How will new technologies make age-related diseases a thing of the past?

Building an engaged aging strategy

EY

Building a better working world
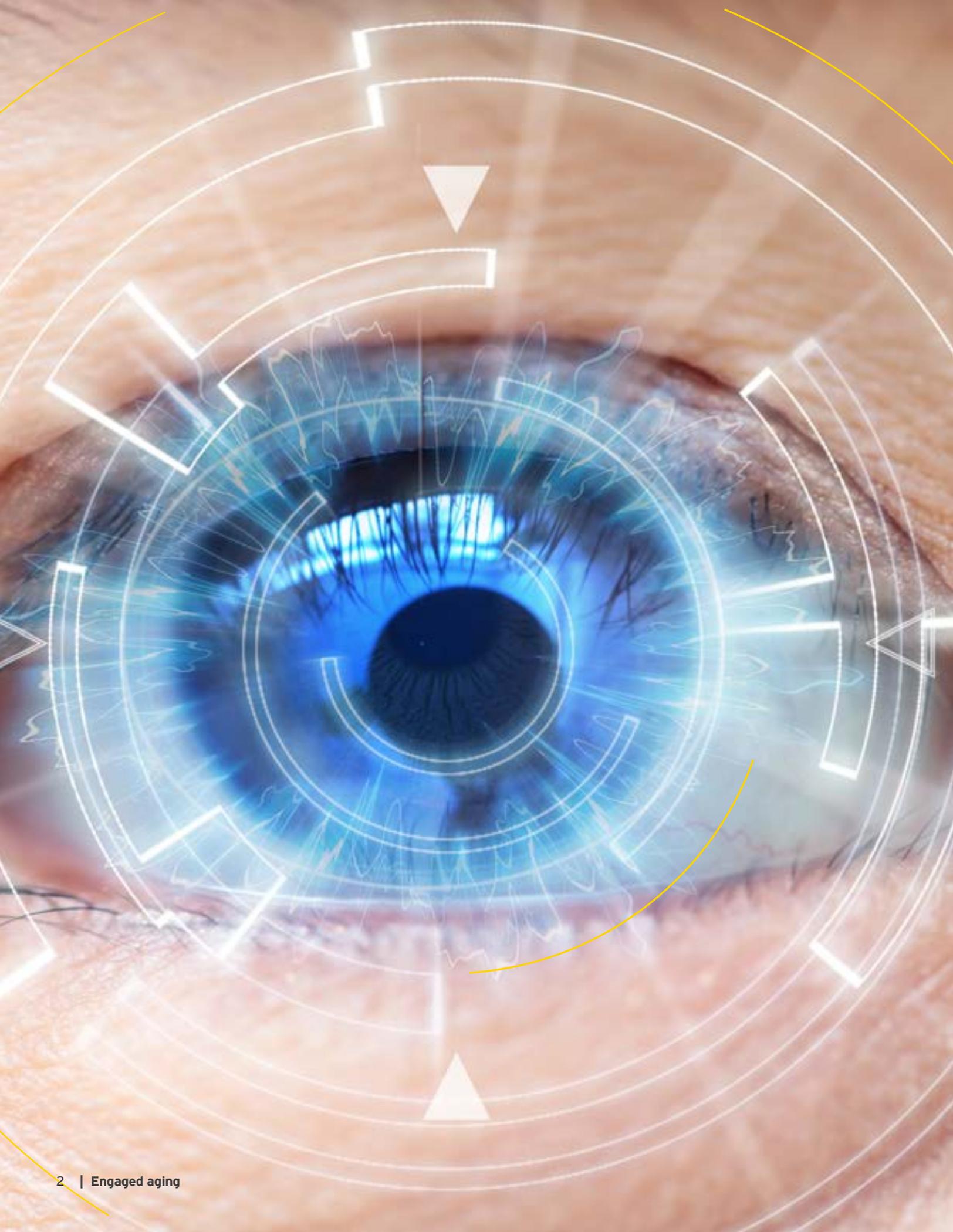
In September 2016, Mark Zuckerberg stood in front of a packed auditorium to ask a provocative question: "Can we cure, prevent or manage all disease by the end of this century?"

