THE FUTURE OF

Health

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INTRODUCTION

AT THE JACOBS INSTITUTE WE UNDERSTAND THE VALUE OF BREAKING DOWN TRADITIONAL SILOS THAT HAVE DEFINED THE PRACTICE OF MEDICINE FOR SO LONG. OUR BUILDINGS AND

their designed interiors were created to bring people together and encourage the cross-pollination of new ideas. Creating an innovation ecosystem under one roof is what distinguishes our institution. This report was created with that spirit in mind.

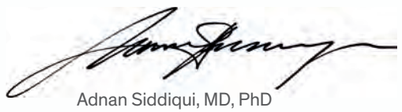
None of the systemic problems facing our healthcare system are easy to solve. Some of our nation's brightest minds have been working on much-needed solutions for decades.

Nevertheless, I remain hopeful.

I'm inspired by the new generation of healers coming into the medical profession. They are brave, smart, outspoken and unwilling to accept the status quo. They are digital natives, open to new approaches. But they believe, as I do, that in this time of rapid technological change, we cannot let screens or new devices disrupt the human connection—the trust and compassion we cultivate with our patients. In particular, the provider-patient bond has been degraded by archaic electronic charting systems and requirements. Improvements in natural language processing, sensors, wearables and AI integration can and should help physicians and nurses return to providing the essential human touch.

While there has been a lot of focus on patient and family experience, not enough has been done to improve the work life of healthcare staff, who spend decades in high-stress environments. We need a new approach to improve the working environment of healthcare professionals to enhance the joy of collaboration and camaraderie.

In these pages we look at the future of healthcare from the broadest possible perspective. It is a reminder that healthcare innovation occurs not just within individual disciplines but through ideas and advances across many disciplines. As the following pages reveal, our profession is inextricably intertwined with many other fields, including data science, politics, socioeconomics, environmental and community studies, architecture, engineering and robotics, among many others. We hope this inspires you to look up from your individual specialties and strike up conversations with a wide range of researchers, thinkers and innovators.



Adnan Siddiqui, MD, PhD

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JACOBS INSTITUTE

THE SPEED OF INNOVATION IN HEALTHCARE IS NOTHING SHORT OF BREATHTAKING, WITH FORCES OF CHANGE COMING FROM BOTH INSIDE AND OUTSIDE TRADITIONAL RESEARCH AND

medical settings. The future is difficult to predict, but we are certain of this: advances in healthcare technology, pharmaceuticals and care delivery are valuable and will lead to better patient care and improved outcomes, especially for those most in need.

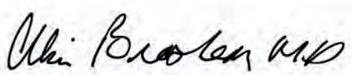
Those training for jobs in healthcare today will experience dynamic careers during which change will only accelerate. The coming decade will be a period of excitement and hope among medical practitioners, researchers and patients alike. Many opportunities and discoveries lie ahead. Clinicians and researchers will need to constantly stay informed, be data-driven and come up with better tools to address health issues faster and at an ever greater scale.

This will only be possible through visionary leadership that brings together education, clinical care and research to provide care that is both efficient and high-quality. By leveraging the knowledge of many, we will be able to harness innovation while keeping in sight a holistic and humanistic view of our patients and their families to assure equitable care across all our communities.

In Western New York, we have a rich cultural history that reflects all the greatest challenges of the American healthcare system. At the Jacobs School, our vision is for our researchers, educators and providers to work in sync to advance the frontiers of medical knowledge, impart those innovations to the next generation of clinicians, and inspire them to improve the health of our citizens.

Medical education at the Jacobs School is undergoing fundamental changes to address structural racism in medicine. This effort was initially inspired by our students—a fact that speaks volumes about the depth of commitment our future physicians and scientists bring to the profession as they work with faculty to achieve health equity in every aspect of patient care.

Every day we witness the impact of the social determinants of health. We see the human-scale consequences of long-present inequities within our communities, including the health impacts of poverty, injustice, racism and unequal access to care. If we keep this hard-earned perspective at the forefront of our efforts in the laboratory, clinic and community, Western New York can become a template for the nation, a model for a healthcare system that reaches beyond our community to positively impact our collective future.



Allison Brashear, MD, MBA

Vice President for Health Sciences
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DIVERSITY, EQUITY, INCLUSION, ACCESSIBILITY & BELONGING

BUILDING AN INCLUSIVE AND EQUITABLE SYSTEM

For decades, our traditional healthcare system has failed to prioritize diversity, equity, inclusion, accessibility and belonging (DEIA&B). While we've made progress in recent years, it hasn't been enough. Healthcare is a fundamental human right that should be available to all individuals. As leaders and stewards of medical institutions, it is our responsibility to ensure that this right is upheld. Eliminating structural racism is crucial for creating a healthcare system that is equitable and just for all individuals. Unequal access can manifest as disparities in care, poorer health outcomes in marginalized communities, and a lack of diversity among healthcare providers and researchers.

One way to promote greater equity in healthcare is to ensure that research includes people from diverse backgrounds with different experiences, which leads to more accurate and relevant findings across a wider range of individuals. Access, especially for people with disabilities, goes beyond architecture and includes "on-ramps" like accessible technologies, high-quality broadband, language options, teletype devices (TTY) and many other technologies to foster a genuine culture of inclusion.

Successful solutions must be rooted in a deep understanding of the social determinants of health, which connects health outcomes to all the conditions in a patient's environment—where they are born, live, learn, work and age. These determinants directly impact people's health, well-being and quality of life.

UNLIKE THE REST OF THE DEVELOPED WORLD, LIFE EXPECTANCY IS DECREASING IN THE US, THANKS TO THE POLITICIZATION OF HEALTHCARE, WEALTH DISPARITY AND DRAMATIC INCREASES IN DEATHS LINKED TO OBESITY, GUN VIOLENCE AND DRUG ADDICTION.

Looming behind these national dynamics is **global climate change, poised to become the world's top public health crisis.** These facts are a call to action and emphasize the need to take a holistic view of healthcare in our country.

Despite the dire statistics, we believe **there is much to be optimistic about.** Perhaps surprisingly, the most optimistic section of this report is about cancer—a look at how far we've come and the encouraging prospects of individualized cancer treatment. Other bright spots:

- High-powered, flexible **artificial intelligence** is emerging as an aide and guide in virtually every field of medicine, with the potential to distribute and apply the world's best medical practices far and wide.
- Advances in **life-extension science** promise not just to make our lives longer, but to make our later years healthy, fulfilling and productive.
- Momentum in the field of **phenomics**, which combines genomics, proteomics, epigenomics and other biological sciences to allow development of increasingly targeted approaches to health.
- **Neuro-connected bionic prosthetics** are becoming more accessible to people across the socioeconomic spectrum.
- Increasingly powerful **personal health technology** that helps people monitor their own biological systems and act early to address issues before they cause illness.

But new technologies will not be enough. **In the 2017 Future of Medicine report, we forecast a pandemic that would "galvanize political will and spur development of technology to accelerate vaccine production and distribution."** The crisis we predicted arrived only a few years later—and for what now seems like a distant, shining moment, governments and the pharmaceutical industry showed what's possible by working together to rapidly create and distribute Covid vaccines globally. Solving the health crises of the near future will require similar levels of collaboration, commitment to innovation, and willingness to transcend politics.

From the beginning of recorded history, healthcare has been a defining achievement of civilization. **The Code of Hammurabi, written in cuneiform nearly four millennia ago, mandates the measurement of outcomes from medical procedures and incentives for doctors to provide the best form of care.** It also specifies minimum standards of care for even the least privileged members of society. Thousands of years later, our nation still struggles to realize those Mesopotamian standards.

It's our hope that this report will spur the leaders of the institutions that shape health in the US—hospital systems, insurance carriers, pharmaceutical companies, medical schools and most of all policymaking and regulatory bodies—to seize the opportunities presented by the emerging technologies of today and tomorrow, and to **reengineer our health system** with compassion, common sense and ethical clarity.

Josh McHugh
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THE FUTURE OF HEALTH TEAM

JOSH MCHUGH
EDITOR IN CHIEF – CEO OF ATTENTION SPAN AND EDITOR, ATTENTION FWD

Josh's experience at the intersection of technology, media and business began at *Forbes*, where he chronicled the brainiacs and billionaires behind the turn-of-the-century tech upheaval as an associate editor while opening *Forbes*'s Bay Area office. A contributing editor at *Wired* for six years, Josh briefly expired while volunteering in a NASA hypergravity endurance experiment. He has also written for *Vanity Fair*, *Outside* and shelfloads of other publications, and served as editor in chief of 2017's *Future of Medicine* report. Josh graduated from Yale with a BA in English and holds an executive education certificate in Sustainable Capitalism and ESG from Berkeley Law.

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David is an award-winning life science and political journalist in print, television and radio; a best-selling author of 11 books published in 21 languages, including the global bestseller *Calendar*; and an entrepreneur and researcher. He writes for *Vanity Fair*, *Scientific American*, *Wired*, *The New York Times*, *The Atlantic*, *Fortune* and many others. His latest book is *Talking to Robots: Tales from Our Human-Robot Futures*. David is a former commentator for NPR's *Morning Edition* and a former special correspondent and producer for ABC's *Nightline* and *20/20*. He is the cofounder and CEO of Arc Fusion, which convenes top leaders in life sciences for discussions about major issues of the day; he is the founding director of the Center of Life Science Policy at UC Berkeley and a former Health Strategist in Residence at IDEO. He has won numerous awards, including Magazine Story of the Year from AAAS and three nominations for National Magazine Awards. David's next nonfiction book is *The Secret Lives of the Sea: Voyages into the Ocean's Microbiome*, due out on September 12, 2023. David has been on the faculty of Singularity University and is a member of the SF Writers Grotto.

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Ethan is a journalist who has spent the last two decades writing about culture and psychology. He is the author of *Crazy Like Us: The Globalization of the American Psyche* and *Urban Tribes: A Generation Redefines Friendship, Family, and Commitment*. His writing has appeared in *The New York Times Magazine*, *Outside*, *Discover*, *Men's Journal* and *Wired*, among other national publications.

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Rebecca Ferrini is a full-time medical director for Edgemoor, the County of San Diego's skilled nursing facility. She has specialties in hospice, palliative medicine and general preventive medicine. During her tenure at Edgemoor, the facility has achieved the highest possible ratings from the Centers for Medicaid and Medicare Services (five stars, 20/20 CMS), has been named a top nursing home in *US News and World Report* for seven years and received the American Health Care Association / National Center for Assisted Living 2017 Gold – Excellence in Quality Award. In 2019, she received a California Association of Long Term Care Medicine Statewide Leadership Award, and in 2009, the American Medical Directors Association named her Medical Director of the Year. She is faculty for the Core Curriculum used to train nationally certified long-term-care medical directors and has become a nationwide expert in the care of younger adults, Huntington's disease, risk management, management of behavioral problems and improving quality.

