

14th Annual Edition

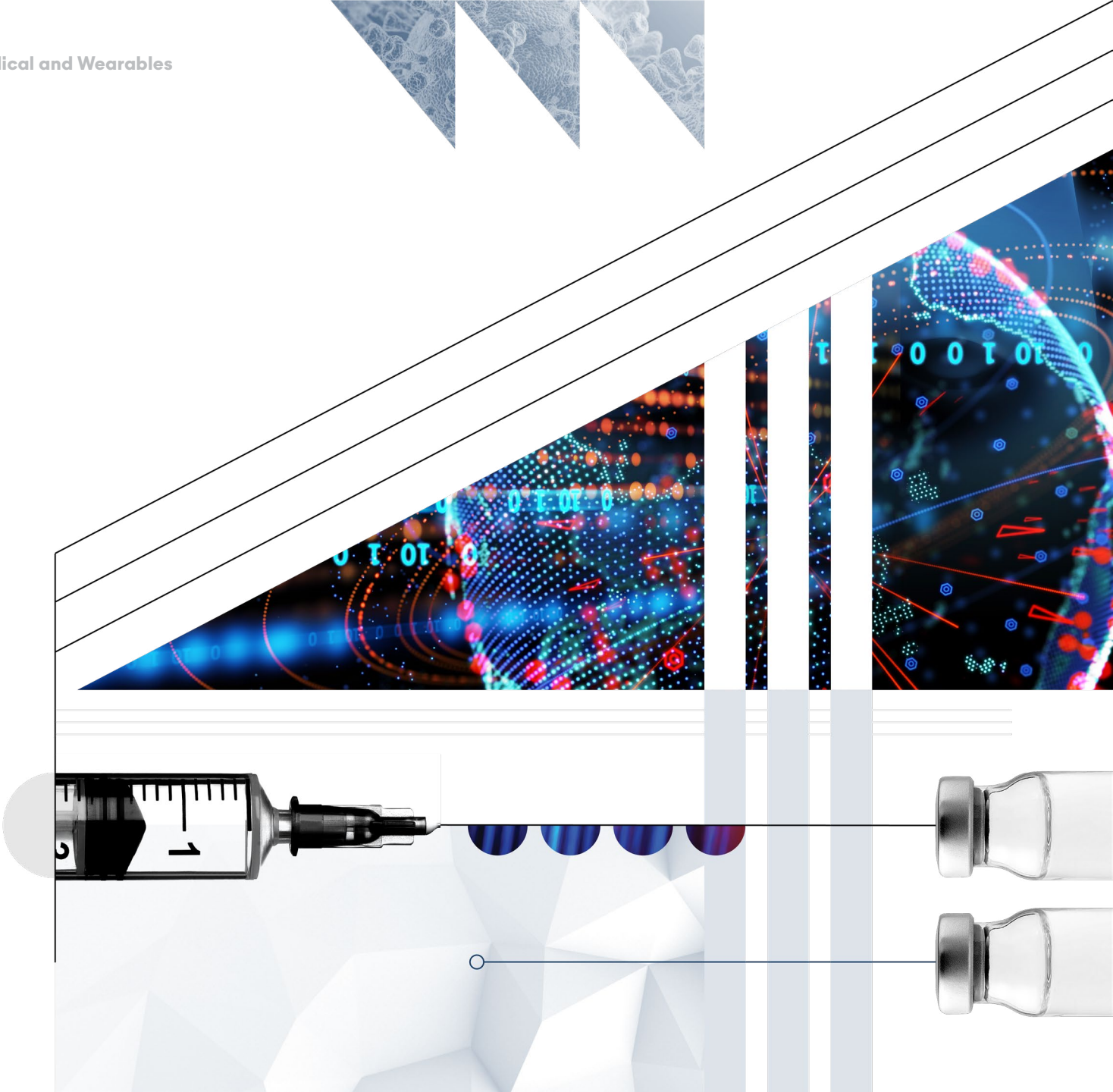
2021 Tech Trends Report

Strategic trends that will influence business, government, education, media and society in the coming year.



Health
Medical
Wearables

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Overview



The 1920s began in chaos. Cataclysmic disruption resulting from the first world war and the Spanish flu shuttered businesses and provoked xenophobia. Technological marvels like the radio, refrigerator, vacuum cleaner, moving assembly line and electronic power transmission generated new growth, even as the wealth gap widened. More than two-thirds of Americans survived on wages too low to sustain everyday living. The pace of scientific innovation—the discovery of insulin, the first modern antibiotics, and insights into theoretical physics and the structure of atoms—forced people to reconsider their cherished beliefs.

The sheer scale of change, and the great uncertainty that came with it, produced two factions: those who wanted to reverse time and return the world to normal, and those who embraced the chaos, faced forward, and got busy building the future.

It's difficult not to see striking parallels to our modern world. A tumultuous U.S. election, extreme weather events and Covid-19 continue to test our resolve and our resilience. Exponential technologies—artificial intelligence, synthetic biology, exascale computing, autonomous robots, and off-planet missions to space—are challenging our assumptions about human potential. Under lockdown, we've learned how to work from our kitchen tables, lead from our spare rooms, and support each other from afar. But this disruption has only just begun.

With the benefit of both hindsight and strategic foresight, we can choose a path of reinvention. Our 2021 Tech Trends Report is designed to help you confront deep uncertainty, adapt and thrive. For this year's edition, the magnitude of new signals required us to create 12 separate volumes, and each report focuses on a cluster of relat-

ed trends. In total, we've analyzed nearly 500 technology and science trends across multiple industry sectors. In each volume, we discuss the disruptive forces, opportunities and strategies that will drive your organization in the near future.

Now, more than ever, your organization should examine the potential near and long-term impact of tech trends. You must factor the trends in this report into your strategic thinking for the coming year, and adjust your planning, operations and business models accordingly. But we hope you will make time for creative exploration. From chaos, a new world will come.

Amy Webb

Founder
The Future Today Institute

Macro Forces and Emerging Trends

For nearly two decades, the Future Today Institute has meticulously researched macro forces of change and the emerging trends that result. Our focus: understanding how these forces and trends will shape our futures. Our 14th annual Tech Trends Report identifies new opportunities for growth and potential collaborations in and adjacent to your business. We also highlight emerging or atypical threats across most industries, including all levels of government. For those in creative fields, you will find a wealth of new ideas that will spark your imagination.

Our framework organizes nearly 500 trends into 12 clear categories.

Within those categories are specific use cases and recommendations for key roles in many organizations: strategy, innovation, R&D, and risk.

Each trend offers six important insights.

1. Years on the List

We track longitudinal tech and science trends. This measurement indicates how long we have followed the trend and its progression.

2. Key Insight

Concise description of this trend that can be easily understood and repeated to others.

3. Examples

Real-world use cases, some of which should be familiar to you.

4. Disruptive Impact

The implications of this trend on your business, government, or society.

5. Emerging Players

Individuals, research teams, startups, and other organizations emerging in this space.

6. Action Scale

FTI's analysis of what action your organization should take. Fields include:

Watch Closely

Mounting evidence and data, but more maturity is needed. Use it to inform your vision, planning, and research.

Informs Strategy

Strong evidence and data. Longer-term uncertainties remain. Use it to inform your strategic planning.

Act Now

Ample evidence and data. This trend is already mature and requires action.

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Health, Medical, Wearables

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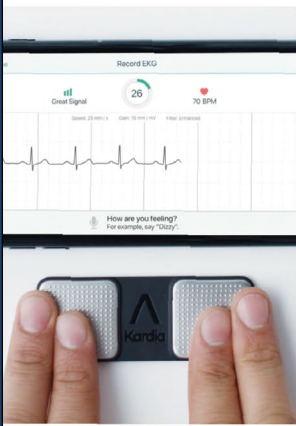
Watch Closely

Informs Strategy

Act Now

1ST YEAR ON THE LIST — 1

Doctorless Exams



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Key Insight — 2

Advancements in diagnostic testing and remote monitoring, supported by cloud computing, machine learning, and low-cost technology are upending traditional doctor visits. Patient data are triaged by algorithm, rather than human doctors alone.

Examples — 3

Smartphones and smartwatches now take blood pressure readings and perform electrocardiograms, using apps approved by the U.S. Food and Drug Administration. Phones don't just record data; they interpret it. People who wear an Apple Watch know that an unusually high or low heart rate or irregular rhythm may suggest atrial fibrillation. The VROR system, a VR-based eye exam, emulates an eye doctor's ultra-widefield imaging machine but within a compact headset. Data are sent to a mobile app for an understanding of a patient's optic nerve health. StethIO is a mobile stethoscope that uses a smartphone to capture, decode and analyze heart sounds. AliveCor is an FDA-Cleared wireless personal EKG that connects to a phone. Butterfly iQ is a portable ultrasound device that delivers a 2D image. The ParatusPerio Test analyzes different bacteria and sources of inflammation in a patient's mouth.

Disruptive Impact — 4

Continual monitoring helps patients know their baseline vital stats and track any changes. This disrupts traditional healthcare in a few ways. First, with continual monitoring, patients are more likely to intercept an emerging problem in advance and seek out care. For example, if a patient's smartwatch warns of atrial fibrillation, they can call their doctor for next steps. This reduces strain on emergency departments. It also unlocks new opportunities for healthcare systems and insurers willing to use those data and to make medical records systems interoperable. Financial forecasting that harnesses real-time data could be algorithmically recalibrated, and more accurately assess risk. But connected devices aren't accessible to everyone, which means that a new digital divide could be on the horizon, further reducing health equity in many communities.

Emerging Players — 5

- The Clue period tracking app
- Apple Health
- StethIO
- Healthy.io
- Paratus Diagnostics
- Butterfly Network
- AliveCor

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Macro Forces and Emerging Trends

Scenarios Describe Plausible Outcomes

You will find scenarios imagining future worlds as trends evolve and converge. Scenarios offer a fresh perspective on trends and often challenge your deeply held beliefs. They prompt you to consider high-impact, high-uncertainty situations using signals available today.

1. Headline

A short description offering you a glimpse into future changes.