Sound audacious? It is.

Through the Chan Zuckerberg Initiative, the Facebook founder and his wife, Dr. Priscilla Chan, are dedicating US$3 billion over the next decade to prevent, cure and manage some of the world's costliest diseases, including heart disease, cancer, stroke and neurological disorders.[1] Not by chance, these global chronic killers also happen to be increasingly common as the world's population ages and grows more sedentary.

If ever there was a time for bold statements and even bolder ambitions, now is the moment.

It is estimated that sometime before 2020 – for the first time ever – the global population of individuals aged 65 and older will outnumber children under age five.[2] With today's life expectancy, the health care expenditures could be enormous: the World Economic Forum estimates treating chronic, non-communicable disorders could cost an estimated US$47 trillion from 2010 to 2030.[3]

When life span means health span

By some estimates, we spend about 50 times more as a society managing diseases as they occur than we do on research that might prevent those diseases from happening in the first place. New genetic and digital technologies could make aging more sustainable, accelerating the discovery and creation of solutions (see Figure 1).

"Today we are healthy in the absence of disease," says Ken Bloom, President of Human Longevity. "But in reality, we are only 'healthy' because we haven't identified the events that will age us," Bloom notes. After years-long exposure to insults such as ultraviolet radiation and oxidative stress, our cells reach a point where they can no longer maintain optimal function and falter, which manifests as age-related disease. The goal is to use transformative technologies to delay the breakdown of function and extend the health span — the ability to age disease-free.

In the near term that means deploying sensors and Internet of things (IoT) technology in phones and ever smaller wearables to cost-effectively monitor, and then manage, known diseases associated with aging. Longer term, innovations in genetic and regenerative medicine, coupled with cheap computing power, improved analytics and a growing understanding of both human behavior and the biology of aging will move treatment upstream to the pre-disease state, where conditions should be cheaper and easier to remedy.

Yet the real shift to wellness will come when pre-emptive efforts are so entrenched in day-to-day life that they no longer merit the label "prevention." Wellness will be just another part of the normal routine, like brushing one's teeth or washing one's face.

Figure 1: Enabling technologies to make aging more sustainable
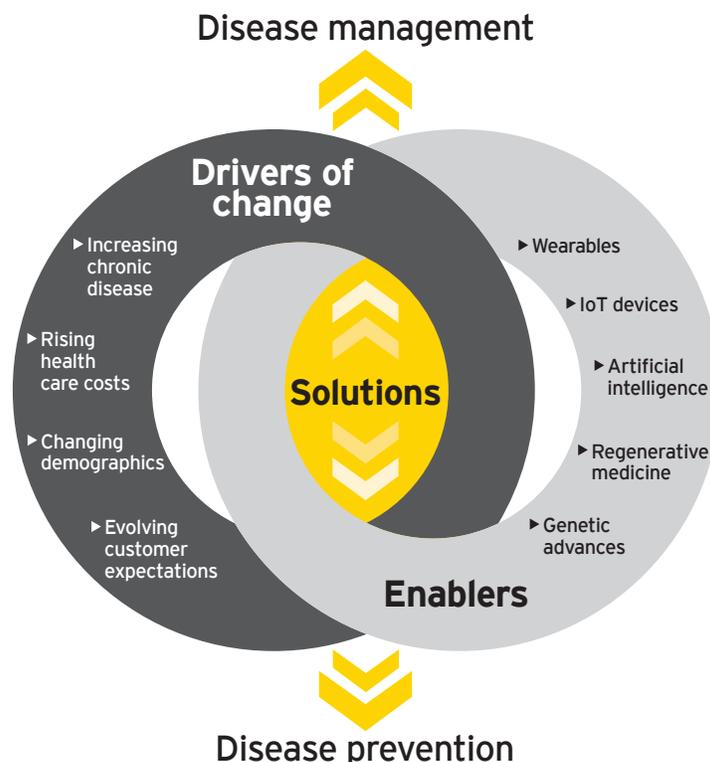
Stepping along the continuum: from disease management to wellness

A range of technologies are needed to move us down the path to lifelong wellness. Many components already exist — or will in the near future (see Figure 2).