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Jonathan is an assistant professor of emergency medicine at Harvard Medical School and an attending emergency physician at the Massachusetts General Hospital. He is chair of the Mass General Brigham Enterprise Emergency Medicine Quality and Safety Council and chair of quality and safety for the MGH ED. Dr. Sonis also serves as an associate medical director at CRICO, Harvard's patient safety and medical malpractice company. Dr. Sonis has extensive leadership experience related to quality improvement, provider and staff communication, and patient experience, and he lectures and publishes frequently on these topics. He received his MD with Alpha Omega Alpha honors from the Tufts University School of Medicine and trained at the Harvard Affiliated Emergency Medicine Residency, where he served as a chief resident. He has completed educational programs in leadership, quality service and value-based healthcare, and earned his Master's in Health Care Management at the Harvard School of Public Health.

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Joshua is a practicing dermatologic surgeon and author. His bestselling thrillers (*Isolation Ward* and *Flawless*) have earned comparisons to Michael Crichton and Scott Turow. He has published numerous clinical and scientific papers and was a contributing editor on the *Future of Medicine* report. He holds degrees from Yale and Stanford Medical School.

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Danny has been the West Coast correspondent for *The Sunday Times* since the beginning of 2017, covering all things technology and Silicon Valley. He also hosts the weekly *Danny in the Valley* podcast. Before moving back to California, he spent 15 years in Britain, and has reported from more than 25 countries.

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Laura is an award-winning San Francisco–based journalist and the author of four books, including *The New York Times*–bestselling memoir *An Italian Affair.* She also writes about science and climate for Genentech and Rewiring America and collaborated with scientist Saul Griffith on his recent book, *Electrify*.

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Tami is a DEIA&B (Diversity, Equity, Inclusion, Accessibility and Belonging) consultant, leader and change-maker. She runs workshops on DEIA&B, and advises C-suites, executive leadership teams and human resource professionals on how to incorporate diversity into one's corporate culture to increase loyalty and value. She is also a motivational speaker, encouraging others to build more confident, meaningful and successful lives. She was a journalist for many years with NBC News, first at *Nightly News with Tom Brokaw* and then with *Dateline NBC*. Tami was born with a physical disability and later in life was diagnosed with an invisible disability. She uses her life experiences to shed light on the fact that many people move between multiple underrepresented communities. Tami was a ski racer on an international circuit and uses that competitive spirit to stand up for a community that is often neither seen nor heard in boardrooms. She prides herself on getting her foot in the door and having a seat at the table.

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Jenny received her PhD in Biomedical Science (Cancer Biology) from UCSF, where she studied novel drug candidates for pancreatic neuroendocrine tumors. Her essays and poems have been published in *The New York Times*, *The Atlantic*, *Tin House*, *Rattle*, *Zyzzyva* and the *San Francisco Chronicle*, among other places. Her debut poetry collection, *Focal Point*, won the 2020 Steel Toe Books Poetry Award. Most recently, she worked with life science and biopharma groups as a competitive intelligence manager, with a focus on ovarian cancer. In addition to oncology, she has covered health insurance policy, diversity in medicine, medical humanities, end of life, mental health and more.

DOMINIQUE SAINT MALO
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Dominique is a writer and filmmaker whose career has ranged from investigating political and social trends in the US to film analysis and interpretation. Currently a professor of Media Arts, Sciences, and Studies at Ithaca College, she has also worked with StudioBinder, Nantucket Film Festival, DOC NYC, Netflix, NBCUniversal and Hulu. Based in New York's Finger Lakes region, she seeks out new cultural experiences to spotlight in her next script or article. Dominique has traveled to over 20 countries and speaks two and a half languages.

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Natalie is a reporter based in Oakland, California. She loves to work with sound, write prose and dig up facts. When not doing those things, she consumes a lot of media and spends loads of time outside. Some of her favorite topics to cover are health, agriculture, food and the environment. She has reported for NPR, KQED, KALW, *Grist* and *Civil Eats*.

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Patrick has a PhD in neuroscience from Stanford University and writes on science, technology and culture for publications such as *The New Yorker* online and *Slate*. His scientific research has been featured by *The New York Times*, *National Geographic* and *Radiolab*, among other outlets. His book, *Nineteen Ways of Looking at Consciousness*, was published in October 2022.

THE FUTURE OF HEALTH TEAM

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Andrew explores the near future of biology and biotechnology. He is the cofounder of the Center of Excellence for Engineering Biology and the Genome Project-write, the international scientific effort to design and build large genomes, including the human genome. He also cofounded Humane Genomics, a New York-based developer of precision artificial viruses targeting cancer. Andrew is a former distinguished research scientist at Autodesk Life Sciences. His book, *The Genesis Machine: Our Quest to Rewrite Life in the Age of Synthetic Biology*, coauthored with futurist Amy Webb, was released in February 2022. He is currently exploring how our cells are a new asset class in the sense that they can be collected, analyzed and used in a variety of ways that have the potential to generate significant value.

KENNETH TRAUNER, MD
ADVISOR

Ken double-majored in biological sciences and mechanical engineering at Stanford University. He later performed his medical training at Harvard Medical School, where he graduated in 1990 after taking a year off to do engineering development of new surgical laser systems. After completing his orthopedic residency at UC Davis, he completed two years of fellowship at Massachusetts General Hospital before returning to UC Davis as an assistant professor specializing in adult reconstructive orthopedics. He also continued to perform engineering work in conjunction with scientists at Lawrence Livermore National Laboratories, with whom he later helped to establish the National Science Foundation National Center for Biophotonics. He has 77 issued US patents, and founded and served as CEO and chairman for both Invuity (acquired by Stryker) and Bespoke Innovations (acquired by 3D Systems). He has subsequently founded several active companies and now practices orthopedic surgery in the San Francisco Bay Area.

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Larry is managing editor for special projects at Attention Span, and cofounder and executive editor of Travelers' Tales publishers, where he has worked on all of the company's 160-plus books and helps oversee their publishing program. For three decades he wrote a newspaper column about travel security, as well as travel stories in major newspapers and magazines. He is also cofounder of The Prose Doctors, an editors consortium with more than 125 years of collective editorial experience. He has traveled in over 60 countries, from the Himalayas to the Dead Sea, the Arctic to equatorial rainforests. He holds a BA in English from Dartmouth.

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Alba is a sustainability director based in Attention Span's Boston office. She focuses on strategic projects related to sustainability, diversity and inclusion, stakeholder engagement and event planning and execution. Prior to Attention Span, Alba spent eight years at Ceres—a sustainability advocacy organization—where she managed relationships with a cross-sector group of Fortune 500 companies and led a network of 100-plus nonprofit organizations. Alba holds a degree in Environmental Science, a Master's in Corporate Social Responsibility from the EOI Business School in Madrid and a sustainability certificate from Harvard Extension School.

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Elijah is a recent graduate of Pitzer College, where he studied cognitive science and premed. His interests include topics in 4E cognition, the use of tools in sensation and perception, and critical neuroscience.

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Garrett leads strategy development for Attention Span's clients in food, health and nutrition. An Emmy-winning technologist, Garrett honed his savvy as VP, CFO and general manager of KHIZ-TV Los Angeles as the youngest GM in LA television. He oversaw all operations of the station and company, executing its successful turnaround and engineering overhaul. Before KHIZ, he helped launch Global Outsight—a biotech and media strategy and M&A consultancy in Cambridge, Massachusetts—and was on the staff of the mayor of Boston as the analyst for the Boston Fire Department. He is a Harvard graduate who studied engineering and the History of Science. Garrett is chairman of the Cancer Nutrition Consortium, a volunteer firefighter, and served on the boards of Find the Cause Breast Cancer Foundation and Project Hope Alliance.

PETER WHITE
INTERNATIONAL EDITOR – EXECUTIVE CHAIRMAN AT ATTENTION SPAN

Peter leads the team at Attention Span, after a decade as CEO of a Cambridge, Massachusetts, strategy consulting firm where he successfully created new companies, facilitated university tech transfer to startups, and turned around underperforming ventures. Previously, Peter was the CEO of KHIZ-TV Los Angeles and of Initial Broadcasting of California, where he led the transformation of an underperforming LA broadcast station into a cash-flowing digital TV pioneer, winning an Emmy in the process and producing a successful exit. He devotes a lot of his time to nonprofit endeavors, having served as chairman of the International Rett Syndrome Foundation and the Cancer Nutrition Consortium, and now focuses on higher education access and food security. Peter graduated from Hamilton College and did his graduate work at Harvard University, where he taught Asia-related economic development courses for eight years.

TYSON LAW
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Tyson manages the design team in Ithaca, New York. His expertise is in brand strategy, UX/UI and architectural environments. He has contributed to dozens of award-winning projects that include printed materials, films, websites and architecture. He received his Master's in Architecture from the Weitzman School of Design at the University of Pennsylvania, where he studied digital fabrication and computational design. He also holds a BS in Electronic Media, Arts and Communication from Rensselaer Polytechnic Institute.

SHAWN ROBERTSON
SENIOR ART DIRECTOR

Shawn is an award-winning San Francisco Bay Area–based senior art director and designer. She has worked for world-class advertising agencies and design clients on accounts ranging from cars to food, fashion to tech, education to biotech. She studied design, art, textiles, interior environments, theater and women's studies at California College of the Arts, San Diego State University and UCLA.

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DESIGNER – SENIOR DESIGNER AND DEVELOPER AT ATTENTION SPAN

Ethan is an interdisciplinary designer and programmer working out of the Attention Span Ithaca, New York, design lab. Specializing in website production and human–computer interactions, he has experience working with everything from print media to virtual reality environments. Previously, Ethan worked as a front-end developer at a number of website start-ups and spent several years as an undergraduate researcher and designer at Ithaca College. While there, he worked with a team of researchers and faculty members creating an interactive, narrative-driven, purposeful game to mimic the kind of informal foreign language acquisition students can experience while studying abroad. Ethan received his BS in Emerging Media Design and Production from Ithaca College, where he also triple-minored in Web Programming, Game Development and Computer Science.