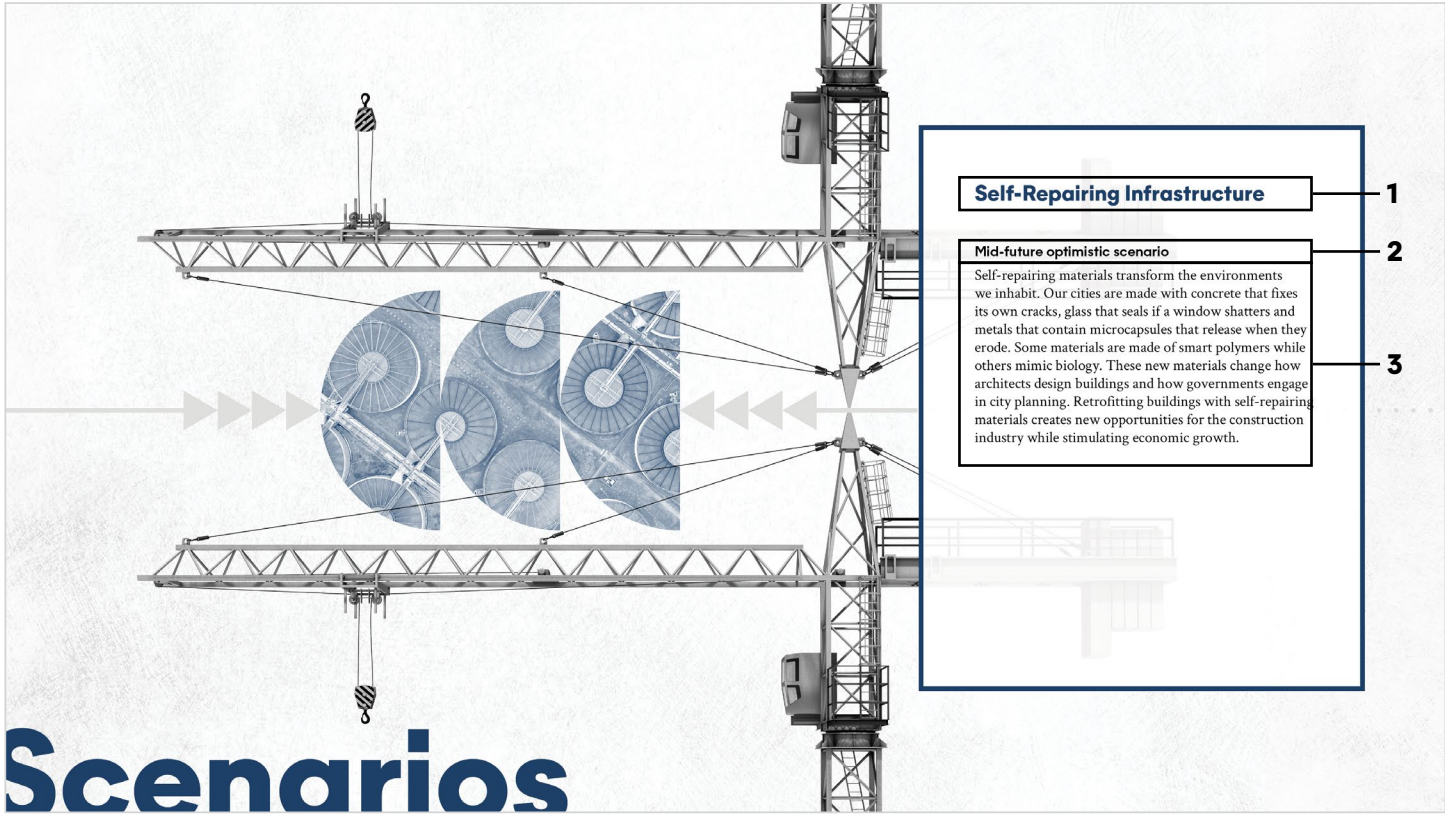
2. Temporal and Emotive Tags

A label explaining both when in the future this scenario is set and whether it is optimistic, neutral, pessimistic, or catastrophic.

3. Narrative

The descriptive elements of our imagined world, including the developments leading us to this point in our future history.

Scenario sources: The Future Today Institute uses a wide array of qualitative and quantitative data to create our scenarios. Some of our typical sources include patent filings, academic preprint servers, archival research, policy briefings, conference papers, data sets, structured interviews with experts, conversations with kids, critical design, and speculative fiction.

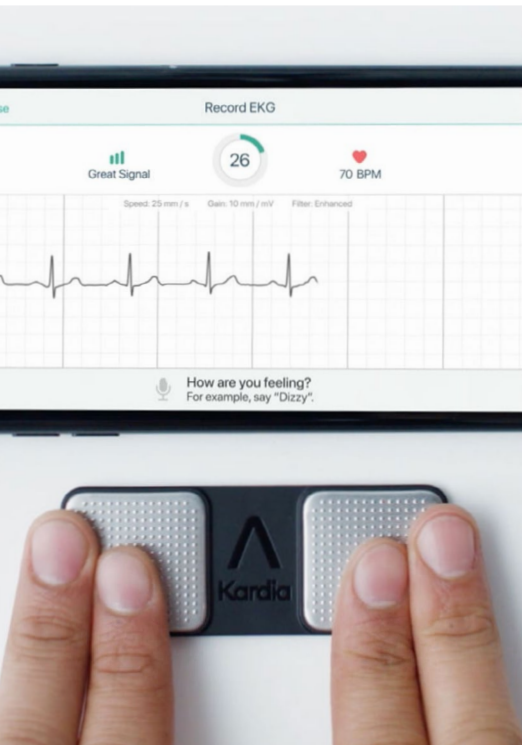


Health Medical Wearables Summary

- + Health care is the next battleground for big tech companies. Amazon, Google, Apple, and Facebook see health care as ripe for disruption—and an industry where they can make positive improvements.
- + Because of its scale and reach, Amazon could force established pharmaceutical companies, health care systems, and insurers to adapt and evolve.
- + COVID-19 accelerated the adoption of telemedicine visits, which spurred a new digital transformation effort in health care.
- + More diagnostic tests are being done at home using connected devices, including smart mirrors and smart toilets.
- + Last year was a sudden dress rehearsal for widespread remote patient monitoring.
- + The last few years saw the launch of smart fitness equipment, which includes mirrors, bikes, and treadmills. The pandemic accelerated sales and helped the market grow significantly.
- + Video games are being developed to treat certain conditions and diseases. Prescription-strength games even carry Food and Drug Administration approval.
- + Sleep tech is big business: By 2026, the market size could be upward of \$30 billion.
- + This could be the year that Facebook and Apple launch their smart glasses.

1ST YEAR ON THE LIST

Doctorless Exams



AliveCor's personal EKG monitoring system.

KEY INSIGHT

Advancements in diagnostic testing and remote monitoring, supported by cloud computing, machine learning, and low-cost technology, are upending traditional doctor visits. Patient data is triaged by algorithm, rather than human doctors alone.

EXAMPLES

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DISRUPTIVE IMPACT

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- EMERGING PLAYERS**
- The Clue period tracking app
 - Apple Health
 - Steth IO
 - Healthy.io
 - Paratus Diagnostics
 - Butterfly Network
 - AliveCor

1ST YEAR ON THE LIST

At-Home Medical Laboratory Tests



The Toto Wellness Toilet can analyze your waste.

KEY INSIGHT

The everyday equipment in your bathroom will soon be used to collect biological samples for daily monitoring and testing. You won't have to worry about making appointments to visit a diagnostic lab—and then wait in lines and wait even longer for results—as a new crop of technologies intends to conduct scans at home.

EXAMPLES

Because toilets are in direct contact with two key sources of data—our skin and our waste—they offer opportunities to analyze our real-time health. Stanford University researchers identified different cancers, liver diseases, and gut disorders using motion and pressure sensors, urinalysis strips, computer vision, and infrared sensors. Toto's new Wellness Toilet builds on that research by using sensors to analyze "key outputs" and give users insights on hydration and their diets. Kohler's smart toilet uses Amazon Alexa voice controls. Healthy.io's Velieve, a urinary tract infection test kit, uses a mobile app to connect patients who have positive results with an online doctor and sends a prescription to a nearby pharmacy if needed. Healthy.io also partnered with the National Kidney Foundation to offer an annual kidney test kit to detect early disease.

DISRUPTIVE IMPACT

COVID-19 accelerated the use of telemedicine in the U.S. and other countries where remote visits were previously restricted. With telemedicine as a new normal, at-home lab tests will increase and disrupt diagnostic companies, such as Labcorp and Quest Diagnostics, and drugstore retailers with clinics, such as Target and CVS.

EMERGING PLAYERS

- Healthy.io
- Toto
- Everlywell
- Imaware
- FoodMarble
- Lumen
- LetsGetChecked

1ST YEAR ON THE LIST

Telemedicine



A young family consults with their doctor using a telemedicine app.

KEY INSIGHT

Telemedicine isn’t a new concept. The technology for facilitating and encrypting video consults has been available for years, but it represented a paradigm shift in the traditional doctor visit. COVID-19 forced an overnight change as lockdowns prevented health care providers from seeing patients except in cases of emergency.

EXAMPLES

Telemedicine had previously been offered only to people in difficult-to-reach locations, such as sparsely populated rural areas or the International Space Station. Medicare restrictions limited remote visits to patients who met certain criteria or forced them to travel to approved centers for the video meetings. But telemedicine has since flourished. A study by nonprofit group FAIR Health showed a 4,347% surge in telemedicine claims in the U.S. between March 2019 and March 2020. The Centers for Medicare and Medicaid Services also added 80 more services to be delivered remotely and now allow providers to bill at the same rate as in-person visits. Artificial intelligence is part of telehealth’s evolution. Recognition technologies for voice, emotion, gesture, posture, and more can add to a doctor’s evaluation of a patient. AI can already detect whether someone has a cold or is despondent, relative to their normal disposition.

DISRUPTIVE IMPACT

Telemedicine unlocks new opportunities for growth, not to mention easier access to health care and a chance to improve health equity. For example, telemedicine can address the rising challenges of provider workloads, hospital or clinic space, and labor-intensive data entry. Remote visits reduce strain on facilities, while adjacent technologies (automated medical transcription, fitness and health monitoring apps and wearables, at-home diagnostic tests) and machine learning can optimize the speed and scope of data collection. Clinics and hospitals can scale treatment without adding new staff resources and reduce hospital readmission rates by remotely coordinating with home care providers.