Consider the genetic and scientific advances that underpin the emerging field of precision medicine (i.e., getting the right drug to the right patient at the right time). With the ability to sequence a person's entire genome poised to cost less than US$100, it will soon be reasonable to map the genetic blueprints of large numbers of individuals. As a result, it will be possible to uncover rare signals that, when linked to observable characteristics — called phenotypes — identify new markers for disease risk.

Ongoing efforts to understand the human genome will be further enhanced by combining genetic data with a range of other data types, including:

▸ Traditional clinical laboratory results

▸ So-called "multi-omics" analyses that quantify collections of biological molecules, including the totality of proteins or genetic transcripts

▸ Real-time data generated by wearables and other mobile technologies

▸ Behavioral data gleaned from social media sites (e.g., Facebook and Twitter) and advocacy organizations (e.g., PatientsLikeMe)

The integration of these data will ultimately transform health care and expand precision medicine approaches to health writ-large.

Accelerating this shift to precision health, what researchers also call scientific wellness, are a range of enabling tools that include third-party clouds for data sharing and artificial intelligence (AI).

Indeed, one branch of AI, deep learning, could shorten the time to reach R&D milestones. Advances in computational power now make it possible for deep learning software to replicate the neuronal activity in human brains. As a result, the software can now be used to identify patterns in extremely large data sets, revealing potential new linkages between specific genes or proteins and disease more rapidly than human counterparts could find them.

Deep learning algorithms could be particularly important in enabling probabilistic disease prediction before symptoms manifest, developing new drug targets for age-related diseases as well as identifying key points for behavioral interventions. Already a range of start-ups, including Calico and Insilico Medicine, are using the approach to advance the science of longevity.

Figure 2: Solutions to promote healthy aging can be arrayed on a disease management — prevention continuum

Disease management — Current state

Disease prevention — Future state

Clinical and molecular diagnostics

IoT-enabled devices and wearables

Invisibles

Aritificial intelligence

Regenerative medicine

Gene sequencing/-omics
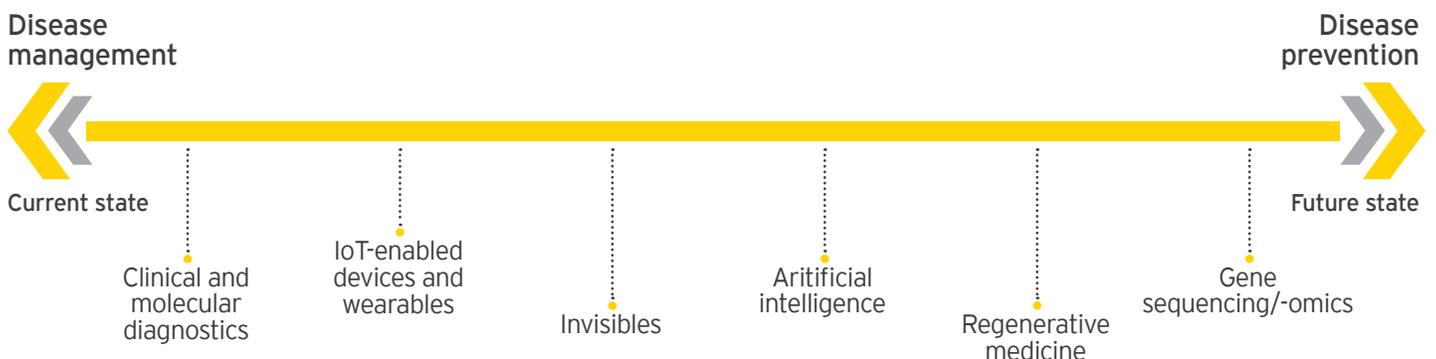
The ability to shrink, and sync, sensors and electronics is also important. Smaller devices can be incorporated seamlessly into our current environment via clothing, jewelry, furniture or even tattoos, passively collecting data and monitoring for biological and environmental changes. The "always on" phenomenon reduces the hassle factor; consumers don't have to engage with a clunky device, remembering to charge it or sync it with other health tools or download the data to actually make a behavior change. As we will cover in a forthcoming piece, embedding technology into consumers' lives in such a fundamental way should reduce the wearable tech fatigue that can limit lasting behavior change.