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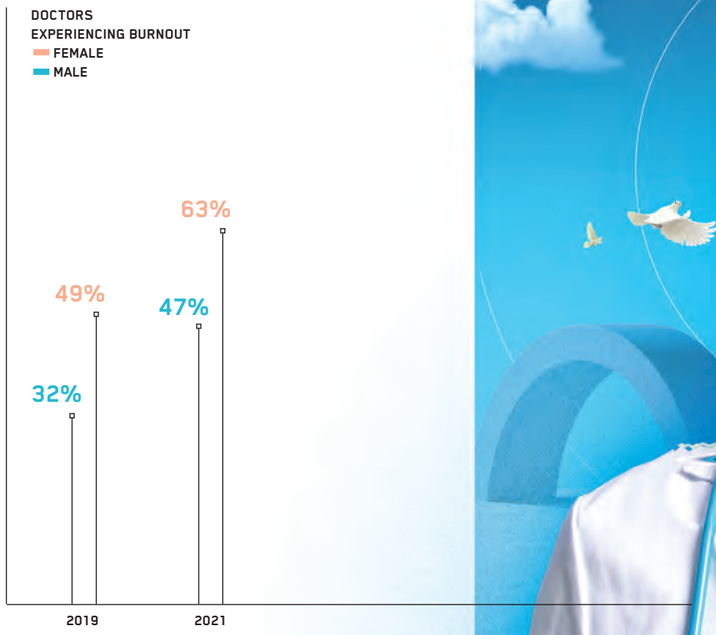
IF CURRENT TRENDS CONTINUE UNCHECKED, WE ARE ON TRACK FOR A SHORTAGE OF 139,000 DOCTORS AND 1 MILLION NURSES BY 2035. ONE THING IS CLEAR, HOWEVER: HEALTHCARE DELIVERY AND THE HEALTHCARE WORKFORCE WILL CHANGE RADICALLY OVER THE NEXT DECADES. TELEMEDICINE WILL EXTEND CLINICIANS' REACH; VR AND AR WILL HELP TRAIN NEW DOCTORS AND NURSES AND REDUCE THEIR WORKLOAD; AI AND ROBOTS WILL TAKE ON TEDIOUS TASKS AND SPEED UP CARE DELIVERY.



01 TOMORROW'S CAREFORCE

CAREGIVERS BOLTING

Even before the pandemic, half of all doctors and nurses said they had considered leaving medicine. The number one cause for doctors and nurses departing is burnout. Although the number of doctors feeling burned out decreased from 2014 to 2020, burnout has returned with a vengeance in the age of Covid-19, which amplified fears of infection and health resource shortages. In 2019, 48% of female doctors and 38% of male doctors reported being burned out. In 2022, those rates hit 63% for female doctors and 47% for male doctors. Doctors from minority or marginalized communities are even more likely to experience the onset of stress and anxiety from difficult working conditions.

Covid aggravated the caregiver shortage, **but the fundamental problems at the root of physician dissatisfaction remain: bureaucratic burdens (including EMRs and "heads buried in screens"), lack of respect (from administration/staff/patients), excessive workload, scheduling issues and chronic low pay for nurses and primary doctors.**

"This is the biggest increase of emotional exhaustion that I've ever seen…."

—**Bryan Sexton, Director, Duke University Center for Healthcare Safety and Quality, as quoted in *The New York Times*, 9/29/2022**

GOOD DESIGN CAN DECREASE BURNOUT

Most large hospitals are architectural labyrinths, with departments often separated by floors or even buildings. Better design can improve care coordination, treatment and collegiality, thereby reducing burnout and promoting collaboration. Intentionally designed buildings use space to bring specialists from related areas together.

"I walk out of my neurosurgery operating room and I'm interacting with a cardiologist. The next turn is a radiologist. The next turn is a vascular surgeon. … We're able to have coffee and lunch together. … We hang out. We solve problems collaboratively, and this improves staff morale and the medical care of patients."

—Adnan H. Siddiqui, MD, PhD; CEO and Chief Medical Officer, Jacobs Institute; Professor and Vice Chairman of Neurosurgery, Jacobs School of Medicine and Biomedical Sciences

A LIGHT AT THE END OF THE TUNNEL

- In a recent Texas Tech study, nurses whose break rooms had windows with views of the outdoors reported 18% less stress, 26% less emotional exhaustion and 40% less dehumanization ("feeling like a robot") compared with those whose break rooms had no windows.
- A SUNY Upstate Medical University study showed that simply opening shades in a work area reduced emotional exhaustion by 25% and dehumanization by 33%.
- The building that houses the Jacobs School of Medicine and Biomedical Sciences opened in 2017 and features an open six-story light-filled atrium that fosters interaction among physicians, innovation and a strong sense of community.
- **The choice of location of new healthcare facilities communicates which groups are being served.** The Jacobs School of Medicine's location in downtown Buffalo puts it within walking distance of a traditionally underserved population in the predominantly lower-middle-income Allentown neighborhood.

"In our hospital system we have more than enough data; the key is understanding it and acting upon it. Make it functional and actionable."

—Johnson Scaria, Director of Periop and Procedural Business Ops, Kaleida Health

UP TO 1/3
of total healthcare costs are administrative

$250B
Potential annual savings from standardization of systems with AI

AUTOMATE THIS!

Unlike clinical medicine, which is complex and variable, healthcare administration is replete with menial, repetitive tasks ripe for automation. Administration accounts for nearly a third of total healthcare costs ($1.2 trillion of $4.1 trillion), and a recent McKinsey study suggested that **standardization of systems powered by AI could save around $250 billion per year.** We expect a 20x increase in investment in AI technology for healthcare, with a focus on patient administration. Medical coders, billers and schedulers will see their ranks thin drastically.

IS THERE A ROBOT IN THE HOUSE?

Robots have been used for years in surgery, as well as for pharmacy tasks and the on-site transport of lab samples, food and medication. Robots using ultraviolet light help cleaning teams reduce the number of hospital-acquired infections. Robotic tools have become commonplace in laparoscopic surgery, and we expect use of robots in surgery to quadruple by 2030, but fully autonomous robots in the OR are still years away and face significant hurdles from hospitals and regulators.

AI AND THE MEDICAL CHART

Remarkably, nurses and doctors spend between a quarter and half their working day on documentation. Companies like Augmedix and Nuance listen to provider-patient interactions and use automated speech recognition and natural language processing to generate clinical notes, cutting charting time by 40%. **By 2030, automatic documentation technology will chart 70% of patient encounters, alleviating one of the leading causes of provider burnout.**

TELEMEDICINE

Covid drove a 154% increase in e-visits. Use has fallen since 2020, but not to pre-pandemic levels. Telemedicine will grow steadily in the next ten years as it becomes part of a hybrid care-delivery approach. Though touted as a means of reducing burnout, recent data suggests that telemedicine increases physicians' after-hours EHR-work burden. **As documentation AI improves, telemedicine will finally deliver on its anti-burnout promise.** In the next five years, hospitals will adopt natural language processing to generate a structured patient record immediately following each telemedicine encounter.

AUGMENTED REALITY AND VIRTUAL REALITY IN MEDICAL INSTRUCTION

The educational use of augmented reality and virtual reality technologies is accelerating. Studies have demonstrated its effectiveness in improved knowledge gain (anatomy) and technical skill acquisition (surgery and line placement), along with empathy, communication skills and clinical decision-making. In certain cases, AR and VR will supplant real-world experience (e.g., the cadaver lab), but more often will be woven into medical school curricula and resident training. Coupled with more robust artificial intelligence, AR/VR will offer bespoke, dynamic scenarios to meet specific learning goals. Furthermore, researchers are combining 3D AR headset displays with older technologies like ultrasound to improve the accuracy of procedures like needle insertion. This will likely become a core competency for medical students.

Keeping up with the boomers, 2020–2030

"The worst-case scenario is where we are today, but with 20 million more older people."

—Lisa Gables, CEO, American Academy of Physician Associates

DR. SHORTAGE, US 200K

NURSE SHORTAGE, US 1.3M

INCREASE IN HEALTHCARE USERS OVER AGE 65 +17M

DEMAND FOR HEALTHCARE WORKERS IS GROWING; SUPPLY IS SHRINKING

Even with new technology, the supply of caregivers may not be large enough to meet demand. **The 65-plus population—which consumes three times more healthcare than younger groups—is on a steep growth curve, from 56 million in 2020 to 73 million by 2030.** The educational and training pipeline for healthcare workers is too constricted on the front end, and we are losing too many experienced caregivers to burnout in their prime years.

One major reason is a misaligned education pipeline. In the past 20 years medical schools have increased enrollment by more than half, but there's been no commensurate increase in residency positions. Changes in government policies and funding will be critical in turning the tide. **The vast majority (80%) of residency positions are paid for by Medicare, but Congress has added funding for only 1,000 new positions since 1997, and repeated bills to increase funding have failed.** In 2022, there were 39,205 residency positions and 42,549 applicants. If underserved populations begin to use healthcare like higher-income Americans—which we would all like to see—there will be a total deficit of 200,000 doctors in the US in the mid-2030s.

Congress and state governments also have failed to increase funding to train new nurses, while restrictions on immigrants are impacting the supply of foreign-born nurses, who make up about one-sixth of the workforce.

By 2025, the nurse shortage will be as much as 450,000; by 2030 it could be up to 1.3 million. Nurse training programs have for years turned away tens of thousands of qualified applicants due to a lack of faculty and clinical training locations. Physician organizations continue to lobby against the expansion of clinical roles for physician assistants and nurse practitioners in order to preserve higher incomes for doctors.

Nurse practitioners (NPs) are more likely than doctors to practice primary care in underserved areas, particularly rural regions. By 2030, a patient will be twice as likely to see an NP versus a doctor for primary care in a rural setting. In primary care, multiple studies and systematic reviews show that NP and PA patient outcomes are similar or better than care provided by physicians alone; they also lower costs. Already, **26 states and Washington, DC, have passed laws that allow NPs to practice independent of physician supervision. By 2030, more than 40 states will have similar laws, which will help NPs and PAs deliver effective care to more diverse populations, especially those where access to care is a major impediment.**

"Ninety-nine percent of the reason we can't get full practice authority passed in all states is because of the physicians."

—Maryann Alexander, Chief Officer, Nursing Regulation, National Council of State Boards of Nursing

PROVIDER DIVERSITY MATTERS IN PATIENT OUTCOMES

A recent study published in the *American Economic Review* highlighted the potential of creating a more ethnically diverse workforce. The study, conducted in Oakland, California, showed that African American men were more likely to agree to preventive services after meeting with an African American doctor. The study authors concluded that increasing the number of black doctors could reduce gaps in black-white mortality by 19%.

CREATING A DIVERSE HEALTHCARE WORKFORCE

A diverse country needs ethnically and socioeconomically diverse doctors. Teaching hospitals play a critical role in our healthcare system by providing exceptional medical care and helping to catalyze medical innovation. The Association of American Medical Colleges (AAMC), a large network consisting of over 150 medical schools, 400 teaching hospitals and nearly 80 academic societies, has created an educational framework to help medical schools increase diversity in healthcare.

The overwhelming majority of medical schools and teaching hospitals have diversity initiatives, and the class of 2021 was the most ethnically and racially diverse yet. Geographic and socioeconomic diversity remains a challenge. **Only 5% of medical school matriculants are from rural counties and only 5% come from families in the lowest 20% by income.** In the medium term, the focus on ethnic and racial diversity will be matched by geographical and socioeconomic considerations.

As the medical students become more diverse, schools' curricula are being redesigned to embed racial considerations. In 2022, spurred by students, the Jacobs School of Medicine and Biomedical Sciences at the University at Buffalo introduced a new medical curriculum with antiracism at its core. Rather than relegate the issue to stand-alone courses, the Jacobs School integrates antiracism holistically, highlighting the theme across all educational settings.