EMERGING PLAYERS

- Eko
- Aluna
- Biofourmis
- Current Health
- Myia Health
- Olive
- Notable Health
- Alpha Health
- Qventus
- Augmedix
- Suki
- CloudMedx
- Corti
- Butterfly Network
- Arterys

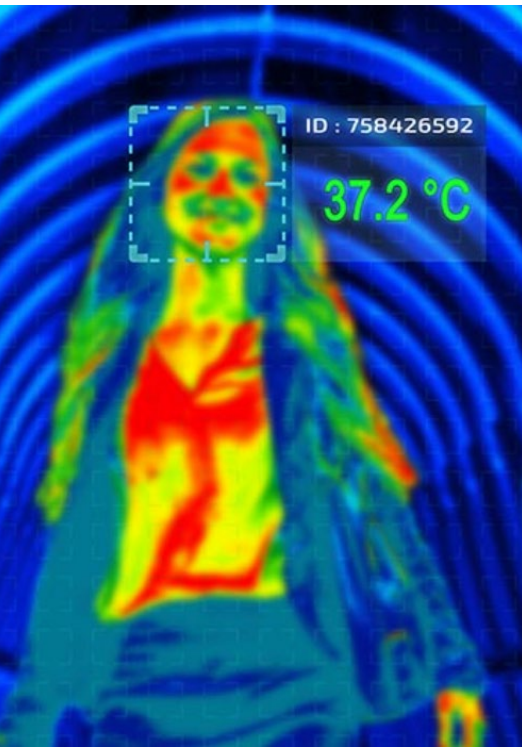
A New Kind of Body Shop

Mid-future neutral scenario

Implanting technology in the human body for various aesthetic and functional purposes has entered the mainstream as a popular new form of self-expression. Tech-focused body modification—called grinding when performed DIY—emerges as a new market situated somewhere between the decorative piercing industry and the medical field. A new type of establishment begins to appear in major cities to serve this subculture, a hybrid of a walk-in neighborhood clinic and a tattoo shop. These body shops have retail storefronts, but with enough equipment, trained staff, and permits to allow them to perform minimally invasive surgeries. The most popular requests for implants? Magnets, RFID chips, glow-in-the-dark shapes, and wireless data storage. Sounds pretty cool, until you walk through your next metal detector.

1ST YEAR ON THE LIST

Biometric Screening Systems



New biometric screening systems use thermal imaging to check temperatures.

KEY INSIGHT

In the wake of COVID-19, schools, offices, and even homeowners began using biometric scanning systems to determine whether someone is sick—and to grant or deny them entry.

EXAMPLES

Office buildings, grocery stores, movie theaters, and health care facilities now use temperature checks to screen for COVID-19 symptoms, based on guidance from the Centers for Disease Control and Prevention. This year, Plott will introduce the Ettie, a \$300 video doorbell system that performs an automatic temperature check and displays it back to the user. An LED panel will glow red if a visitor has a fever, and the system will refuse her entry. Ettie can also be programmed to limit the capacity of entrants; when capacity is hit, the door will not unlock (even if that person has been temperature-cleared). FLIR Systems, an infrared camera maker, sells FDA-certified cameras that can check workers in 10 seconds or less and focuses on tear ducts, which tend to give a truer reading of someone's body temperature than the forehead, which can be warmed by hats, hoods, and direct sunlight.

DISRUPTIVE IMPACT

Biometric screening systems run up against paradoxical regulations in the U.S. While the Health Insurance Portability and Accountability Act (HIPAA) requires companies to develop and follow procedures that ensure the confidentiality and security of protected health information—meaning that workers would need to consent to be scanned—customers and other members of the public are not covered under HIPAA (unless the owner of the camera is a health care provider). It's not clear whether infrared doorbells on private homes would be allowed under California's Consumer Privacy Act. Laws in Illinois, Texas, and Washington now regulate the collection of biometric data, including body scans.

EMERGING PLAYERS

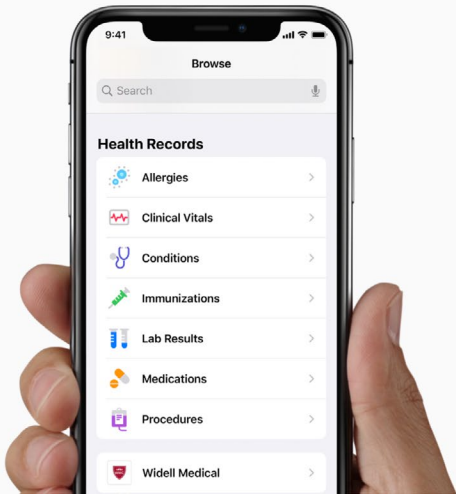
- Plott
- FLIR Systems
- Electronic Frontier Foundation
- Thermoteknix Systems
- Opgal
- Mobotix
- Dahua Technology

3RD YEAR ON THE LIST

Big Tech Disrupts Health Care

Empower your patients with Health Records on iPhone.

The Health app makes it easier than ever for users to visualize and securely store their health records. Now your patients can aggregate their health records from multiple institutions alongside their patient-generated data, creating a more holistic view of their health.



Apple's Health Records offers an alternative to traditional electronic health records. systems.

KEY INSIGHT

Health care is the next battleground for big tech companies. Amazon, Google, Apple, and Facebook see health care as ripe for disruption—and an industry where they can make positive improvements.

EXAMPLES

Data scraped from Fitbit devices—steps taken, heart rate, hours of sleep, and other key metrics—lets Google make recommendations and optimize consumer habits. It also opens a giant pool of data for research. Google and Ascension, one of the largest health care systems in the U.S., will build a robust search tool to aggregate patient data—lab results, hospitalization records, vital statistics—and house it under one system. The Apple Watch Series 4 doubles as a medical device, able to detect when someone has a hard fall and to call 911; identify a dangerous heart rhythm condition called atrial fibrillation; and track menstrual cycles, heart rate, and overall mobility. Apple's Health Records, launched in 2018, pulls data from other Apple products to help patients and providers see comprehensive data—medications, lab results, immunizations—in one spot. Meanwhile, AC Wellness, a subsidiary of

Apple and a clinic for Apple employees, started offering free genetic screening in 2019. Facebook's Preventive Health tool lets users set reminders for health screenings and find nearby providers.

Big Tech Disrupts Health Care continued



Amazon is among the big tech companies disrupting traditional health care.

DISRUPTIVE IMPACT

The world's largest tech companies are tackling the \$3.6 trillion U.S. health care industry with initiatives spanning basic scientific research and health care application research, revamping insurance, creating new clinics, and melding our data with their interactive devices. Google is a world leader in applying AI to medical research—its automated breast cancer detection system already outperforms oncologists. Pre-pandemic, health and medicine inquiries made up 7% of all Google searches. Google's \$2 billion Fitbit purchase should spur more health care innovation. Facebook's preventive health tool could influence health outcomes for users by relying on the social media company's standard notifications. Yet Amazon's plans are the most comprehensive of all tech companies—and potentially the most disruptive to the health care industry. (See: *Amazon's Health Care Ambitions*.)

EMERGING PLAYERS

- Google Health VP Dr. David Feinberg
- Google Senior Fellow Dr. Jeff Dean
- Google Cloud
- Apple Chief Operating Officer Jeff Williams
- AC Wellness
- Facebook Head of Health Technology Dr. Freddy Abnoui

Amazon's Healthcare Ambitions

When Amazon acquired mail-order pharmacy PillPack in 2018, many thought it was just an extension of the company's logistics and delivery business. If consumers were already buying toilet paper at Amazon.com, why not blood pressure medication? Those who intentionally connected the dots between Amazon's different strategic initiatives saw a clearer, bolder picture of Amazon's health care ambitions—a massive disruption of health care was already underway.

In 2019, Amazon rebranded its acquisition as PillPack by Amazon Pharmacy, which launched in late 2020. Now patients can ask their doctors to send prescriptions directly to Amazon, which then ships medications to consumers. This signals interesting changes on the horizon. Because of its scale and reach, Amazon could force pharmaceutical manufacturers to lower drug costs, just as it pushed down the average prices of other product categories available on its retail site.

Zooming out, there are many other ways in which Amazon will (or has already begun to) disrupt the entire health care ecosystem, from drug development to insurance management. Here are just a few key areas of innovation:

Data Analytics

Amazon Web Services (AWS) launched HealthLake, a health care analytics platform that is HIPAA-eligible and works to standardize unstructured clinical data for the cloud (solving a major pain point for providers). HealthLake will make it easier for Amazon to partner with more health care providers and build its health ecosystem.

Drug Development

Partnering with Accenture and Merck, AWS created a cloud-based informatics research platform to improve productivity, efficiency, and innovation in the early stages of drug development.

Telemedicine

Amazon Care, the company's telemedicine program, has been expanded to a broad range of employees beyond its Seattle-focused beginnings. Early pitches of the service to outside employers could start to upend the current provider and insurer market.

Online Pharmacy

Amazon Pharmacy offers online prescription fulfillment and home delivery of medications via the Amazon website or mobile app. Amazon Prime members get free two-day delivery, of course. There are now 118 million Prime members in the U.S.—if even 10% move their prescriptions away from a traditional drugstore retailer (like a CVS, Walgreens, Rite Aid, or a local pharmacy), it could cause serious disruption to the \$312 billion pharmacy and drugstore retailer market.

Medical Transcription

Amazon Transcribe Medical is an automatic speech recognition service enabling providers to transcribe examinations and other medical commentary in real time.

Senior Care

Last year, Amazon launched Care Hub, a tool to assist caregivers in senior home centers. One feature: If a senior says “Alexa, call for help,” it will automatically ping the caregiver.

Personal Diagnostics

Alexa now recognizes changes in individual voices, by detecting emotional states and other factors, such as whether someone has a stuffy nose. Last year, Amazon launched Halo, its data-hungry health monitoring wristband. Halo measures body fat percentage, listens to the user's emotional state, and monitors heart rate and other activity. One of the largest electronic medical record companies, Cerner, said that Halo users will have the option to upload information collected by the device to their physicians' Cerner health record, beginning with the Sharp Health-Care system in San Diego. Insurer John Hancock is partnering with Amazon to offer members a free Halo and three-year membership in exchange for data.