It's still early, but these data-driven approaches are already bearing fruit (see Figure 3). To better understand the underlying causes of diseases of aging, researchers at Stanford University have joined forces with Apple to study the genetic characteristics of the super well, extreme athletes. Verily, formerly Google Life Sciences, has launched its own 10,000-person Baseline study to better define health based on genomic, molecular and imaging big data signals. In addition, Regeneron and Geisinger Health System have already uncovered a novel marker that significantly reduces the risk of coronary artery disease based on observed associations between patient data and genetic signatures in 100,000 participants.[4]

Figure 3: Pioneering start-ups look for the upsides of aging

Company (founding date)	Focus
Arivale (2014)	Personalized health and weight loss services based on multiple data inputs create a scientific picture of wellness
Calico (2013)	Hybrid academic-biotech founded by Alphabet to combat aging and age-associated diseases
Forward (2016)	Primary care practice using sensors and AI to provide consumers with slick, seamless, personalized health care
Human Longevity (2013)	Concierge service couples -omic technologies and machine learning to make medicine more data driven
iCarbonX (2015)	AI-driven platform provides customized health and medical advice to consumers via app
Insilico Medicine (2014)	Biotech using deep learning and analytics for in silico drug discovery and to repurpose existing drugs to treat age-related diseases
Unity Biotechnology (2016)	Biotech developing therapeutics that prevent, halt or reverse diseases of aging; most advanced product treats osteoarthritis

Source: EY analysis.

P-medicine

It is important to note that the pivot from disease management to precision health intersects with another larger trend redefining health care: P-medicine, which is medical care that is personalized, precise, preventative, predictive, pharmaco-therapeutic and participatory. At its heart, P-medicine doesn't simply encompass new technologies and science; it represents a new mindset that emphasizes prevention and greater collaboration between physicians, consumers and other stakeholders in pre-empting and/or solving health challenges (see Figure 4).

Currently, health care recommendations are based on large population-based data sets that demonstrate a behavior change (e.g., eating more fruits and vegetables) or an intervention (e.g., taking statins to reduce cholesterol) results in a positive health outcome. But what's really needed is an understanding at the individual level of the potential disease burden that arises as a result of interactions between a person's genetic code and the environment, including behaviors that promote – or limit – health.

The ultimate goal of P-medicine is to use knowledge gleaned from these data-driven efforts to develop more integrated treatment approaches to complex diseases such as mild cognitive impairment, a precursor to Alzheimer's disease. Indeed, by capturing biological, clinical and behavioral outputs, the approach could refine how

providers educate individuals about both disease risk and illness so that behavioral prompts are delivered not just to the right patient at the right time but in the right way to achieve maximal health.

Start-ups such as Human Longevity and Arivale are using P-medicine to reposition health as a scientifically driven process. Human Longevity's Health Nucleus program, for instance, has analyzed whole genome sequences of hundreds of individuals to identify regions of the DNA that are unique to people who died between 50 and 75. It's still early days, but the expectation is that by studying these specific genetic regions in greater detail, scientists at the biotech can identify root causes of age-related diseases that can be monitored via diagnostics or treated via new therapeutic interventions.

Arivale, meanwhile, combines cutting-edge research, personalized data and tailored coaching to help participants optimize their wellness. The start-up takes advantage of the convergence of systems biology, big data and consumer engagement, integrating whole genome sequencing results with clinical and other data. Currently, more than 4000 people are signed up for Arivale's scientific wellness program, either as individuals or at an enterprise level. Highly trained coaches, with the support of a clinical team, translate complex scientific information into actionable health recommendations for participants.