"Academic medical institutions should be a driver of economic development in underserved communities. Beyond creating career paths for students, they are an engine of economic growth and opportunity by attracting startups, labs and other new businesses. Medical schools can improve the health of citizens and the local economy at the same time."

—Allison Brashear, MD, MBA, Vice President for Health Sciences and Dean of the Jacobs School of Medicine and Biomedical Sciences

THE PATIENT EXPERIENCE TODAY IS FRAUGHT WITH LONG WAITS, OVERCROWDED CLINICS AND HOSPITALS, AND OUTMODED SYSTEMS FOR COMMUNICATION. BUT INNOVATORS ARE BUSY CREATING A NEW FUTURE FOR THE PATIENT EXPERIENCE.

02 PATIENT EXPERIENCE

A BETTER EXPERIENCE IS EMERGING

Patients often confront a healthcare system that can seem baffling, difficult to navigate, user-unfriendly—and at times inaccessible physically and technically. They experience limited face time with their clinicians; overcrowded emergency departments, clinics and hospitals; confusing forms, instructions and bills; labyrinthian hospitals and uncomfortable waiting rooms; and outdated methods of scheduling and communication—conditions that would be cringeworthy in almost any other industry—retail, hospitality, even airlines.

Across the country, hospitals and medical systems are working with hundreds of startups, innovators and patient advocacy groups to develop improved technologies and processes. According to a recent study, **nine out of ten healthcare organizations are actively investing in new technology to improve patient experience.** These include newly designed patient portals and proprietary apps to improve scheduling, reduce wait times, track health data, answer questions and provide clinical information.

The primary point of care will be less in doctor's offices and hospitals, and more in clinics located in pharmacies like Walgreens and CVS, as well as major retailers—starting with Walmart. As service locations proliferate, access to quality care will improve across the socioeconomic spectrum.

Wealthy patients already have options outside the doctor's office, including $40,000-a-year full-service, high-touch services like San Francisco's Private Medical. Thanks to competition and innovation driving down costs, concierge medicine is now affordable beyond the 1%. Sollis Health offers 24-hour access to on-demand imaging services, unlimited doctor's office visits with no wait time, and even emergency medicine at locations that include Manhattan, Beverly Hills, the Hamptons and Palm Beach for $3,500 to $6,500 a year (house calls cost extra)—an amount within reach of families with incomes in the top 10%. One Medical, with a $200 annual membership fee, has many of the logistics-improving features of the concierge services.

Eventually, most medical exams and diagnostics will take place in the comfort of the patient's home, assisted by always-on health monitoring devices and home delivery of diagnostic assays that individuals can perform on themselves.

"Equity and inclusion … represents an essential consideration in patient experience improvement efforts as healthcare leaders strive to provide more accessible, timely and affordable care within their local communities."

—Laura Cooley, Editor-in-Chief, *Journal of Patient Experience*

VALUE-BASED CARE: A MORE HUMAN APPROACH

The healthcare system has long relied on a fee-for-service model where insurers, Medicare, Medicaid and other payers compensate caregivers and providers based on the volume of services—incentivizing providers to do as many procedures as possible. **A movement is growing to shift to value-based care, which focuses on—and rewards—preventive and positive health outcomes.** Moving payments "from volume to value" will be critical in addressing racial and socioeconomic disparities in healthcare and staving off the perennially debated insolvency of the Medicare Trust Fund.

A handful of innovative medical systems are providing a blueprint for the future by embracing value-based medicine that prioritizes patients' long-term health.

- Kaiser Permanente, based in California, is at the forefront of the shift from fee-for-service, and uses detailed patient data to drive evidence-based care—which improves outcomes, like having newborns spend fewer days in neonatal intensive care.
- Geisinger, based in Pennsylvania, has partnered with an AI-driven machine-learning platform to smooth the payment authorization process and allow for more timely, higher-value care.
- In Florida, orthopedic surgeons at Holy Cross Medical Group are teaming up with postoperative discharge coordinators and physical therapy providers to dramatically reduce post-joint-replacement recovery times—and rehospitalization rates. The resulting savings are divided up between the doctors, coordinators and therapists, and patients benefit from a faster return to an active lifestyle.

For lower-income populations that rely on Medicaid, organizations like Oak Street Health emphasize value-based care and community outreach. Oak Street, headquartered in Chicago and serving over 150,000 at-risk patients across 20 states, organizes social events like cooking classes to engage seniors and promote healthy eating. Other caregivers are helping patients with services like teaching how to improve diets, and van transportation to cancer screenings and other early detection appointments. **Over the next decade, community-oriented, patient-centric services will become commonplace and will reach diverse communities as more and more providers prioritize keeping their patients healthy, not hospitalized.**

CASE STUDY: VALUE-BASED TRANSITIONAL CARE

Evolv Health is removing inefficiencies from the traditional transitional care system with automated discharge plans, centralized patient data and personalized patient management that reduces hospital stay time and rehospitalization. Using a platform built on a database of 700,000 patient records, Evolv's system cuts social workers' time by 50% and reduces typical discharge time from three days to three hours.

4 DAYS ↓
PER ADMISSION
Reduced stays at skilled nursing facilities for at-risk clients by automating the discharge service coordination process

49%
DECREASE
30-day post-discharge rehospitalization rate

Using real-time actionable data allows proactive management of deviations and complications within the transitional process

"In the value-based model, sophisticated providers understand that increasing the coordination of services will reduce high costs. The system has traditionally been focused on being a 'care limiter' looking to reduce services to reduce costs. Our system has shown that just by increasing a patient's confidence, it can reduce their rehab stay by one day, which is millions of dollars when aggregated."

—Sean Lane, CEO, Evolv Health

"The two biggest consumer engagement platforms we have access to today are, by far, the mobile phone and messaging—and that includes mobile texting. Ninety-seven percent of text messages are opened in under three minutes. Conversational systems are powerful and they're game-changing."

—Greg Johnson, CEO, Lifelink Systems

PLACES AND PEOPLE CAN RUIN—OR MAKE—A PATIENT'S DAY

Consumers expect a clean, spacious and logically organized building when shopping for groceries or navigating a hotel lobby. Yet today, patients visiting healthcare settings like emergency departments and inpatient wards often encounter cramped, confusing and outdated quarters. Beyond obvious privacy and infection-control implications, inadequate physical spaces are antitherapeutic to those recovering from illness or surgery. **New healthcare facilities are better designed, with private exam rooms, improved lighting, curated artwork and comfortable furniture.**

» At UMass Memorial Medical Center in Worcester, Massachusetts, facilities leaders removed familiar Monet and Van Gogh prints in favor of locally produced art reflecting the diverse cultural experiences of their patient population. The hospital offers self-guided healing art tours for patients and visitors.

» Designers working with the Cleveland Clinic Children's Hospital partnered with Danish artist Per Arnoldi to use art to aid in touch-free wayfinding throughout the hospital.

Well-designed interactions with caregivers are as important as clean, well-lighted spaces. Some medical centers are improving patient encounters by creating new programs with an emphasis on teaching employees to be kinder and gentler with patients—training that has long been a core feature of many service industries.

» At Mass General Hospital in Boston, emergency department staff who participated in a formalized "icare" empathic communication curriculum overwhelmingly reported its usefulness in improving their practice.

» At Cleveland Clinic, the "Communicate with H.E.A.R.T." model has been used to empower staff across the healthcare system to listen to patient complaints and communicate with compassion.

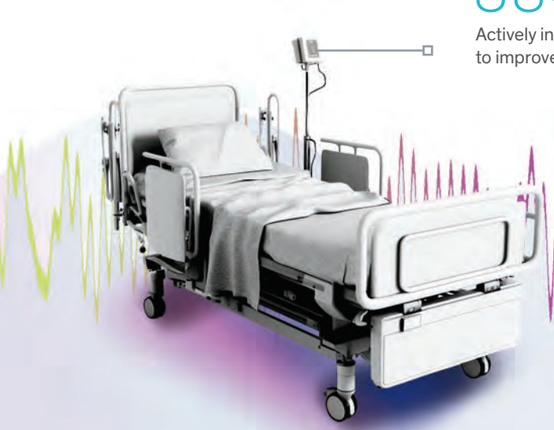
While rare today, patient experience ratings will be increasingly factored into healthcare payments. This will drive leaders to embrace the customer-service side of medicine.

APPS GALORE AND TALKING AI SYSTEMS: MOVING BEYOND SIRI AND ALEXA

With more than 80% of adults—and 95% of those between 18 and 29—using text messaging regularly, patients will no longer call a receptionist or wait on hold. Instead, real-time text communication pioneered in other industries will become the norm, creating new levels of flexibility and efficiency. Widespread use of new biometrics and information security, if embraced by healthcare, will reduce clumsy logins and multistep authentication procedures. **Conversational AI assistants will simplify and improve information gathering and planning of treatment and follow-ups through advanced natural language processing (in multiple languages).**

In emergency departments and clinics inside and outside hospitals, chatbots will integrate with the electronic health records, bed management systems and other sources to tell patients what to expect next—and when. This sort of communication can alleviate anxiety and relieve the stress of being a patient.

88% of HEALTHCARE ORGANIZATIONS
Actively investing in new technology to improve patient experience



"Hospitals will one day be sites of emergency, short-stay observation, operative and intensive care as we transition the site of most healthcare from hospital floors to patients' homes. The future of medicine will be a reversion to the house calls of yore."

—Stephen Dorner, MD, MPH, MSc, Chief Clinical and Innovation Officer for Home-Based Care, Mass General Brigham

THE GREAT MIGRATION FROM HOSPITALS TO HOSPITALS-AT-HOME

By 2025, being "admitted" could mean a trip to your own bedroom, where a mobile EMT team arrives to set up advanced remote heart and lung monitoring gear, video equipment and even a hospital bed. Regular visits—both in-person and virtual—from physicians, advanced practice providers, nurses, physical or occupational therapists and others will allow patients with illnesses ranging from straightforward to complex to be cared for without ever occupying an inpatient hospital room.

At Mass General Brigham, the largest health system in Massachusetts, more than 200 patients who otherwise would have required inpatient admission will soon be cared for in their homes, ultimately leaving the majority of brick-and-mortar hospital care for emergency, operative and intensive care. Given the myriad benefits of home hospitalization for select patients (including decreased rates of readmission, lessened anxiety and lowered costs), this model will grow exponentially in the coming decade, with thousands of hospitals across the US offering home-based acute care programs.

The home may not be the only place for patients to receive high-quality care. Pre-pandemic, international medical tourism was an $80B–$90B industry with $3,500-plus spent per trip. The global market is growing 15%–25% as patients flock to popular destinations in Mexico, Southeast Asia and South Asia. The medical tourism market will continue to become more sophisticated, offering services for cancer care, cardiac surgeries, stem cell treatments and organ replacements.