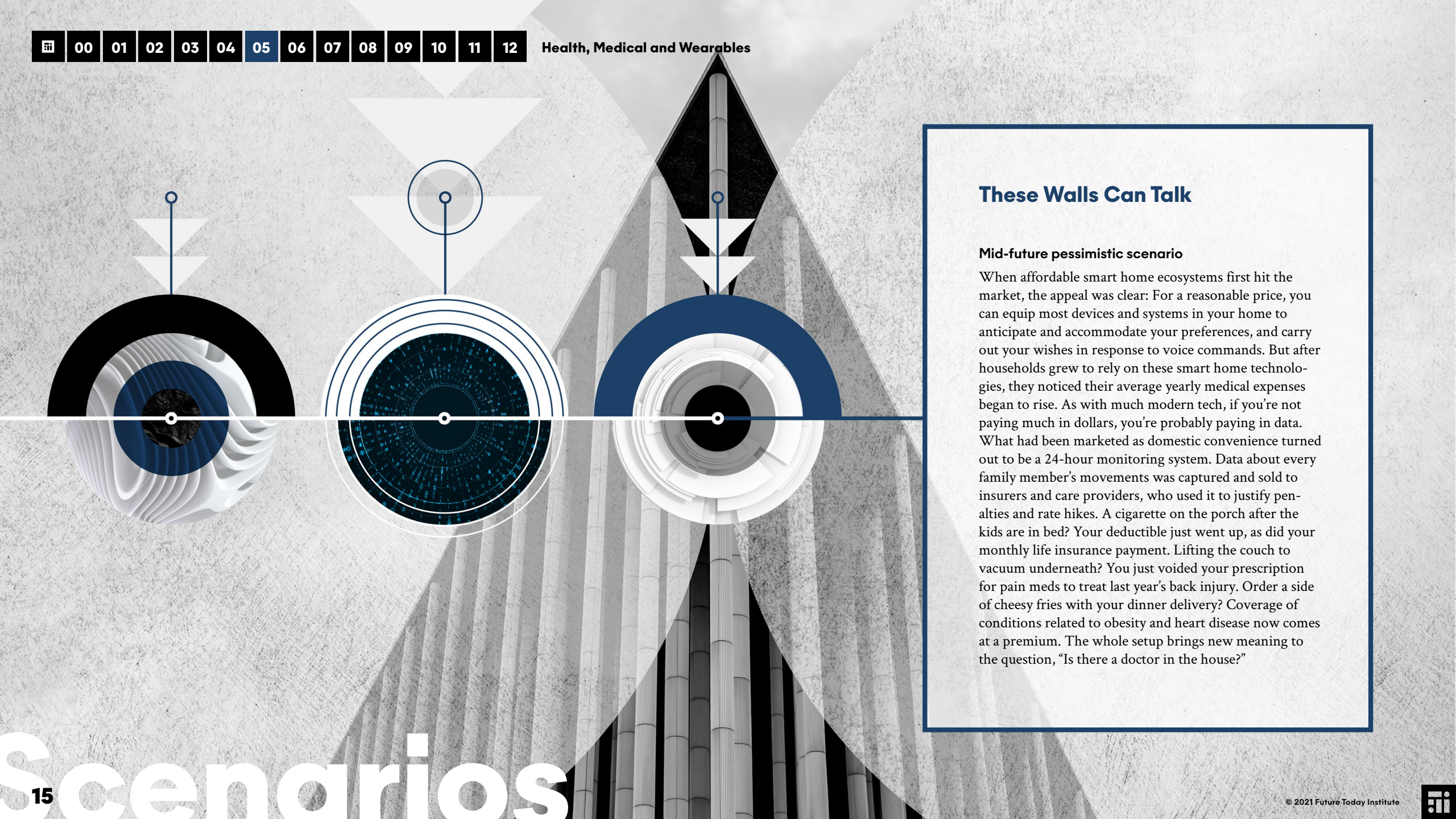
Grocery Stores

At Amazon Go grocery stores, shoppers select foods and pay using gestures or other biometric recognition. Shopping data is stored and can be correlated with other health data. Quantifying how many bags of chips bought in a year—versus how many apples—could be an interesting data point on a future personal health record.

Bottom Line

As Amazon continues to prioritize customers and their experiences, it poses an additional threat to traditional health care providers. In the U.S., customer service throughout the health care value chain—scheduling appointments, getting lab results, standardizing medical records, billing, insurance—is notoriously bad. Amazon stands to cut out middlemen that drive up health care costs. It could transform the cadence of work, by creating instant medical records and offering immediate diagnostic results.

For those who point to the dissolution of Haven, Amazon's joint venture with Berkshire Hathaway and JP Morgan Chase, as a sign of trouble, note that the collaboration resulted in Amazon making tremendous progress on its own Amazon Care program.



These Walls Can Talk

Mid-future pessimistic scenario

When affordable smart home ecosystems first hit the market, the appeal was clear: For a reasonable price, you can equip most devices and systems in your home to anticipate and accommodate your preferences, and carry out your wishes in response to voice commands. But after households grew to rely on these smart home technologies, they noticed their average yearly medical expenses began to rise. As with much modern tech, if you're not paying much in dollars, you're probably paying in data. What had been marketed as domestic convenience turned out to be a 24-hour monitoring system. Data about every family member's movements was captured and sold to insurers and care providers, who used it to justify penalties and rate hikes. A cigarette on the porch after the kids are in bed? Your deductible just went up, as did your monthly life insurance payment. Lifting the couch to vacuum underneath? You just voided your prescription for pain meds to treat last year's back injury. Order a side of cheesy fries with your dinner delivery? Coverage of conditions related to obesity and heart disease now comes at a premium. The whole setup brings new meaning to the question, "Is there a doctor in the house?"

1ST YEAR ON THE LIST

Chief Health Officers



In January, Delta Air Lines hired its first chief health officer, Dr. Henry Ting, a medical leader with deep and broad experience in patient care, medical research, education, and management.

KEY INSIGHT

Health is the state of wellness—it’s the opposite of sickness. Companies are beginning to add chief health officers to the C-suite, to direct strategy for employee wellness and consumer health. Previously, CHOs (as well as chief medical officers) were limited to pharmaceutical companies, hospitals, medical systems, and insurance companies.

EXAMPLES

In January, Delta Air Lines hired its first chief health officer, Dr. Henry Ting. He joined Delta from Mayo Clinic and will now focus on health and well-being, safety, data strategies, and health-related partnerships for the airline. Colleges and universities are adding CHOs to their executive cabinets to develop policies and strategies that promote health and wellness to students, faculty, and staff—in the past two years, Bowling Green State University and the University of Michigan have hired CHOs. The position is also included in the org charts of IBM, Apple, Amazon, and Google.

DISRUPTIVE IMPACT

COVID-19 accelerated the visibility of CHOs. Royal Caribbean Group and Viking River Cruises hired their first CHOs last year, which makes sense: The cruise industry struggled to maintain health and safety in the wake of the virus. Beyond the pandemic, CHOs are looking holistically at employee and customer wellness. If people are healthy and safe, then they’re more productive—and as consumers, potentially willing to spend more on products and services.

EMERGING PLAYERS

- Association of State and Territorial Health Officials
- Johns Hopkins Center for Health Security
- Johns Hopkins Bloomberg School of Public Health
- Amazon Halo

1ST YEAR ON THE LIST

High-Tech Concierge Care



Forward is a concierge care system focused on high-tech, evidence-based medicine.

KEY INSIGHT

Concierge care services have gone high tech. Medical providers are upgrading their membership models, which combine medical care with tech-first wellness, personal data, and luxury hospitality.

EXAMPLES

Forward is a preventive health care membership that relies on advanced technologies to diagnose and treat patients. Visits include biometric body scanning, a blood panel, genetic analysis, skin screening, and a mental health assessment. Patients then download an app, which is continuously connected to wearables, medical devices, and medical records aggregated from previous caregivers. The Lanby, a medical and wellness club, is slated to open in New York City in fall 2021. For \$3,500 annually, members get a baseline assessment with a full physical and labs, a personal care plan, and monthly checkups, using telemedicine. These clubs could administer certain exams and treatments in an ultra-modern medi-spa ambience rather than that of a clinic.

DISRUPTIVE IMPACT

Concierge medical practices first opened in the U.S. in the 1990s, and doctors commanded annual fees of \$10,000–\$50,000 (and sometimes more) for 24/7 access to care. Fees were out of reach for most, and this model incentivized slow, personalized, ongoing care rather than the fast, efficient visits only during times of need, which insurers prefer. A concierge doctor could therefore maintain his existing salary by managing far fewer patients.

This next generation of concierge care relies on home diagnostics, self-monitoring, and telemedicine, and that will allow providers to scale back up again to service a large patient base and further threaten the traditional business model for health care.

EMERGING PLAYERS

- The Lanby
- Forward
- Tia
- Higi
- mPort

1ST YEAR ON THE LIST

Remote Patient Monitoring



The Zio patch allows doctors to remotely monitor patients.

KEY INSIGHT

Last year was a sudden dress rehearsal for widespread remote patient monitoring (RPM). Due to COVID-19 lockdowns, the market for RPM technologies flourished, while hospitals and health systems launched new ways of collecting data and billing patients.

EXAMPLES

The Cardea SOLO ECG System is a wearable heart monitor that sends data back to a monitoring center. Electrocardiogram data is analyzed and reports are generated within minutes to expedite a diagnosis and treatment if necessary. The Zio patch from iRhythm Technologies is a complete ambulatory cardiac monitoring solution.

DISRUPTIVE IMPACT

RPM uses digital technologies, the internet, and the cloud to collect medical data from patients in one area and transmit it for assessment by providers working somewhere else. Lots of data—heart rate, electrocardiograms, blood pressure, blood oxygen levels, kidney function, and more—can be mined and used to manage cases off-site. RPM can keep older people out of nursing homes and reduce the number of in-person visits to clinics and hospitals. As the number of chronic health conditions rises, RPM will gain a stronger foothold in health care.

EMERGING PLAYERS

- VitalConnect
- Ascom
- G Medical Innovations
- Gyant
- Huma
- Ejenta
- CardiMo
- Cardiac Insight
- Rhythm Technologies
- 100Plus
- Neteera

1ST YEAR ON THE LIST

Digital Transformation in Health Care



Health care has lagged behind in digital transformation, but that is changing.

KEY INSIGHT

When it comes to digital transformation, health care has lagged behind most every major industry, including retail, banking, consumer packaged goods, and even government. Roughly 70% of U.S. hospitals still rely on fax machines to move patient records around. That makes the industry ripe for disruption—and attractive to startups and investors alike.

EXAMPLES

Investors poured \$8.4 billion into global health funding in just the third quarter of 2020 alone—much of those dollars were aimed at helping health care providers cross the digital transom, according to research firm CB Insights. Mayo Clinic and Medically Home will provide hospital-level care to patients' bedrooms, performing lab tests, infusions, and remote monitoring while processing all of the needed data for patient and hospital records, insurers, and government agencies. Epic, one of the largest U.S. medical records system providers, will make its data more accessible from business to business. Its partnership with Nuance Communications' voice recognition software platform will allow doctors to send dictated notes to other medical specialists. It's also experimenting with ride hailing company Lyft to bring patients to hospitals.

DISRUPTIVE IMPACT

There is a push for standardized, open data in health care, and the largest providers are starting to see the value of making their data interoperable. Dedicated cloud services, standardization of data, robust electronic medical records systems, encryption, and a host of medical-grade consumer devices are forcing the notoriously stodgy industry to evolve and adapt to the modern realities of technology. Medicine's regulatory minefield has so far prevented investment outside of a narrow field of innovations. That's all starting to change, in part because of the big technology companies endeavoring to disrupt the business.