Figure 4: P-medicine combines the science of medicine and the science of behavior
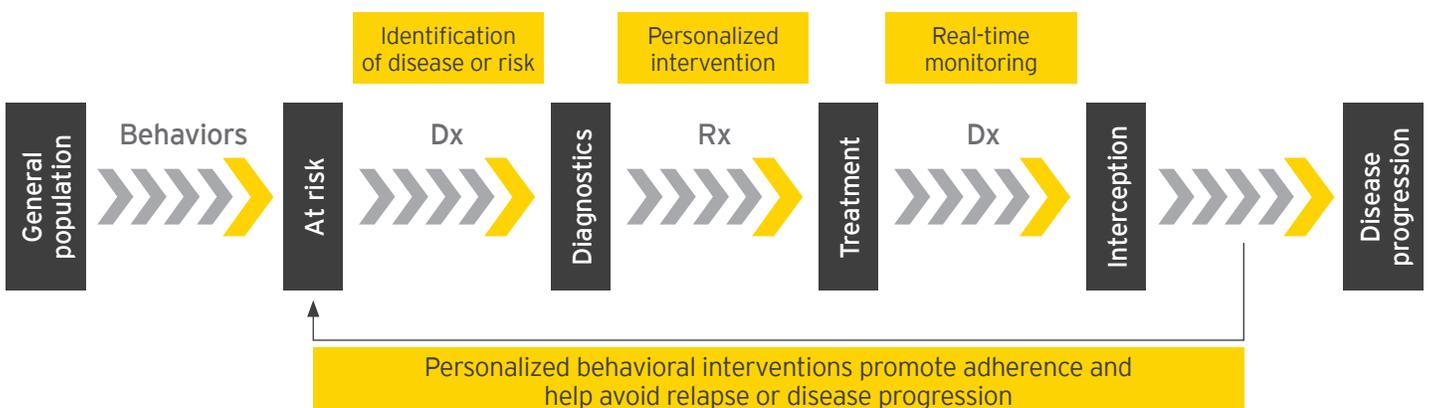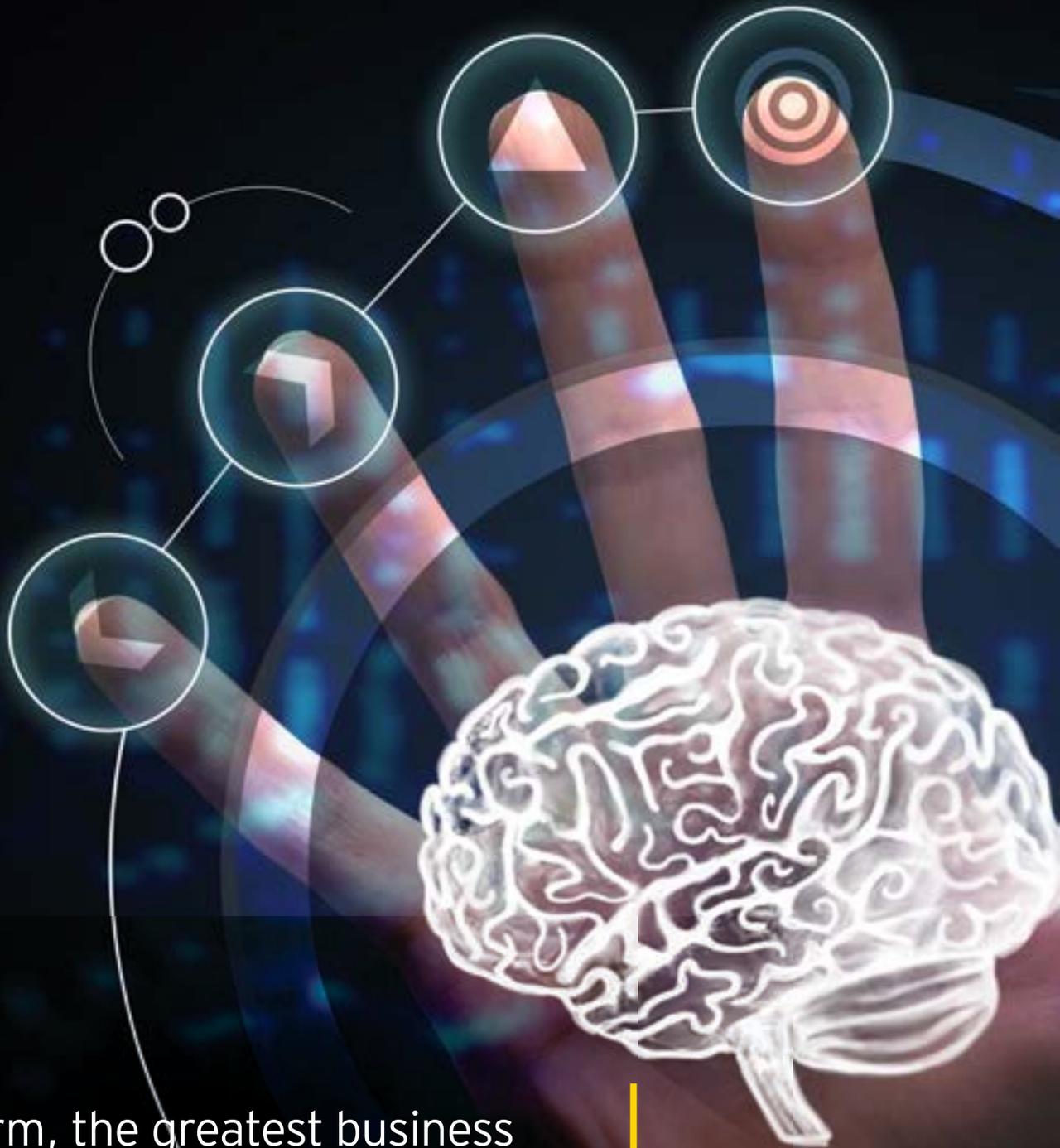
Near term, the greatest business opportunity is the development of simple, concierge services that either coordinate care or support wellness by integrating insights from big data with high-touch behavioral tools.