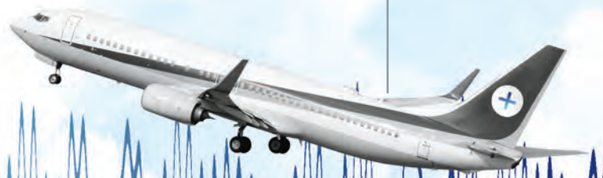
YOUR CHECKUP WILL BE ON AISLE EIGHT

Retail clinics like CVS MinuteClinic (offering low-complexity care at over 1,100 locations) are already well established. In addition, CVS, Walmart, Dollar General and other retail chains will increase investments in these points of care and plan to bring a greater breadth and depth to the services provided. For instance, Walmart Health has announced plans to open 4,000 new primary care "supercenters" to include medical, dental and vision care.

Putting comprehensive healthcare where people already are going will improve access to care, particularly for the most vulnerable among us such as the uninsured or those living in one of the country's many healthcare deserts.

4000↑
Walmart Health primary care medical, dental and vision supercenters opening soon

10x Increase in medical tourism market by 2030



US hospitals offering home-based acute home care programs in 2022 259

INDIVIDUALS WILL TAKE MORE CONTROL OF THEIR OWN HEALTHCARE USING WEARABLES, SMART DEVICES AND APPS THAT MEASURE METRICS LIKE SLEEP, EXERCISE AND HEART RATE. OTHER ALWAYS-ON CONSUMER DEVICES WILL GATHER DOZENS OF OTHER BIOMARKERS. APPS BACKED BY POWERFUL ALGORITHMS WILL HARNESS THIS DATA TO CREATE HOLISTIC PICTURES OF INDIVIDUAL HEALTH. THE NUMBERS OF PEOPLE TAKING SUPPLEMENTS AND DRUGS OUTSIDE TRADITIONAL MEDICINE WILL SKYROCKET; SO WILL MEDICAL TOURISM.

03 SELF-HEALTH RISING

THE CONTINUOUS SMART DEVICE CHECKUP

The consumer market for medical IT devices and apps has exploded in recent years, with over 435,000 health-related apps currently available. That market is estimated to grow from $300 billion today to almost $1 trillion in 2030. Nearly half of all Americans—led by Gen Xers and young people—wear smartwatches with apps that monitor dozens of health metrics including steps, calories burned, blood oxygen levels, heart rate, sleep patterns and menstrual cycles.

Smartwatches made by Apple, Fitbit, Garmin and others now include ECG monitors that the FDA has cleared to detect atrial fibrillation as well as Parkinson's symptoms and respiratory illnesses. As human trials on these devices continue, they will become FDA-approved to monitor an ever-increasing number of conditions. Major retailers like Best Buy are betting heavily on wearables and home medical devices as a significant new area for technology sales. Currently, few of these expensive over-the-counter devices are covered by insurance and are marketed only for higher income populations. **While the cost of consumer technology tends to come down over time, private or government insurance programs will have to change policies for the larger population to benefit from these advances.**

Cameras on cell phones can document and facilitate the diagnosis of skin diseases, including carcinomas. FDA-approved apps treat substance use disorder, ADHD and sleep disorders. Virtual and augmented reality games and apps are already being used as therapeutics to treat neurological disorders, manage pain and monitor physical therapy progress.

Perhaps the most significant change will be the next generation of wearables that will constantly monitor blood pressure, stress hormones, blood sugar levels and other metabolic health markers. Combined with population-level data sets, these biomarkers will help predict the onset of heart disease and type 2 diabetes, two conditions most responsive to diet and lifestyle changes. Early awareness and intervention could save millions of lives and significantly decrease healthcare costs.

SELF DIAGNOSIS AND AT-HOME MEDICAL RESEARCH

Early 2023 saw an explosion of new AI apps such as ChatGPT, growing within a few months to over 100 million active users. Trained on massive amounts of data from the internet, ChatGPT will answer most any question, including medical queries. Unfortunately, ChatGPT often provides factually inaccurate information—it has no mechanism to distinguish good information from bad. This new "generative" technology is still in development but will certainly be another way that people learn about their health challenges.

SMART HOMES KEEP A DIGITAL EYE ON YOU

A new generation of off-the-shelf consumer products to use at home are emerging to monitor health metrics once available only in a clinic—vital signs, food intake and calories, changes in cognition, and mental health status. Weight scales in your home can now measure BMI, body fat, subcutaneous fat, body water, skeletal muscle and muscle mass, and are wirelessly linked to apps that collect and analyze health trends. Environmental sensors measure indoor air quality. Increasingly, **these "always-on" networked devices will share and interact with each other—and eventually with wearables and other personal data—creating a remarkably holistic understanding of an individual's health.**

"The home is the next frontier in terms of where you can best ensure value-based care, and we are at an inflection point."
—Andrew Agwunobi, MD, President of Humana's Home Solutions

Here are a few examples of what's arriving to equip the smart home of the future:

- **Diagnostic toilets** will automatically test for signs of health and diseases in urine and stool, including blood, nutrition and gut microbiome.
- Alexa-like interfaces will listen to your **voice** for signs of stress or depression or the onset of disorders like Parkinson's and other neurological conditions.
- Through 30-second selfies taken on tablets and smartphones, we will check **vital signs** and run hundreds of **diagnostics**, including markers for hypertension, stroke, heart disease and diabetes.
- Touch screens on tablets and smartphones will also monitor changes in **finger dexterity** as a sign of depression or other mental disorders, and the onset of dementia.
- GPS tracking will trace **geographic exposures to diseases**—STIs, monkeypox, Covid, flu, measles, etc.
- Handheld kitchen **spectrometers** will analyze your food for toxins, allergens and nutritional components.
- At-home devices will analyze your **breath** for biomarkers of diseases, including bacterial infections, cancer, Alzheimer's and Parkinson's.
- Smartwatches and other wearables will monitor you as you **sleep**, ready to alert family and medical personnel of any signs of atrial fibrillation or stroke.
- Diagnostics will arrive by Uber-style **delivery** or by drone.

THE RISE OF PHENOMICS: BEYOND KNOWING YOUR DNA

phe·nom·ics | fə'nämiks | noun the study of how the environment and a person's lifestyle interact with the expression of their genes to influence their health and risk of disease.

Consumers and patients have gotten used to ordering profiles of their DNA to look for certain health indicators. A limited number of FDA-cleared tests that provide risk factors for acquiring a serious disease are also available, including the APOE4 gene variant that increases a person's risk of Alzheimer's disease, and BRCA2, which significantly increases the risk of breast cancer. Providing these tests to consumers, however, is controversial, with most physicians preferring that trained medical caregivers deliver news for diseases that either have no cure (Alzheimer's) or may entail a radical medical intervention (breast cancer).

And it turns out that genomically identified markers for most common diseases have proven to be less important in many cases than lifestyle and other factors. This is leading to a more expansive range of tests—phenomics—that can measure everything from a person's gut microbiome to profiles of their epigenome, proteins and metabolites.

A wave of phenomics-oriented start-ups will combine advanced AI, using ever more sophisticated models to predict and prevent disease. Most phenomic tests now are either in early human-testing stages or need to be ordered by a physician. In the future, consumers will be able to perform these tests with home devices with no or minimal input from traditional medicine. (See the *Wellness and Nutrition* section for more on this subject.) While this might benefit some patients who get alerted early to a serious condition, there is a downside as well. Health facilities could be overwhelmed by symptom-free individuals seeking unnecessary or even dangerous treatments for diseases predicted through these new technologies.

WHAT COULD POSSIBLY GO WRONG?

The plethora of health apps and devices are mostly coming from tech startup founders who know less than medical professionals and researchers about the human body's complexities. The IT industry also frequently runs afoul of the strict regulations that govern medical and health devices and treatments. This disconnect has led to devices that aren't always accurate or well-grounded in medicine and human biology, a gap between IT and biomedicine that is lessening as engineers and biologists work better to connect their worlds.

Personal data and financial safety are also at risk. Unscrupulous marketers of health apps will have the means and profit motive to target those with health vulnerabilities. **We'll need to develop safeguards and establish ethics rules and laws to better protect people from potential abuses of their digital health data by hackers, advertisers, companies and governments.**

"We found that app development processes significantly lack the involvement of relevant healthcare professionals or agencies. ... Their absence from the process can lead to poor quality of content."

—Saba Akbar et al., Center for Health Informatics, Macquarie University

RESISTANCE IS FUTILE: INTEGRATING SELF-HEALTH AND TRADITIONAL MEDICINE

Traditional medicine has been slow to integrate new over-the-counter self-health tools, in part because so many of these devices haven't been tested and verified for accuracy or approved by the FDA.

To date, most health data from wearables and at-home devices is being collected and analyzed by organizations outside traditional medical systems. This started in genomics with companies like 23andMe and Toolbox Genomics collecting DNA data through home kits and informing consumers of certain disease risks. The Seattle-based company Arivale offered hundreds of phenomic tests to customers, combining everything from Fitbit data to DNA profiles to measurements of metabolites, proteins and other molecular data, all independent of a doctor or clinic. The company eventually closed down because of the high costs of some testing. As costs go down, look for more companies to make meaning from the home-created health data. For instance, **testing one's complete genome—all of the ACGTs inside you—recently dropped to a cost of about $200 from millions of dollars** just 15 years ago.

Integrating self-health data from wearables and home devices also represents a culture shift for everyone: most patients now go to doctors and clinics for testing by approved labs in controlled settings. As more devices and app-based algorithms are rigorously tested and cleared, healthcare's incumbent powers will be pressured to integrate self-health data with clinical tests and electronic health records (EHRs).

In the coming years, the combination of clinical and self-health testing will profoundly change healthcare by predicting diseases far in advance of symptoms. This will lead to personalized and early targeted interventions to prevent or mitigate disease onset. Currently, over-the-counter devices, like smart watches, that gather health data are marketed mostly for consumers with higher disposable incomes. Delivering effective care for all will also require collecting a generation's worth of data from socioeconomically and racially diverse populations.

THE TIKTOK-ING OF MEDICAL ADVICE

In recent years there has been an explosion of medical advice on social media and the internet. **YouTube hosts 600,000 videos about prostate cancer alone. The information ranges from serious medical research to quack cures.** Currently, there are few restrictions on social media platforms as to who can masquerade as a medical expert and what type of advice they can offer. Social media sites like TikTok, Facebook and YouTube not only host medical quackery, their recommendation algorithms are encouraging users to consume more and more of it.

The self-appointed medical gurus who populate social media sites have encouraged a new wave of mostly young people to experiment on themselves with new devices and unproven remedies. Sales of drugs and supplements—including controlled substances—are booming on the internet. Facebook and Instagram have become the cyber equivalent of open-air markets for prescription and illegal or unregulated drugs.

Despite some dangers, the self-health trend is largely positive. **More people will start taking their own health in hand by improving their diets, exercising more, and increasing their understanding through self-collected data.** The ever-lowering cost of consumer health IT technology will make self-monitoring devices increasingly accessible for those with lower incomes. (For more on healthy living, see the *Wellness and Nutrition* section.)