EMERGING PLAYERS

- General Catalyst
- Geisinger
- Epic
- Accenture
- Alibaba's AliHealth
- Qualcomm
- Nokia

3RD YEAR ON THE LIST

Patient-Generated Health Data



Validic uses mobile health APIs to access data from a host of devices and apps and make it usable with a patient's EHR.

KEY INSIGHT

Patients are creating a trove of data that could contribute to their health care provider's overall health assessment. Packaging all that data—and figuring out how to make use of it—is still a challenge.

EXAMPLES

From Google's Fitbit, to Apple's Watches and AirPods, to household smart scales, hundreds of devices can now collect and monitor patients' health. We also generate data at the doctor's office, and under federal law, that data must be filed and stored electronically. The problem is in aggregation. Because the data is structured differently, an intermediary is needed to make practical use of it. The result: a new market for businesses that can clean, structure, and package patient-generated health data. Software from companies like Validic allows doctors to collect this type of data and incorporate it into their medical records. This software uses mobile health APIs to access data from devices and apps and incorporate it with a patient's electronic health record (EHR). GE Healthcare, Meditech, Allscripts, eClinicalWorks, and Cerner are all building products to make better use of our data.

DISRUPTIVE IMPACT

Safely moving, storing, and making use of this data will require encryption. But there is also value in taking a fuller view at the community, state, or even national level. Differential privacy measures will enable companies to anonymize a patient's details while still making their data useful to scientific researchers.

EMERGING PLAYERS

- Validic
- Apple's Health Records
- Amazon Transcribe Medical
- Salesforce
- Google Health
- Meditech
- Allscripts
- eClinicalWorks
- Cerner



2ND YEAR ON THE LIST

Automatic Medical Transcribing



Microsoft's EmpowerMD listens to clinical conversations between doctors and patients.

KEY INSIGHT

Dictating patient notes is a core task in a clinical practice. But transcribing recordings is a tedious process that relies on excellent sound quality and a good understanding of medical terminology—not to mention one that requires confidentiality. Artificial intelligence promises faster transcriptions as well as real-time diagnostic analysis.

EXAMPLES

Amazon’s Transcribe Medical frees up doctors’ time by transcribing doctor-patient interactions directly into an electronic record. Amazons Comprehend Medical helps developers use unstructured medical text for diagnostic tools, while AWS’s software integrates into devices and apps using an API. Microsoft’s Project EmpowerMD partnered with Nuance Communications to listen to conversations between doctors and patients and automatically integrate information from the patient’s EHR in real-time. Built on Azure, it uses a rich set of machine learning algorithms to tackle natural language challenges and generate a medical summary. Meanwhile Google plans to leverage its speech recognition for medical conversations.

DISRUPTIVE IMPACT

To meet compliance regulations, a strict protocol must be followed when a third party transcribes sensitive doctor-patient audio. But what if the transcription is performed in real time? Not only would it be easier and more cost-effective in building patient records, an additional layer of machine learning could help doctors learn more about their patients during each visit.

EMERGING PLAYERS

- AWS’s Amazon Transcribe Medical and Amazon Comprehend Medical
- Nuance Communications
- Microsoft Azure’s Project EmpowerMD
- IBM Watson’s Speech to Text



3D Printing in the ER

Near-future optimistic scenario

Hospitals across the country embrace 3D and 4D printing. In partnership with medical product designers, 3D printing technicians become critical to care ecosystems, particularly in the emergency room. Rather than storing a fixed inventory of equipment, hospitals use additive manufacturing to produce items on demand ranging from personal protective equipment and ventilator components to stents and custom braces, and then break them down or sterilize and recycle them when they're no longer needed. It's all about efficiency, personalization, and real-time response to the emergencies that come through the doors. Ambulances and mobile hospitals are equipped with printers, too, so that they can treat patients during transport.

1ST YEAR ON THE LIST

Smart Biohazard Wearables



Production Club's Micrashell is a smart biohazard wearable designed for clubbing.

KEY INSIGHT

At the height of the COVID-19 pandemic, many people went in search of high-quality masks that would prevent viral transmission and also collect air quality data. But given the uptick in dangerous air quality due to wildfires and pollution, smart biohazard wearables are attracting more attention.

EXAMPLES

The AirPop face mask protects against environmental and biological contaminants. A sensor embedded in the mask connects with a mobile app to analyze the general air quality; it also displays the pollutants blocked, whether or not the filter needs to be cleaned, and personal breathing metrics. Razer's Project Hazel is a surgical N95-grade mask with a clear face panel design, a microphone to help project your voice, and UV light disinfection that promises to kill bacteria. The Atmoblue, which launched as an IndieGogo project and raised 10 times its initial funding goal, includes a smart, wearable air purifier with HEPA filters and dual, high-speed centrifugal fans.

DISRUPTIVE IMPACT

Between worsening environmental pollution and the worldwide spread of an airborne pathogen, the consumer demand for medical-grade protection from biohazards has grown significantly. Expect an influx of investment in response to that demand, with a focus on additional protective functionality, added data-capture tech, certification from medical institutions, and potential partnerships to equip at-risk workforces.

EMERGING PLAYERS

- Razer
- AirPop
- Atmoblue
- Production Club



1ST YEAR ON THE LIST

Cognitive and Neural Optimization



Bitbrain's headsets optimize neural activity.

KEY INSIGHT

Most cognitive training programs are nothing more than clever memory games, but a new crop of technologies promises to optimize neural function. People who engage in this form of training report feeling quicker, sharper, and more capable of sensing, parsing, and acting on information.

EXAMPLES

One key element of this trend is neuroplasticity, or how well the brain adapts and toggles speed and accuracy with the information it receives. Plasticity-based challenges form new neural pathways in the brain, which can be later called upon to process a greater range of stimuli. Reflexion promises to help people train for speed and accuracy in competition, which is why college athletic departments and researchers at Pennsylvania State University, Duke University, and the U.S. Air Force Academy all use the platform. The cloud-based system has a 55-inch touchscreen light board that comes with a series of visual exercise drills and analytics to track and strengthen brain fitness. It measures peripheral vision, decision-making, reaction time, and hand-eye coordination.

Halo Neuroscience makes a brain-stimulating headband for “neuropriming,” using electrical stimulation to increase plasticity in the brain prior to an activity. The headband transmits weak electrical pulses into the user’s brain with the intent of enhancing the efficiency of physical training. Bitbrain Technologies makes a training system for the brain to accelerate information processing and improve concentration.

Cognitive and Neural Optimization continued



Cognitive and neural technologies promise to optimize brain function.

DISRUPTIVE IMPACT

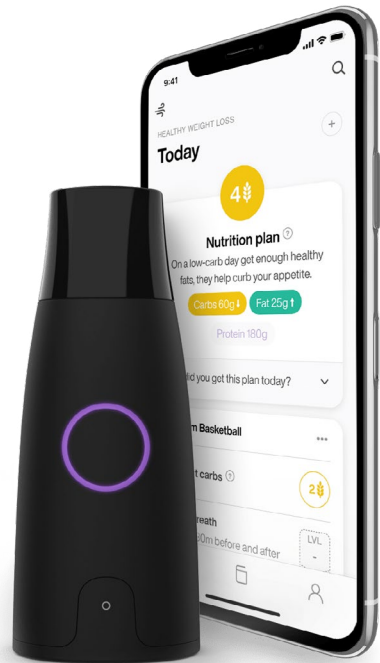
More data is needed to analyze the results of neuro optimization devices, but there are now dozens of early and mid-stage companies working in this space. Given conclusive evidence that these systems are able to significantly enhance cognitive performance, we can expect to see initial adoption in a range of competitive fields—followed, in all likelihood, by complex attempts to regulate the use of the technology.

EMERGING PLAYERS

- Halo Neuroscience
- Bitbrain Technologies
- Reflexion

1ST YEAR ON THE LIST

Metabolic Monitoring



Lumen determines whether fats or carbs are being used for fuel.

KEY INSIGHT

Metabolism can be monitored using breath, and new devices use machine learning to determine the body’s metabolic rate in real time. The respiratory exchange ratio, or RER, is the ratio of carbon dioxide produced in metabolism and the oxygen used, and indicates which fuel—carbohydrates or fats—is being metabolized to supply the body with energy.

EXAMPLES

Two sisters with doctorates in physiology developed a metabolic monitor while training for an Iron Man competition to measure carbon dioxide using a Bluetooth sensor. Lumen is now a more comprehensive automated metabolic monitor that looks like a vape device and connects to a mobile app, which provides recommendations for training and meals.

For serious athletes, the Pnoë Metabolic Analysis System offers measurements of metabolic, heart, lung, and cellular function. After a baseline test, it creates personalized workouts and nutrition plans, and recommends specific types of exercises. Cosmed’s K5 is a wearable, portable metabolic system that tracks exercise, heart rate, and stress.

DISRUPTIVE IMPACT

Metabolic monitoring is useful for athletes in training, hospital patients, and people hoping to optimize how their bodies use the food they eat.

EMERGING PLAYERS

- Breezing
- Cosmed
- Lumen
- Pnoë

1ST YEAR ON THE LIST

Prescription-Strength Gaming



EndeavorRx is an FDA-approved game that treats ADHD.

KEY INSIGHT

While we often hear research about the addictive nature of video games, certain types of games can have beneficial therapeutic effects. Gaming has served as a therapeutic tool extending all the way back to the beginnings of virtual reality.

EXAMPLES

Early VR systems were intended to help treat post-traumatic stress disorder. Now dynamic gaming experiences are being developed to treat attention deficit hyperactivity disorder (ADHD) in children. In 2020, the Food and Drug Administration approved EndeavorRx, a first-person racing game developed by a neuroscientist at the University of California–San Francisco that significantly improved clinical markers of attention in patients with ADHD. It looks like a kids video game, but the stimuli target and activate the prefrontal cortex. As game play progresses, it adapts and personalizes treatment. Harvard University and Massachusetts Institute of Technology researchers developed The Guardians: Unite the Realms to address behavioral-activation therapy for depression. It serves to break rumination loops and uses the same psychological tactics that mobile apps rely on to goad people into spending more attention or money—but instead uses the tactics to improve moods and emotional states.