Shifting business models

The invisible touch

As our understanding of the drivers of age-related diseases grows, the demarcation between disease management and disease prevention will blur, leading to earlier disease interception. In essence, that means broadening the definition of disease to include susceptibility based on the relationship between biological markers and the development of full-blown symptoms.

Driven by new technologies, this shift to prediction and pre-emption will necessitate changes in health care delivery and biopharma business models (see Figure 5).

In the current state, when attention is given to prevention, it is largely ad hoc and episodic. In a consumer empowered future, however, providers will be able to personalize care further, moving away from reliance on population-based metrics to individualized risk assessments. Near term, the greatest business opportunity is the development of simple, concierge services that either coordinate care or support wellness by integrating insights from big data with high-touch behavioral tools.

The biopharma equivalent of "An apple a day …"

Biopharmaceutical companies currently invest billions in preclinical R&D to develop expensive products designed to treat the body when disease manifests, or, in a small number of cases, to treat a single or small number of risk factors (e.g., statins and heart disease). But as wellness and disease interception become the norm, there will be less need for such products, exacerbating pricing and utilization pressures that already limit revenue growth.

That's not to say pharmaceuticals won't be needed — lifestyle interventions, even if delivered at the right time and via the right format, won't be sufficient to maintain optimal health. But the types of products, and the data demonstrating their value, will shift when disease interception and disease prevention become more mainstream. Companies will need to develop medicines that deliver smaller interventions safely and affordably. The current model, which supports charging hundreds of thousands of dollars for an anti-cancer drug, won't apply — or be palatable — when the intervention counteracts not an actual disease but a disease risk.

The good news is we already have multiple examples of marketed biopharmaceuticals that intercept disease. Vaccines prevent both childhood scourges such as pertussis and diphtheria, as well as adult conditions such as shingles. Bisphosphonates, which inhibit bone resorption, and statins, which lower cholesterol, are two other examples worth noting. Both treat early symptoms of more serious and costly conditions — fractures due to osteoporosis and heart attacks, respectively. Biopharma companies will need to assess how they can develop — and build the evidence case for — similar interventions in other therapeutic areas.