41%

Users who have shared wearable-device health data with their doctor

HEALTH STARTUPS TO WATCH

At the massive 2023 Consumer Electronics Show, hundreds of start-ups demonstrated advances that will give every home the diagnostic tools of today's doctors' offices. (See the *Wellness and Nutrition* section for more on this subject.)

- **U-Scan – At-Home Urinalysis** Scans users' urine for biomarkers such as hydration and vitamin levels.
- **Evie – Medical Grade Health-Monitoring Ring** Ring designed to give women a full picture of their health.
- **NuraLogix's Anura – Potentially Life-Saving Selfie** App can check vital signs from a cell phone selfie.
- **Epicore Biosystems – Connected Hydration Monitor** Electronic sweat patch continuously measures sweat fluid and electrolyte levels while monitoring skin temperature and movement.
- **Whispp – Amplifying Hidden Voices** Mobile app converts whispered speech, vocal cord–impaired speech and severe stutters into a natural-sounding voice in real time.
- **Opteev Technologies' ViraWarn – Portable Virus Detector** This breath analyzer is intended to detect Covid-19, influenza and RSV in less than 60 seconds; under FDA review.

"We currently drive cars that have dashboards that monitor the health of the vehicle but we have no real equivalent for humans. We should be continuously collecting data on people while they are healthy so we can see when things are going off the rails."

—Michael Snyder, PhD, Director, Center for Genomics and Personalized Medicine at Stanford University

LONGEVITY RESEARCH INTO THE MECHANISMS OF AGING WILL COMBINE GENOMICS AND OTHER ''OMICS'' WITH POWERFUL TOOLS LIKE STEM CELL THERAPIES, GENE EDITING, BIONICS AND AI. GAINS IN LIFESPAN WILL INITIALLY BE INCREMENTAL—MEASURED IN MONTHS AND YEARS, THEN POSSIBLY DECADES—ROILING SOCIETY BUT ULTIMATELY IMPROVING QUALITY OF LIFE FOR ALL.

04

LIVE LONG & PROSPER

A SHIFT IN MINDSET: AGING IS A HOLISTIC CAUSE OF DISEASE

The new science of antiaging is rapidly changing the perception that diseases like Alzheimer's, heart disease, diabetes and arthritis are distinct and separate. It's becoming clear that they share many underlying biological processes associated with the human organism growing old. Scientists have narrowed these down, broadly, into nine "hallmarks of aging," such as stem cell exhaustion, inflammation and cellular senescence.

Modern longevity science began in 1993 when structural biologist Cynthia Kenyon of the University of California, San Francisco, discovered that modifying a single gene in a tiny worm called *Caenorhabditis elegans* could double its lifespan. Her findings suggested that aging might be regulated by genes in some organisms, an insight that inspired a broad scientific inquiry around antiaging. Researchers have since been able to extend the lifespan of worms tenfold and of mice by a third. In some cases they have reversed aging in animals as measured by biomarkers. So far, scientists have not gotten the same results in humans, although currently **at least 10 drugs targeting aging pathways are in clinical trials.**

TRENDING: LONGER LIVES

Since 1900, when average life expectancy in America was 47 years, Americans have gained about 2.65 years on average every decade. The United Nations has predicted that by the end of the 21st century the average lifespan will max out in the upper 90s. But new interventions to slow aging are poised to bend the curve upward again.

AMERICAN ASTERISK: US LIFESPANS ARE REVERSING THANKS TO COVID, DRUG ABUSE AND OBESITY

Life expectancy in America fell to 76.1 years in 2021, down from 79 years in 2019. Driven by Covid, opioid overdoses and obesity, 2022 saw the second consecutive annual fall. These reversals brought to a halt a century-plus of extraordinary gains. **The long-term trend is likely to resume, given the resources pouring into longevity innovation.** Other factors: a massive public health effort to fight Covid (despite political challenges) and long-overdue government-level actions against Purdue Pharma and other corporations that fueled the surge of premature deaths caused by the opioid epidemic.

"Within a decade, 70 will be the new 50."
—James Peyer, CEO and cofounder, Cambrian Biopharma

"This emergence of antiaging science is a new public health paradigm and its impact will be on the order of magnitude of the introduction of basic public health in the early part of the 20th century, or antibiotics and vaccines in the middle of the 20th century."

—Jay Olshansky, University of Illinois School of Public Health

"HEALTHSPAN" IS THE NEW LIFESPAN—HOW DO WE GET THERE?

Leaps in lifespan have historically raced ahead of science's ability to maintain healthspan. By the age of 65, 80% of Americans typically suffer from one chronic "disease of aging." By 70, most are dealing with two such conditions, making aging beyond a certain point something to endure, not to look forward to.

Gains in lifespan in the near future will be incremental and measured in months or a small number of years. For instance, **if cancer were cured tomorrow, the average lifespan would rise by just 2.5 years.** Scientists are developing a menu of incremental treatments and approaches for a variety of diseases and conditions that together will expand this equation and alter what it means to age. Getting older is likely to get better.

A new generation of companies is emerging that hope to translate decades of lab work into **decades of additional healthspan**. Approaches vary wildly and include:

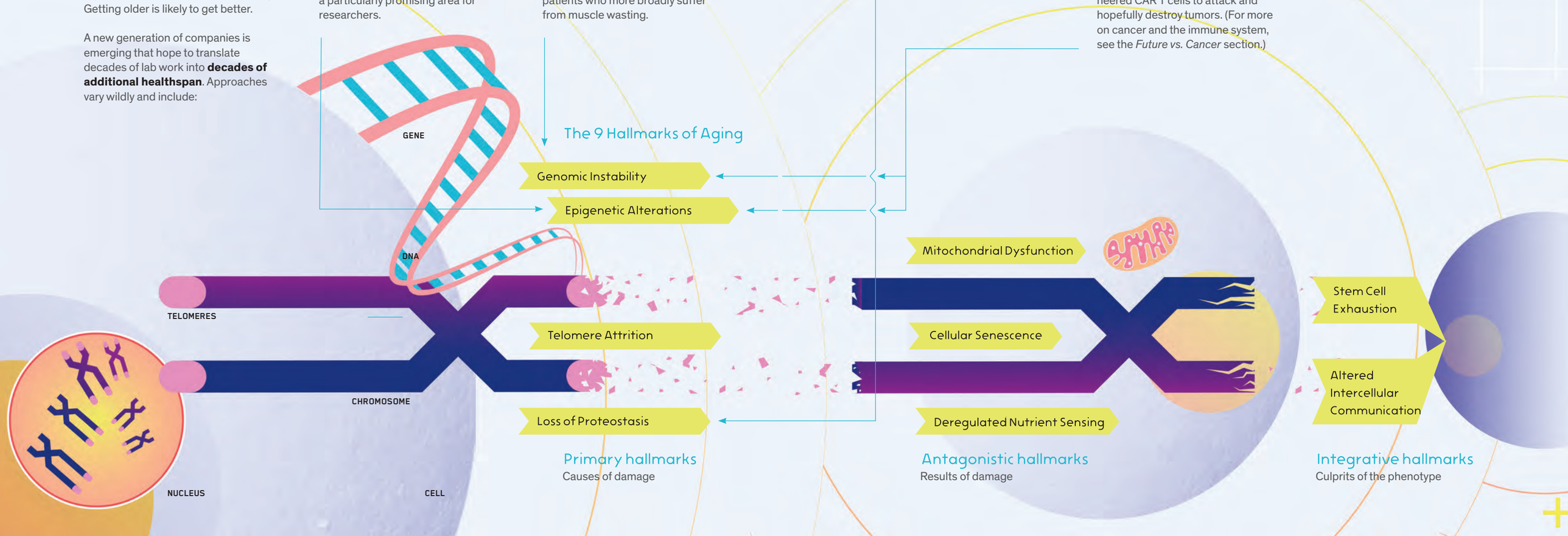
» **Age Reversal Therapies** The emerging field of **epigenetics focuses on how changes in lifestyle, nutrition and environment affect how one's genes work. By tweaking the mechanisms of epigenetics that turn genes on and off, scientists have succeeded in reprogramming mouse cells to make them act genetically younger.** Animal researchers are discovering that an extra bit of a vitamin, physical exercise, a brief exposure to a toxin, and even an added dose of maternal nurturing can send signals through our epigenome and have lifelong impacts on the body and brain. The epigenetic connection to brain health in the elderly is proving a particularly promising area for researchers.

» **Synthetic Biology** Therapeutics that use bioengineered cells to correct genetic mutations and to repair damaged tissue are in the early stages of being tested in human clinical trials, often on patients with rare diseases that strike younger people. Vita Therapeutics, for example, is close to launching clinical trials of a treatment for Limb-Girdle Muscular Dystrophy, which typically affects children. **The company's technology creates stem cells derived from a patient's own cells that its scientists then gene-edit using CRISPR to correct a mutation that causes the disease.** The goal is to prove efficacy in children, and then to seek a much broader use for older patients who more broadly suffer from muscle wasting.

» **Phenomics** This new field aims to collect, monitor and analyze with AI a host of biomarkers—including DNA, proteins and other molecular markers—that can be used to better predict and prevent disease. One use of this data: polygenic embryo testing, used to predict the chance of disease. These tests, available in fertility clinics today, analyze embryonic chromosomes and assign them a score based on the likelihood that they will develop diseases like cancer and diabetes. (For more on phenomics, see the *Self-Health Rising*, *Future vs. Cancer* and *Wellness and Nutrition* sections.)

» **The Immune System** Scientists are working to better understand the role of the immune system in virtually all diseases, including efforts by the newly launched Human Immunome Project based in New York City that is setting out to research a project on the scale of the Human Genome Project. **Better vaccines using new technologies like mRNA will expand over the next few years along with other interventions that bump up the immune system to fend off diseases.** Exciting approaches are emerging to activate the immune system to kill cancer cells. New therapeutics use monoclonal antibodies to disable viruses and bacteria, and bioengineered CAR T cells to attack and hopefully destroy tumors. (For more on cancer and the immune system, see the *Future vs. Cancer* section.)

» **Machine Solutions** Yet another tack to extending lifespan is building better-engineered spare parts, including human-engineered prosthetics, 3D-printed organs, better hip, knee and other replacements, and lifesaving devices like pacemakers. (For more on machine solutions, see the *Make Me Bionic* section.)



"Half of the children born today will be centenarians."
—Eric Verdin, Chief Executive, Buck Institute for Research on Aging

LONGEVITY IN A PILL

A pill that dramatically increases lifespan does not yet exist. But scientists are working with compounds like NAD+, thought to promote longevity. More drugs will be coming that will slow down cell death and activate telomere maintenance and other antiaging mechanisms.