DISRUPTIVE IMPACT

It will take time for the long-term effectiveness of therapeutic gaming to be determined, but with promising initial results, this field is due for growth. Therapeutic games could serve as the backbone of telehealth for sufferers of chronic illness or those under remote patient monitoring. Games played in the home would generate detailed patient data and communicate it directly to the doctor, who would adjust treatment accordingly—all without requiring an office visit, and neutralizing the bias of unreliable self-reported patient data.

EMERGING PLAYERS

- Azure Kinect
- Intel RealSense Depth Camera
- MIT Media Lab
- EndeavorRx
- Akili
- The Guardians: Unite the Realms

6TH YEAR ON THE LIST

Digital Fitness and Training



The EMStyle smart bodysuit and mobile app allow you to track your workouts through your phone.

KEY INSIGHT

The last few years saw the rise of smart fitness equipment including mirrors, bikes, and treadmills. The pandemic accelerated sales and helped the market grow significantly.

EXAMPLES

In 2020, memberships to Peloton (the connected bike and treadmill platform), surged 232% to \$757.9 million. JaxJox KettlebellConnect is a kettlebell set that tracks performance using Bluetooth. Mirror is an interactive gym masquerading as—wait for it—a full-length, wall-mounted mirror. It has recorded or live classes, and the smart mirror surface helps you adjust your form. The Hydrow rower is a connected rowing machine with adjustable resistance levels and prerecorded workouts. FightCamp Gym is a punching bag that connects to classes on iOS devices. YogiFi Series-1 is a connected smart mat that tracks movements, offers haptic feedback, recommends wellness programs, and includes aroma diffusers. This year, Samsung announced Smart Trainer, a device that offers real-time feedback on exercise routines, and Xenoma launched its e-skin EMStyle bodysuit with 24 electrodes to stimulate muscles and provide a full-body workout.

DISRUPTIVE IMPACT

There are multiple intended settings for smart fitness equipment—amid the pandemic, as individuals and families invested in their own private spaces and adapted to extended spells indoors, smart fitness equipment for the home saw a pronounced spike in demand. But as home equipment becomes more advanced and personalized, gyms and fitness centers will have to upgrade their equipment to compete, especially as home subscription plans undercut in-person membership rates.

EMERGING PLAYERS

- Peloton
- Ultrahuman
- YogiFi
- CLMBR
- Sworkit
- Oculus Quest 2
- Ergatta Rower
- Hydrow Rower
- Samsung
- FightCamp Gym
- Mirror
- Tonal
- JaxJox

6TH YEAR ON THE LIST

Sleep Tech



Somnox's robot simulates the feeling of sleeping next to a parent.

KEY INSIGHT

We spend about a third of our lives sleeping. The average adult needs between seven and nine hours of good quality sleep every night, according to Mayo Clinic—but a variety of factors, ranging from anxiety and stress to noisy streets or a partner who snores can interrupt sleep cycles. New technologies promise to optimize sleep, even in challenging circumstances.

EXAMPLES

The OOLER sleep system by ChiliSleep automatically prechills the bed to the user's desired temperature using a connected mattress cover and a connected weighted blanket, and then slowly increases the morning temperature for natural waking—instead of a jarring alarm clock. The Somnox Sleep Robot is an adaptive pillow to help people steady and deepen their breathing rate. The Sunrise sleep monitor tracks snoring and fitful sleeping—and can help diagnose sleep apnea—using a small sensor that fits on the chin, just under the mouth. After a few nights' sleep, the analysis goes directly to the user, avoiding a visit to a sleep center. The Apollo Neuro, an ankle or wrist device, uses gentle vibrations to improve heart rate variability, resilience to stress, and, ultimately, improved sleep.

DISRUPTIVE IMPACT

Sleep tech is a growing business, with a flurry of connected blankets, wearable monitors, and robots ready to optimize the hours people spend in bed. Sleep tech is big business, too: By 2026, the market size could be upward of \$30 billion.

EMERGING PLAYERS

- Somnox
- ChiliSleep
- Sunrise
- Beddr
- Oura
- Dreem
- Sana
- Ebb Therapeutics
- Sleep.ai

Scent Diagnostics

Near-future neutral scenario

Augmented reality can change the way we see the world, but it could just as easily change the way we smell it. Health care reaches new levels of diagnostic precision when wearables are integrated with enhanced olfactory sensors. These hypersensitive wearables can “smell” the first traces of a medical emergency or oncoming illness before the patient realizes anything is wrong. This smart “nosewear” can detect the early signs of a stroke, which can affect the victim’s sense of smell, or subtle evidence of diseases like Parkinson’s and malaria, which are shown to be detectable by the sensitive noses of sniffer dogs. The technology is now a key component of a doctor’s toolkit, and a powerful detection tool in preventive care.

9TH YEAR ON THE LIST

Wearables and Biointerfaces



The green light of functional fibers glows.
Image courtesy of AFFOA.

KEY INSIGHT

Consumers can currently choose among more than 1,000 wearable devices, including watches, earbuds, adhesive and pocket-size sensors, headbands, fabrics, and others. We are undergoing a gradual transition from devices that we carry to devices that we wear. As price points become lower and 5G networks are built, wearable devices will enter the global mainstream.

EXAMPLES

It’s important to remember that the wearables market includes more than smart fitness bands and smartwatches. There are devices for glucose monitoring, smart earphones that can amplify or mute ambient sound, and even full-body haptic suits for athletic training and gaming. Wearables are gaining independent connectivity, meaning that a new generation of devices will no longer need to be tethered to a smartphone or computer to see and report data, adjust settings, and archive information.

DISRUPTIVE IMPACT

Companies should begin to develop strategies for emerging wearable systems, even if they are outside of the health and wellness space. Key questions to ask include: How will your organization interact with consumers via wearables? How will consumer expectations change as a result of wearables? What is the business case for wearables within your organization?

EMERGING PLAYERS

- Withings
- Ringly
- Spire Health
- Sony
- Oculus
- Athos
- Amazon
- Harvard University’s Wyss Institute for Biologically Inspired Engineering
- DARPA
- University of Washington’s Center for Neurotechnology
- Tufts University
- Robotics Institute at Beihang University
- Samsung



Wearables and Biointerfaces Trends



Sony's wearable air conditioner.

Emerging Wearables

COVID-19 Sensors

The BioButton is an FDA-cleared, medical-grade wearable designed to be worn all the time. The device tells users if they've been in contact with someone who has COVID-19, and it also monitors temperature and other vital statistics. Its personal screening system is housed in single-use disposable patches that adhere to the skin.

Cloud-based Wireless Body Area Networks

Wireless body area networks (WBANs) communicate information from your wearable devices back to medical servers, app manufacturers, and your home computer. Sensors, such as devices to monitor your heart rate or oxygen level, collect data and send it back to a central hub (most often, your smartphone), which

then relays the information to a medical team or health care monitoring service. There are a lot of benefits: Rather than moving into an assisted living facility or spending a lot of time in the hospital, certain patients can live in their own homes while receiving virtual care. Cloud-based systems allow for the continuous transmission of your data and real-time analysis for issues like chronic disease (hypertension, high blood pressure, asthma). This trend is still in very early stages and will be accelerated as 5G networks proliferate, since a more advanced network will lead to less lag and could help secure personal data.

Adaptive and Assistive Wearables

By serving as replacements for human limbs, exoskeletons and soft exosuits help enhance human mobility for the differently abled or for patients recovering from traumatic injuries. Advanced articulating mechanical systems and

neurointerfaces are making big strides in this field. The hard exoskeletons used today will begin to morph into smaller components and more adaptable designs. Researchers at the Robotics Institute at Beihang University are developing new lower-body gear that is lightweight and responds in real-time to the wearer. Meanwhile scientists at Harvard University's Wyss Institute for Biologically Inspired Engineering are researching how to transition from soft exosuits to implanted neural interfaces—think tiny sensors worn beneath the skin—that will someday help to control neuromuscular activity to help people walk.

Commercial Full-Body Exoskeletons

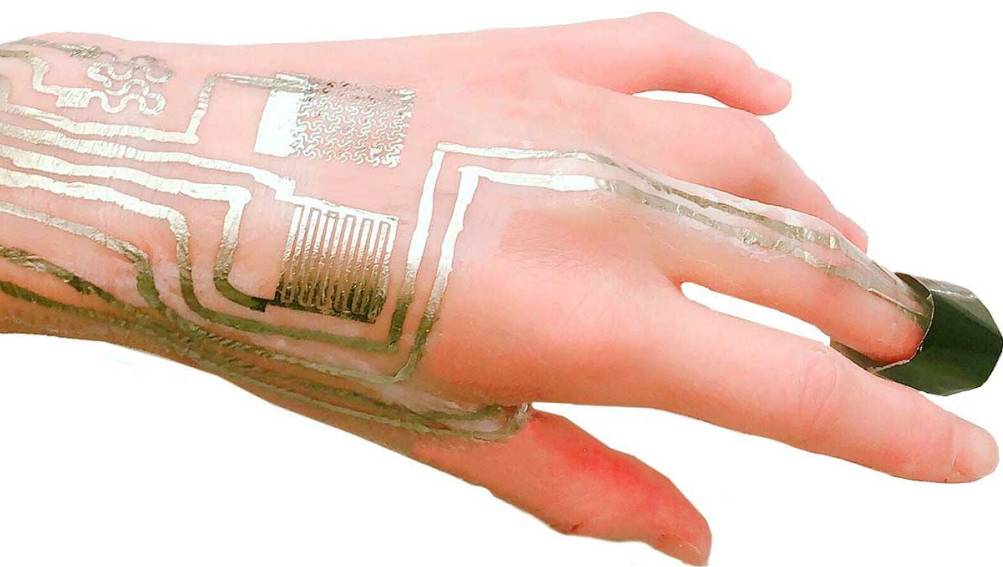
You've seen them in movies like "Iron Man," "Dave," and "Avatar": powered suits that give average workers superhuman abilities. Harvard's Biodesign Lab is developing next-generation soft wearable exo-

skeletons that use innovative textiles to provide a more conformal, unobtrusive, and compliant means to interface to the human body. Sarcos Robotics's Guardian XO is a battery-powered suit intended for construction sites, mines, and factories. Built to enhance worker productivity, the suits help people lift heavy loads—up to 198 pounds—without back strain. Ekso Bionics, which develops medical-grade exoskeletons, created a vest intended to help workers more easily perform overhead tasks.

Wearable Air Conditioners

In Japan and China, workers who must wear protective suits during the intense summer heat for years have worn tiny wearable fans to circulate generated air within their suits, while ventilation flaps allow the warm body heat to escape. But miniature, wearable air conditioners will soon be available to the average consumer. Sony developed the Reon Pocket,

Wearables and Biointerfaces Trends



Electrodes and temperature sensors are directly printed and sintered on the skin surface.

