drugs, and spend less overall on their health than they do today. This change will be a decisive factor in enabling the United States to bend the cost curve and make healthcare affordable. The aim will not be to make the sick care system more efficient, but to keep people as healthy as possible so they don't need sick care.

However, health equity must be a cornerstone of this transition. Today, as mentioned previously, racial minorities receive substantially worse care in the United States than white people do. Similarly, poor folks are at a healthcare disadvantage when compared with affluent people, and rural residents are losing access to healthcare for a variety of reasons, including hospital consolidations. All these disparities will get even worse in a health assurance world unless everyone is guaranteed access to computers or smartphones and a broadband internet connection.

There are also inequities in how AI algorithms are developed. To address these, says Paul Cerrato of the Mayo Clinic, "developers and researchers need to start by improving the data sets upon which their algorithms are based" (Lovett 2022b). In other words, those data sets must be more representative of the population. In addition, the design of the algorithms must be examined to determine what they seek to optimize: quality of care, outcomes, cost, or all three (Kent 2019).

To Taneja, health equity is a precondition of health assurance, and successful digital health entrepreneurs must be cognizant of that. "We need to build these companies so that we can shrink the overall amount that healthcare costs, and reinvest some of those savings in ensuring health equity. Because this is really a societal benefit that we believe everyone should enjoy."

When everything described in this chapter is fully achieved, AI will become a valued servant of consumers and providers without replacing the judgment of either party. But for AI to achieve its potential, we need much better and more comprehensive health data, and it must be universally available. Only then will physicians be able to trust the algorithms enough to focus mostly on health coaching and care coordination for their patients.

Just as in the Bee Gees song "Words," patients will need more than words to judge the health technology you want them to use; they will evaluate it based on how effective it is at assuring their health at work, home, and play. The next chapter examines the progress being made in these areas and offers some hypotheses on where that may lead for patients, providers, and the robots that will work alongside them.

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