These drugs include metformin, a generic diabetes treatment that has been on the market for more than 60 years. **Analysis of more than 70,000 diabetics taking metformin saw a 17% reduction in mortality compared to the general population.** Researchers believe metformin will have similar or better results in nondiabetics, but so far advocates have not been able to raise the funds for a clinical trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is prescribed to prevent organ rejection and has been shown in animal studies to extend life.

THE "EXPOSOME" AND EXERCISE AS LONGEVITY MEDICINE

Right now the most accurate predictor of lifespan—by correlation, not causality—is the ZIP code a person inhabits. In California's Marin County, average life expectancy is 85. In one ZIP code of Fort Worth, Texas, life expectancy is just 66. Location reveals the impact on longevity of the **exposome**—the exposures one encounters from diet and lifestyle to environmental and occupational risks. Higher-income areas tend to have longer life expectancy, directly related to better access to healthcare and healthy foods, and overall better living conditions. (For more on longevity and location, see the *Politics and Healthcare* section.)

Socioeconomics also has a huge impact on the exposome, with residents of low-income areas exposed to poor diets, unsafe levels of chemicals and high rates of crime. Solutions include offering federal funds, especially in underserved communities, to open greengrocers in food deserts and building sidewalks and other pedestrianized zones to promote walking. Quality nutrition and regular exercise remain the best antiaging medicines.

According to the USDA, an area is considered a food desert if at least 500 people or 33% of the population live more than one mile (in urban areas) or 10 miles (in rural areas) from the nearest supermarket or large grocery store. Income levels also factor in: places with a poverty rate of 20% or greater, or a median family income at or below 80% of the statewide or metropolitan area figure, are considered food deserts.

FROM COUNTING STEPS TO MEASURING YOUR BIOLOGICAL AGE

Apps and programs assessing a person's "biological age" will improve, combining genetics and phenomics with measurements of sleep, exercise and diet. A new crop of longevity therapies will lead to an era when counting one's steps will turn into counting one's biological years. **Bryan Johnson, a 45-year-old software mogul turned neurohacker and life extension guinea pig, has created Rejuvenation Olympics, a website that displays a leaderboard of the top 20 age-reduction scores from among thousands who have submitted their epigenetic analyses to the competition.** A wave of new consumer brands will follow suit in the coming decade, turning longevity into a trend where people compete with each other to turn back their biological clocks with lifestyle changes and drug interventions.

EXPOSOME, AVERAGE LIFE EXPECTANCY

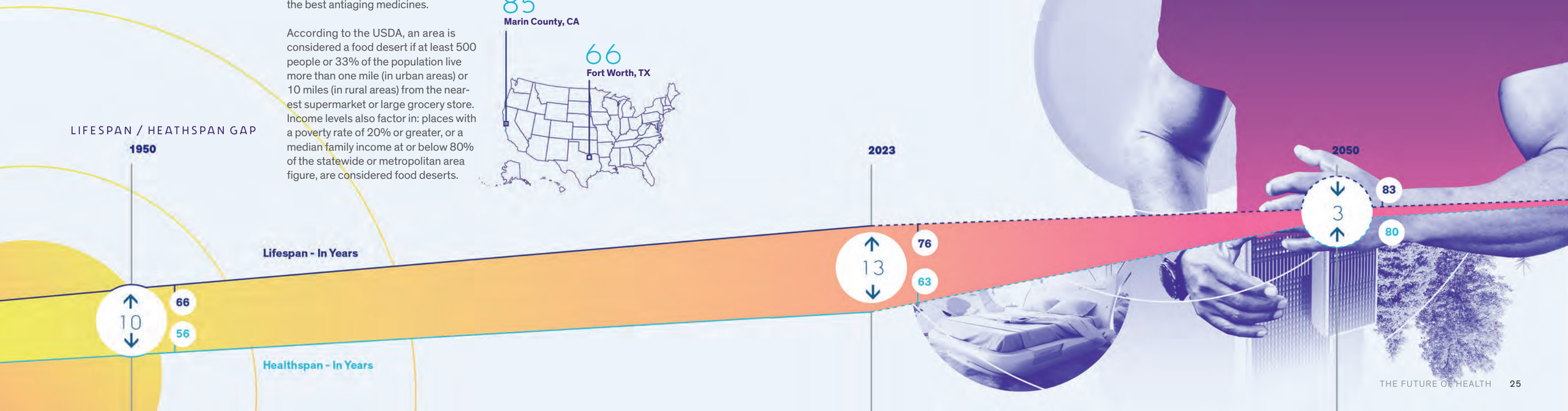
COMPETING VISIONS FOR THE FUTURE OF LONGEVITY

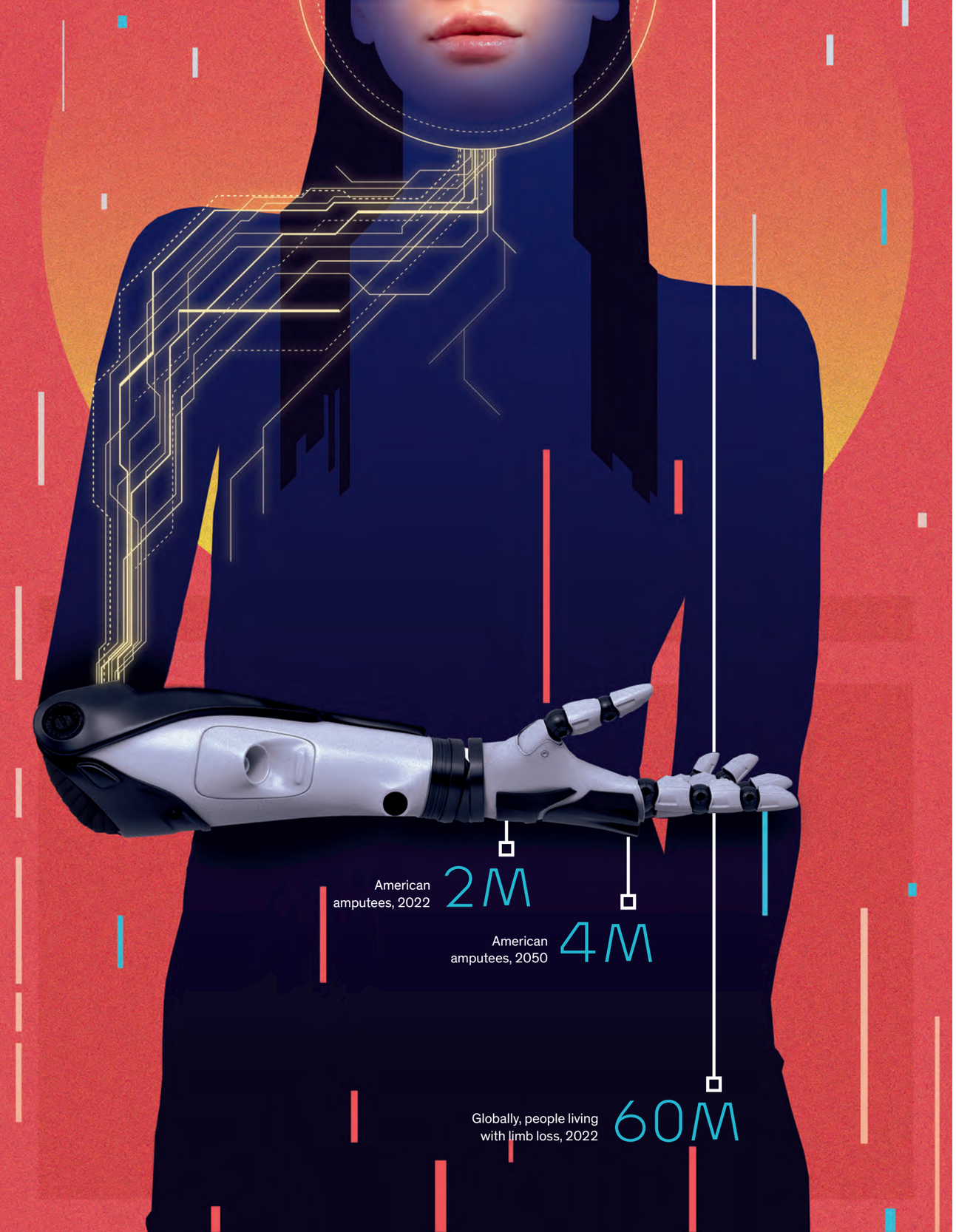
A MALTHUSIAN CASE

Increased longevity, unevenly distributed, will lead to societal conflict. It goes like this: As a wealthy few live longer, more productive lives, Western centenarians suck more resources away from poorer, sicker nations. Younger generations revolt against their vibrant elders who stay in work longer, depriving the youth of opportunities, ushering in an era of violent upheaval.

A MORE LIKELY SCENARIO

Investment in antiaging research—including regenerative therapies, gene editing and advanced bionics—pays off as the world wakes up to the idea that aging is not something we must simply accept, but a condition that can be treated like any other. If these advances are shared equitably, increased healthspan will unleash an economic boom powered by the "longevity dividend," as people work and contribute to the global economy for more years and spend less time in the hospital. "Late-life universities" will spring up to retrain healthy 60- and 70-year-olds who want to change careers. A recent study in *Nature* estimates that **one extra year of healthy life for everyone on Earth would contribute $37 trillion to the global economy.**





NEW BIOELECTRONIC TECHNOLOGIES AND BIO-ENGINEERED STEM CELLS WILL GIVE US REPLACEMENT LIMBS AS GOOD AS THE ORIGINALS (OR BETTER) AND WILL REPAIR, REGULATE AND UPGRADE MAJOR ORGANS—INCLUDING THE BRAIN.

05 MAKE ME BIONIC

Until recently, people who lose their limbs or are born without them have been forced to use prosthetics little advanced from the stereotypical wooden peg leg of yore. Today, 60 million people around the world and nearly 2 million in the US live with limb loss. That number in the US is expected to double by 2050, mostly due to the type 2 diabetes epidemic, as well as vascular disease, trauma and cancer. **The good news: prosthetics are getting better, smarter and cheaper thanks to ever-increasing AI brainpower and the democratization of 3D manufacturing.**

Today, implanted neuroprosthetic devices help restore functionality across a wide range of neurological and behavioral issues, from seizures and Parkinson's to loss of hearing and sight—and, recently, targeting OCD and obesity. The list of deep brain stimulation (DBS)–treatable conditions will grow exponentially. Within a decade, new neuroprosthetic techniques and interfaces will make it unnecessary to perform surgery to implant these life-saving devices.

BUILDING A BETTER ARTIFICIAL LIMB

A new generation of "smart" prosthetic limbs, designed using 3D modeling tools and made with 3D printers, is on the horizon. These include bionic legs that create an effortless gait by anticipating the movements of wearers by continuously monitoring trajectory in relation to the body and the ground. Some plug directly into human nerve tissue for high-fidelity access to electrical signals and muscle movements, while others use sensors in the prosthetic socket to foster neurological connections.