Image courtesy: ACS Applied Materials & Interfaces.

which relies on the Peltier effect to move heat between objects using electrical currents. In place of a servo motor and fan, this device is flat and embedded into an undershirt. Your mobile phone controls the thermostat, cooling your body by 23 degrees Fahrenheit or heating it by 14 degrees Fahrenheit.

Connected Fabrics

Considering how much behavioral, biometric, and ambient data it could potentially capture, our clothing has untapped potential as a sensory interface. In the past, connected clothing required wires and sensors, making fabrics stiff or uncomfortable. That's starting to change, and it should bring more smart clothes to the masses. The Fibers@MIT research group is working on a fabric computer, with architectures that allow fibers to communicate with each other while retaining the conventional qualities of cloth. Soliyarn is working on imperceptible,

flexible sensors woven into self-heating gloves for the U.S. military. The startup is also developing smart pajamas and sleep-sensing masks, while others, including a collaborative effort from Under Armour and football superstar Tom Brady, have developed sleepwear that emits infrared energy for faster muscle recovery following a hard workout. Pivot Yoga makes connected yoga pants—you read that right—that monitor your downward dogs and help you adjust your form. The connected clothing syncs to an app, and a digital assistant offers tips, such as rotating your left hip or moving your feet three inches back on the mat. Spire Health makes a fabric coating for bras and underwear to help track breathing and stress levels.

Touch-Sensitive Materials

Researchers are developing new prosthetic skins and limbs that restore not just movement but touch as well, through

haptic tactile sensations. In 2018, researchers at Johns Hopkins University created an electronic skin to help restore a sense of touch to amputees. Dubbed “e-dermis,” it re-creates tactile sensations (including pain) by sensing stimuli and sending the corresponding signal back to the user’s peripheral nerves. Interdisciplinary researchers at the Center for Wearable Sensors and the Center for Brain and Cognition at the University of California–San Diego are combining materials science and psychophysics to map exactly how humans perceive touch. This research lays the groundwork for advanced prosthetics, and we’ve already seen some exciting developments. Neuroscientists at the University of Chicago are experimenting with touch-sensitive robotics and rhesus monkeys, which have the most similar neural-sensory biology to humans—they have successfully simulated the sensation of touch by stimulating certain areas of the brain. A team of scientists from the Lausanne and Sant’Anna School

Wearables and Biointerfaces Trends

of Advanced Studies and the Agostino Gemelli University Hospital developed a bionic hand that transmits a realistic sense of touch; it's already in use, restoring sensation to a woman who lost her hand in an accident 25 years ago.

Mature Wearables

Watches

Smartwatches offer a wide array of functionality. They are digital wallets, diagnostic tools, fitness trackers, phones, and miniature screens on which to view texts and social media posts. Traditional watchmakers and big tech giants now sell hundreds of different smartwatches. Some models, like the newest Apple Watch, no longer require a mobile phone for pairing; it can connect directly to cellular networks and can perform much of the same functionality as a smartphone. A model built by the Future Today Institute in 2016 showing that smartwatch adoption

is a contributing factor to the decelerating growth of the smartphone market continues to hold in 2021.

Rings and Bracelets

Amazon's Halo smart wristband made headlines when it launched last year. The device listens to your voice, tracks and predicts mood, and optimizes caloric intake and fitness. It also connects to Amazon's digital voice assistant, essentially making it a wearable Alexa. PayPal has been researching its own connected ring for fast and easy payments without digging around for a phone or credit card. The Motiv and Oura rings track sleeping habits, while the ORII ring lets you make calls. Google completed its acquisition of Fitbit in early 2021, potentially threatening Apple's domination in the watch market. Rings and bracelets aren't meant as complete replacements for smartwatches, but for developers looking for single-task application opportunities, rings and

bracelets offer a good alternative to more programming-intensive watch interfaces.

Hearables and Earables

In-ear computers, otherwise known as earables, are here. The Noopl smartphone attachment aims to enhance audio clarity in noisy environments. The JBuds Frames allow users to augment audio as they wish, using a snap-on speaker device for glasses. Sony's 360 Reality Audio uses object-based spatial audio technology to enhance sound; setup requires that you allow photos of your ears to be scanned and analyzed and stored on Sony's servers. Apple's AirPods team is working on biometric sensors that will eventually monitor temperature, perspiration, and heart rate during exercise or sports. Starkey's Livio AI uses an array of sensors and AI to modulate external sound—if you're someone who complains that restaurants are too loud, this device promises to help you hear better, and can also act

as a digital assistant. New iterations will track many personal metrics, including cognitive activity and your engagement patterns with other people, and be able to translate 27 languages in near real-time.

Head Mounted Displays

Virtual reality is commonly experienced through wearable headsets, the next generation of which will collect your biometric data and other personal information in order to provide added functionality. These head-mounted displays could track your movements, pupil dilation, heart rate, and other biometrics, and use that data to curate your simulated environment in real time. (See: New Realities.)

Smart Glasses

The world's largest technology companies—Apple, Amazon, Google, Microsoft, Facebook—are all working, in some way, on connected devices that you wear over your eyes. Facebook and RayBan intend to

launch AR glasses in 2021. Amazon's Echo Frames debuted in 2020; for now, they only offer Alexa audio functionality, but AR features are on the horizon. Apple's glasses will work with the Watch and iPhone, but don't yet have a launch date.

Smart Shoes

Nike's self-lacing Electric Adaptable Reaction Lacing shoes adjust to the contours of your feet. French insole manufacturer Digitsole makes connected insoles that fit inside the shoes of cyclists or runners and provide them with data feedback. They can also keep your feet warm. Under Armour makes connected running shoes with foam soles that include an accelerometer, a gyroscope, a battery, and a Bluetooth module. The shoes collect and store data, freeing you up for a tracked jog without your smartphone. They also set a baseline the first time you use them, and then track your distance, stride length, and running cadence over time.

Wearables and Biointerfaces Trends



Amazon's Halo is a fitness band with emotion detection.

Smart Gloves

In Kenya, a researcher invented smart gloves that can translate sign language into speech. The system, called Sign-IO, uses gesture recognition with sensors embedded in the gloves. Canadian researchers at Simon Fraser University designed a set of interconnected gloves to help transmit a sense of touch through the internet. When someone moves her fingers in one glove, her actions are sent to her partner wearing the other. Sony has been filing patents for haptic glove controllers, which would simulate the physical sensations of slicing, punching, and shooting.

Biointerfaces

Nanomesh Tattoos

Imagine wearing a temporary tattoo rather than taking a handful of pills every day. Research is underway on nanomesh technology as a diagnostic and drug

delivery tool. Scientists at the Institute for Basic Science and Seoul National University in South Korea, the University of Texas at Austin, the University of Tokyo, Stanford University, and the University of California–San Diego are all working on electronic second skins. MC10 has already created microscopic, organic semiconductors and carbon nanotubes that stretch and flex and can be powered wirelessly. The system, called BioStampRC, is far thicker than a tattooable, but the idea is the same—and it's only a matter of time before the technology shrinks.

Dissolving Bioelectronics

For many people, implanted electronics are required to live a healthy life, but receiving the implants can require costly surgery, and devices sometimes need maintenance and replacement parts. In 2018, scientists at Northwestern University revealed new research on flexible, dissolvable electronic materials. In one

case, they showed how the materials could be used during surgery. If nerves have been severed, doctors suture them back together and reawaken them using electrodes and gentle electrical stimulation—but they typically don't have enough time in the operating room to provide that restorative therapy beyond what would be minimally required. The team at Northwestern demonstrated how dissolved electrodes could be used to wirelessly transmit the electrical signal and stimulate repaired nerves for several days, which could cut recovery time in half. Once the therapy is finished, the materials break down and are excreted. The study was done in rats, but it shouldn't be long before we start to see clinical applications in humans.

Nanobots

Tiny robots capable of delivering medicine to a specific area of the body, or assisting with microsurgery, have arrived:

Wearables and Biointerfaces Trends



CuteCircuit's shirt lets people feel music and receive virtual hugs.

They can be steered and threaded, and they can unfold to patch wounds, dislodge swallowed objects, perform biopsies, and deliver targeted medications. Researchers at the University of California–San Diego showed how a nanobot, propelled by gas bubbles, could successfully deliver medicine inside of a live mouse without causing injury. California Institute of Technology scientists developed an autonomous, molecular robot, made of a single strand of DNA, that treats the inside of the human body like a distribution warehouse. The nanobot can walk around, pick up molecules, and deposit them in designated locations. In 2018, scientists at the Chinese University of Hong Kong unveiled a new way to use nanobots within the body. Millions of tiny, magnetic shape-shifting nanoparticles can extend, merge, and collaborate in a swarm. In practical terms, this means

that a surgeon could direct the swarm to assist with eye surgeries, for example, and to deliver targeted medicines. In 2019, researchers at the Massachusetts Institute of Technology Department of Mechanical Engineering figured out how to create arrays of nanoscale magnets that respond to magnetic fields using a technique called electron-beam lithography, resulting in magnetically reconfigurable robots at scales of just a few micrometers. (For comparison, a strand of hair is about 100 to 150 micrometers wide.) In one instance, they made a microscopic bird-like structure that could flap its wings and move as directed. This could someday allow surgeons to perform operations on individual blood vessels or to manipulate single cells. The grand hope with all of these technologies is that nanobots will replace one-size-fits-most medications and therapies, and treat uniquely specific ailments without causing side effects.

Smart Threads

“Smart thread” uses electrical currents to transmit information to doctors following surgeries. Think of smart thread as a sort of temporary smart system, stitched into the skin, that connects to a smartphone or other medical device and reports on your glucose levels, diagnoses an infection, and alerts hospital staff if your body is chemically out of balance. Researchers at Tufts University have successfully embedded nanoscale sensors and electronics into surgical thread that can be used for suturing. At the University of California–Berkeley’s School of Information, researchers are experimenting with smart threads that can change color. These nonsurgical threads are coated with thermochromic paint that changes color when jolted with electricity. Smart thread is just emerging from experimentation, but initial test results show that it can be successfully used as a diagnostic device.

Skinput Systems

Nearly a decade ago, Microsoft experimented with “skinput,” which turned a person’s arm and hand into an interactive interface. You could answer a call by tapping your fingers or skip a song on your playlist by pressing your palm. In the brand’s Hololens 2 extended reality headset, simple taps against your skin activate features. Google’s Project Soli, announced in 2015 during the tech giant’s I/O developer conference, is a miniature radar that understands human motions at various scales, from the tap of your finger to the movements of your body. Since then, Google’s ATAP (Advanced Technology and Projects) division has been advancing that skinput idea: In 2018, the Federal Communications Commission approved its proposed tests of a new chip that uses radar to track micromotions. We’re already transitioning from physical to digital buttons; soon skinput may teach consumers to live without any buttons at all.