Figure 5: New technologies drive changes in the business models of health care and life sciences companies

Technology (example)	Relevance to stakeholder				
	Life sciences	Provider or hospital	Payer	Policymaker	Consumer
Sensors/ wearables (EKG monitors)	Real-world data cognitive and physical function	Improved care in lower cost setting	More cost-effective, patient-centric care	Balancing safety and efficacy with innovation	Peace of mind; greater convenience; privacy concerns
App-enabled services and devices (ElliQ, Uber, Independa)	Close critical care gaps; enable remote monitoring; link health outcomes to medicines	Remote monitoring to support health; greater efficiency of specialists; better care in underserved areas	Avoid high-cost events; proliferation of technologies makes it difficult to know which apps to pay for	New policies needed that clearly define app or service as medical device or consumer product	Convenience; promotes independence; may exacerbate loneliness/ alienation
Regenerative medicine (stem cell therapy)	Curative therapies represent step change in care	Require new protocols for incorporating into clinical practice	High cost may require new payment models	Existing trial methodology may be insufficient	Access and affordability of curative treatment
Genetic advances (low-cost sequencing)	Allows earlier intervention before visible symptoms	Better understanding of current/future disease risk; needs to be integrated into clinical practice	More accurate risk pools as the link between specific behaviors/genetic predispositions and health outcomes are uncovered	Need for data sharing and privacy policies that protect patients	Better understanding of current health/ future disease risk
Artificial intelligence	Greater understanding of disease risk and behavior change	Allows doctors to focus on personal interaction	Helps establish return on investment for intervention	Evolving data-driven rule sets require new regulatory standards	Patients can receive care or wellness regimens particular to their background, environment and health status

Source: EY analysis.

Laying the wellness foundation

The shift from disease management to disease prevention and wellness depends on a number of factors.

▸ **Regulatory flexibility:** Moving from disease management to disease prevention requires utilizing data in new combinations. While regulatory bodies in many countries have well-developed protocols for safety and efficacy, these frameworks are better suited to traditional pharmaceuticals and medical devices than artificially intelligent systems and consumer-generated data. Standards are needed that appropriately measure safety and efficacy but adapt rapidly enough to meet the pace of innovation.

▸ **New reimbursement models:** Even though pay-for-value is gaining traction, the current fee-for-service model incentivizes disease management not disease prevention. To prioritize healthy aging, reimbursement models that emphasize prevention and the coordination of complex care are a must. So, too, are affordable concierge wellness services. Current offerings are not affordable on a population level. Going forward, payers and employers should partner with the companies developing these bespoke services to develop lower cost options that can be deployed more broadly.

▸ **Making behavioral economics mainstream:** Behavioral economics, the use of psychology and economics to understand what drives individual behavior, has been slowly moving into the mainstream. Understanding how cognitive biases affect an individual's ability to invest in long-term health is essential. Only by developing the right nudges and delivering them at the right time will it be possible to help consumers make better health choices, whether those are related to exercise, diet or medication adherence.

▸ **Platform creation:** The pace of technological innovation in the healthy aging space is truly exciting. However, to truly transform aging and extend the health span, it's not enough to use emerging technologies to create point solutions. Partnerships that develop integrated, platform-based offerings that are easy to use and flexible enough to accommodate future innovations will have a competitive advantage.

New genetic and digital technologies are an important component of any future wellness infrastructure. At their core, these technological developments are unlikely to increase human life spans signficantly. Far from pursuing the proverbial fountain of youth, these solutions will instead extend health spans, so that physical and cognitive fitness is maximally aligned with life expectancy. That would be a powerful advance, indeed.

"How will new technologies make age-related diseases a thing of the past?" is the second in a series of articles exploring aging, a megatrend as big as digital disruption. Additional articles will explore the importance of consumer engagement and creative partnerships as societal priorities shift from disease management to wellness.

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