4TH YEAR ON THE LIST

Brain Machine Interfaces



In 2020, Elon Musk demonstrated a plan to create a working brain-to-machine interface with a working prototype implanted in pigs.

KEY INSIGHT

Computer scientist Jacques J. Vidal was the first to talk about “brain machine interfaces” in the early 1970s, and since then the term has grown to encapsulate a range of technologies that serve as interfaces between the brain and the outside world. Researchers are finding new ways to connect humans and other mammals directly to computers—and humans to one another.

EXAMPLES

Elon Musk hopes to someday outfit us with small, wearable computers with threads extending directly into our brains. Last year, Musk’s Neuralink tracked a pig’s brain activity using implanted sensors, and the Food and Drug Administration granted the company a breakthrough device authorization to move quickly on its human research. In 2019, Neuralink built a robot to implant tiny, ultrathin threads deep into the brain—a step closer to complex brain-machine interfaces. The Pentagon has its own body mass index projects that use both threads and pulsating lights. Kernel intends to measure and stimulate the electrical impulses of neurons. Synchron’s implantable device the Stentrode aims to give paralyzed patients direct brain control of mobility-assistive devices. Neuralink is working to let people use brain activity to control software and devices, and NextMind raised \$4.6 million to create noninvasive brain command tech for gamers.

DISRUPTIVE IMPACT

Much of the research to date has focused on rehabilitation. With these human-machine interfaces, people can communicate via thought alone, which promises new options for those suffering from stroke, paralysis, and aphasia. But research is going even further than that: Facebook has been working on several BMI projects, including a noninvasive headband that would read thoughts before we say them aloud. In a partnership with the University of California–San Francisco, researchers used sheets of electrodes placed on the brains of volunteer test subjects to see how much of their thoughts could be read. The social media juggernaut, which also owns VR company Oculus, is working toward a headset that might someday allow us to control music or VR environments simply by thinking.

EMERGING PLAYERS

- Neuralink
- Neurale
- BIOS
- NeuroScouting
- NeuroPace
- MindMaze
- NextMind
- Bitbrain Technologies
- Boston Scientific
- Oculus

Expert Insight



The Post-Pandemic Optimistic Future: From COVID to Consumerism

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I'm convinced the globe faces two existential threats that demand disruption of our businesses, our policies and indeed our lifestyles: climate change and health assurance for all.

Both will require disruption in our way of thinking, creative partnerships with entities that have not worked together to create new ecosystems, and the use of augmented intelligence and other new technologies that may be game changers if constructed properly.

Many have theorized that the increased use of telehealth during the COVID-19 pandemic will become the "iPhone moment" for healthcare, where finally healthcare joins the consumer revolution by bringing care to the home and we begin to build "healthcare at any address."

But there's a twist: We have to ensure that the shift to mobile, digital healthcare is ethical, equitable, and sustainable.

Just as climate change cannot be solved by the energy industry



Just as climate change cannot be solved by the energy industry alone, health assurance cannot be solved by the healthcare delivery industry alone.

alone, health assurance cannot be solved by the healthcare delivery industry alone. The fourth industrial revolution can be defined in a pretty non-threatening way. It's the blurring of boundaries between the digital, physical, and biological worlds. It's a fusion of advances in artificial intelligence, robotics, the internet of things, genetic engineering, quantum computing, 5G, and the kitchen sink of exciting new technologies that will blossom in the next decade.

The impact of a digital economy on healthcare will be immense, and I am hopeful that in a few years we will not just be talking about the technology of self-driving cars, but also about how we can use these technologies to create "self-healing humans."

Here's my framework for equitable and sustainable models of change:

1. Start with ethics.

Trust is more important than technology. Ethics must be injected into product development at the very earliest stage, when values are being assessed. Do not wait until a product is ready for market and then ask marketing to make it trustworthy.

2. Reach across industry.

We talk and plan in silos, but health assurance only comes when our industry talks with those involved in food, transportation, education, policy, and the creation of jobs. We need to move social determinants of health to the mainstream of clinical operations and global payment models.

3. Intellectual property is the new gold, not data.

We must understand how IP is derived from the personal data of our patients, and create bright lines for enhanced consent in the use of this data.

4. Never forget the human in the middle.

As online meets offline (OMO), the excitement tends to focus on the technology. But what's equally important is focusing on humans, on new roles for clinicians in the OMO world, on new services for patients. And on what I call health assurance, by constructing a system where the primary goal is a healthy and happy life for all.



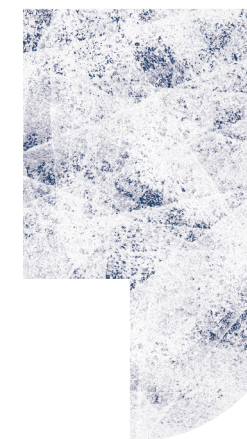
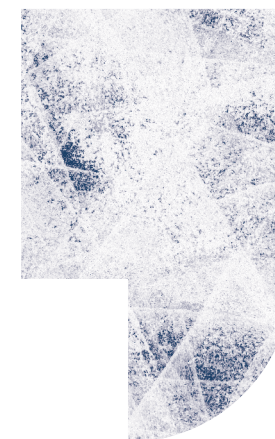
I am hopeful that in a few years we will not just be talking about the technology of self-driving cars, but also about how we can use these technologies to create ‘self-healing humans.’

5. Perhaps, most importantly, there is no such thing as “non-disruptive” disruption.

Disruption, by definition, will be painful to those who don’t want to think differently as new ecosystems are built.

If we are to globally move from sick care to health assurance and bring health into homes and neighborhoods, the home should be the locus of care delivery. It’s time to strip from hospitals everything that can be done in an outpatient setting, leaving hospitals as the location for the very sick and for very complicated therapy. This healthcare “revolution” will require passionate leaders advocating for change—in essence, an army of Greta Thunbergs! Let’s hope the once-in-a-century COVID-19 pandemic of 2020 heralds a new century of global health assurance starting in 2021.

*Dr. Stephen Klasko is an advocate for transformation in healthcare and higher education. As President and CEO of Philadelphia-based Thomas Jefferson University and Jefferson Health since 2013, he has led one of the U.S.’s fastest growing academic health institutions based on his vision of the future of higher education. In 2020, he was named the first Distinguished Fellow of the World Economic Forum. This year he published *Un-Healthcare: A Manifesto for Health Assurance*, with Hemant Taneja, as well as the textbook, *Patient No Longer: Why Healthcare Must Deliver the Care Experience that Consumers Want and Expect*.*



Application



STRATEGY

For chief strategy officers working in health care systems, hospitals, insurance, and the pharmaceutical industry, decisions must be made about the longer-term direction of organizations given the staggering pace of innovation coming from external disruptors. The COVID-19 pandemic accelerated private equity and venture capital investment in a number of different areas, from biometric monitoring to remote patient care. CSOs should pay special attention to the big tech companies as potential sources of opportunity and risk. Now is the time to develop a long-term strategy for your organization’s evolution.



INNOVATION

For those working in the health tech space, this is an incredible time. As wearable devices reach the mainstream, consumers are looking for actionable insights. They are also more health-conscious in the wake of the pandemic. Additional factors include the rollout of 5G networks and relaxed rules on telemedicine and patient record sharing. Innovation teams can develop their visions for the future, using signals and trends to develop plausible scenarios. From this work might come new products, changes in strategic direction, or future business models.



R & D

As excitement grows for health tech, corporate R&D teams will be pushed to productize their work. Unfortunately, there has historically been too much emphasis on “D,” without enough on “R.” In 2021, teams will be confronted with antsy boards of directors and enthusiastic chief marketing officers who want to see next-generation health tech in the marketplace. R&D teams can mitigate the need for speed right now by working together with product and marketing teams on their expectations and road maps.



RISK

Data collected from health tech and wearables is valuable, and the industry is a target. In 2020, there were numerous cyberattacks on hospital systems. Mercifully, the devices people rely on—pacemakers, insulin pumps—haven’t been hit with attacks. Chief risk management officers and those who work in risk-related positions can play a critical role in making sure that not only are devices safe, but the ancillary systems that collect and distribute data are encrypted and secure.

Key Questions

We recommend using this report to support your strategic foresight activity in the coming year. Every executive team should begin by asking these questions about the futures of health care, medicine, and wearables:

1

Is our company tracking disruptions outside of our immediate industry?

What does the Amazon Pharmacy case study tell us about our business?

2

What parts of our business make us a target for disruption?

How could new business models introduced by new entrants pose a threat?

3

Are our digital transformation efforts keeping pace with the changes in health, medical, and wearable technologies?

What assumptions must hold true for our current strategy to succeed?

How will we make needed changes?

Selected Sources

<https://www.nature.com/articles/s41551-020-0534-9#auth-1>

<https://www.beckershospitalreview.com/consumerism/41-of-gen-z-and-one-third-of-millennials-prefer-digital-encounters-with-physicians-over-in-person-visits.html>

<https://www.ehrn.org/articles/telehealth-fad-or-the-future/>

<https://www.gminsights.com/industry-analysis/sleep-tech-devices-market>

<https://aspe.hhs.gov/pdf-report/medicare-beneficiary-use-telehealth>

<https://www.aha.org/factsheet/telehealth>

<https://www.nejm.org/doi/full/10.1056/NEJMs1905390>

<https://covid19researchdatabase.org/>

Mantrawadi, M. et al. (2020). *Wearable device with field replaceable band*. (U.S. Patent Application No. 20200289001). U.S. Patent and Trademark Office.

Graham, D. et al. (2021). *Intelligent automated assistant for media exploration*. (U.S. Patent No. 10,909,171). U.S. Patent and Trademark Office.

Wicksell, M. et al. (2020). *Storage compartment vehicles*. (U.S. Patent No. 10,538,190). U.S. Patent and Trademark Office.

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Why FTI

We answer your most challenging questions using data, creative inquiry, and strategic foresight.

- What are plausible deep (20+ years), long-range (10+ years), and near-term (2+ years) futures?
- What scenarios describe our futures?
- What's happening outside my industry that I should know?
- What companies, startups, and partners make up our future value network?
- What new products, services, or businesses should we build?
- Which tech trends should we monitor? When should we act?
- How can we build an early warning system to see the next disruptive event?
- How do we reduce uncertainty about our futures?

We support executive leaders and their teams.

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