TrueLimb, a durable, 3D-printed prosthetic arm with more than 30 sensors guiding its bionic functionality, is tailored to a user's exact size, shape and even skin tone. Myoelectric sensors in BrainRobotics' prosthetic hands connect to muscles and nerves in residual limbs, **converting electrical signals from the brain into precise finger movements or programmed actions.** Laurent Frossard, a bionic limb scientist at Australia's Griffith University, and David Lloyd, a Boston University mechanical engineer, are combining biomechanics and computational modeling to create wearable and noninvasive diagnostic devices that rely on **designing a precise "digital twin" of each user's own unique residuum (residual limb).** This allows for virtual design and easier refitting and replacements as improved prostheses become available.

"If a salamander can regenerate its limbs, why can't a human? The fact is that humans do regenerate. We're regenerating all the time. The question therefore is how can you induce further regeneration?"
—Anthony Atala, MD, Director of the Wake Forest Institute for Regenerative Medicine

BIONIC BRAINS

Nearly a century ago, one of the world's first pacemakers revived a stillborn baby in Sydney, Australia. Today, about 40,000 people worldwide have had DBS devices surgically implanted in their brains to control tremors from Parkinson's disease and other conditions. Surgeons have implanted hundreds more responsive neurostimulation (RNS) devices in patients with drug-resistant epileptic seizures. Both devices work like heart pacemakers to monitor and sense tremors or seizures as they begin and then activate to stop or mitigate them. **More than 100,000 people in the US have restored or improved hearing thanks to cochlear nerve implants.**

Other brain prosthetics are on the way:

- Surgically implanted devices that **access the optic nerve to restore basic levels of sight** in the same way cochlear implants have restored hearing.
- Implants in the motor cortex allow paralyzed patients to **operate prosthetic limbs, use computer interfaces and control machines using only their thoughts.**
- The Defense Advanced Research Projects Agency (DARPA) has developed a **brain-computer interface system that will enable a military pilot with an implant to operate multiple aircraft simultaneously via thought.** In the next 15 years pilots may be able to control drones and fighter jets with noninvasive or superficially embedded devices that connect with genetically modified brain cells via infrared light signals; no surgery required—DARPA plans to modify the brain cells using nasally inhaled nanomolecular gene therapeutics.
- Neurointerventional electrophysiology is another emerging approach to accessing brain activity without major surgery. Vascular neurosurgeons at the University at Buffalo in partnership with the Jacobs Institute can now insert stent-mounted electrode arrays made by neurotech startup Synchron through blood vessels rather than opening the cranium. **The surgeons guide the devices into specific locations, allowing signals from the brain to operate mobile devices and computers.**

BIOENGINEERING—A (RE)GROWING TREND

The NIH has estimated that over 100 million Americans could benefit from regenerative therapies that use bioengineered cells to repair damaged tissue after a heart attack, cancer surgery or a car crash. Programmed stem cells have regenerated muscle in mice. The first human trials are underway in China, the UK and the US to test **stem-cell generated heart patches.** Dr. Anthony Atala at Wake Forest has successfully implanted lab-grown organs like esophagi and bladders into human patients.

A team at Tufts University led by biologist Michael Levin and funded by Microsoft cofounder Paul Allen's Frontiers Group is **using guided application of electrical fields to help regrow body parts.** Levin's group recently used instructions formulated in what the group calls "the morphogenic code" to turn frog stem cells into self-organizing teams of programmable "Xenobots" that can develop specialized cell structures to move around and record information about their own movements—a major step toward regrowing human limbs and organs.

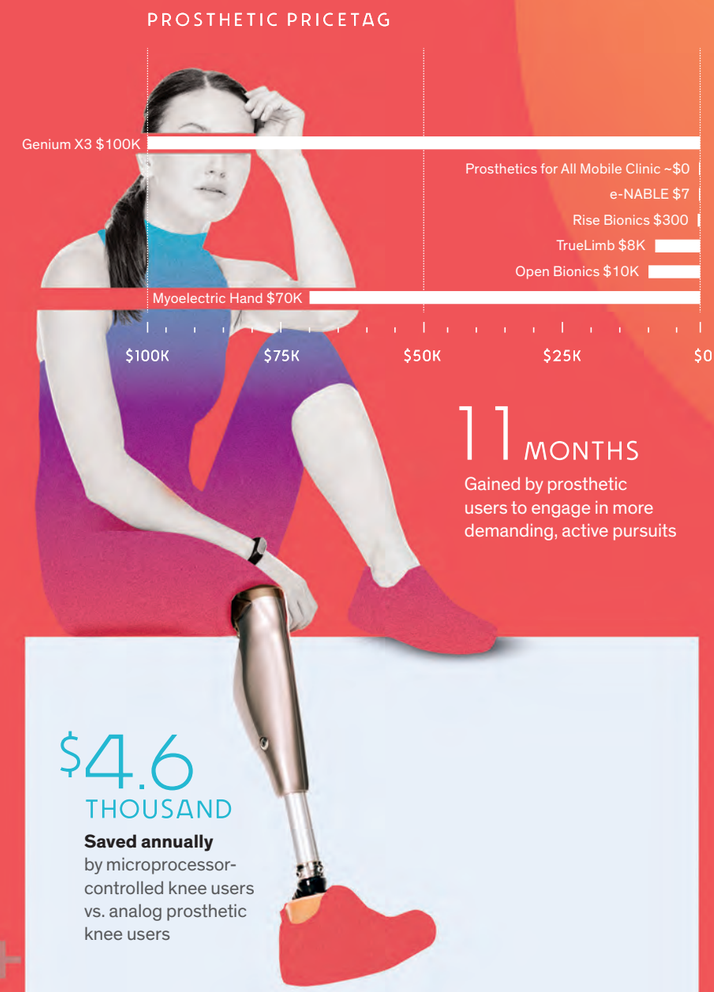
A LEG UP FOR HUMANITY

The most advanced prosthetic limbs can cost upwards of $70,000. BrainRobotics' myoelectric hand, along with next-gen artificial legs being developed at MIT Media Lab and the Bionic Leg from the University of Utah's Bionic Engineering Lab, will all become commercially available within the next five to ten years, but are likely to be very expensive.

A recent analysis by the RAND Corporation shows why investing in prosthetic technology is worth it. RAND compared health outcomes for people with above-the-knee limb loss using microprocessor-controlled prosthetic knees to outcomes for those using analog prosthetic knees. While wearers of microprocessor-enhanced knees spent roughly $15,000 a year in prosthetic-related costs—$1,700 more than analog knee users—they saved $4,600 annually in direct and indirect healthcare costs (thanks to fewer injuries and lower caregiving costs) compared to analog-knee wearers—a $2,900 gain. Perhaps most importantly, **while wearers of microprocessor-equipped prosthetic knees in the study lived about one month longer than their analog counterparts, RAND determined that they gained almost 11 months of "quality-of-life-adjusted" time per person over the 10-year study.** That's 11 extra months to engage in productive, rewarding activities—aka healthspan—a boon both to those with limb loss and to society.

40K People, globally, with deep brain stimulation implants for tremor control

100M Americans who could benefit from regenerative, bioengineered-cell therapies



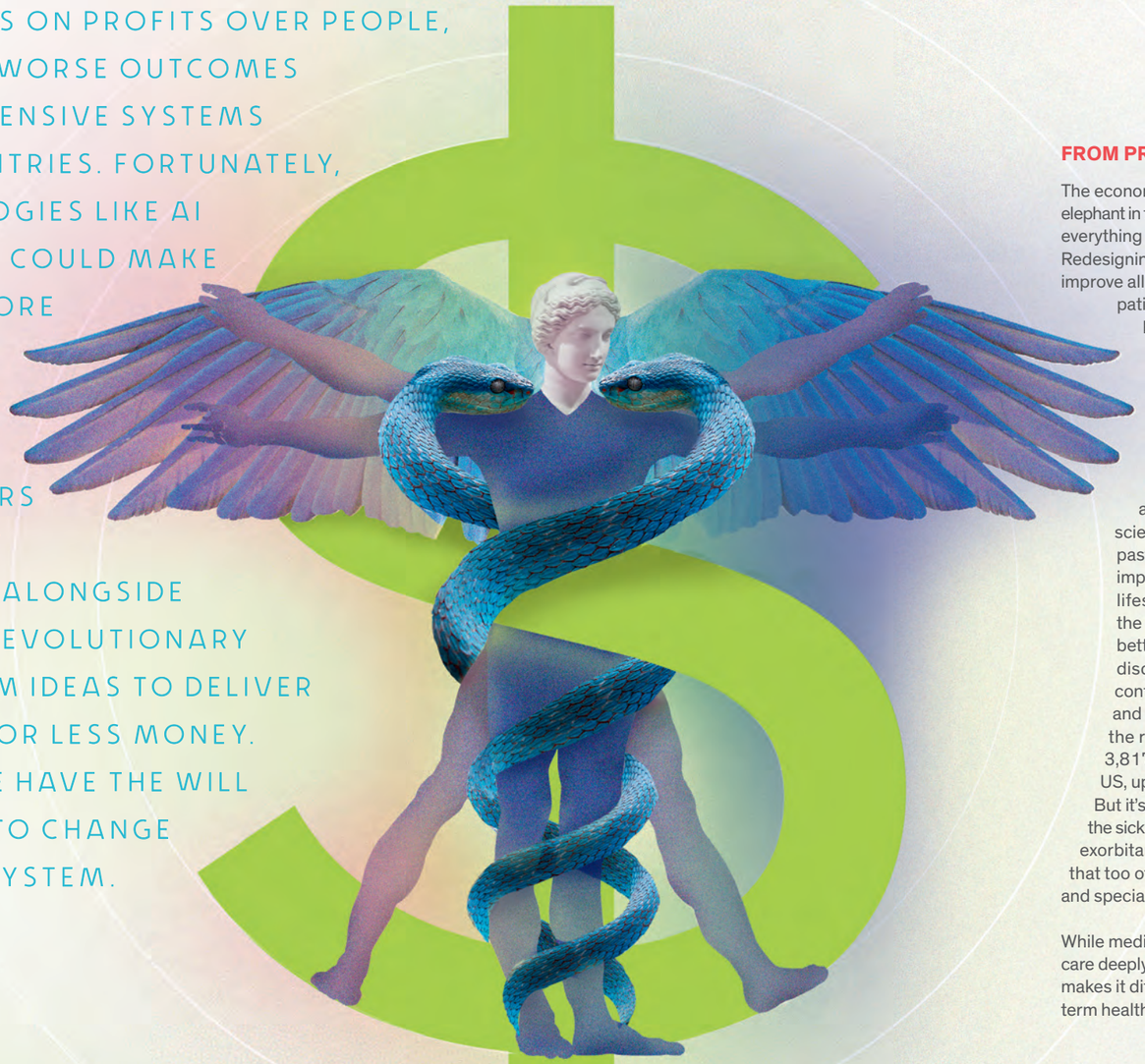
"Cartilage doesn't have a blood supply, so it's hard to regenerate. With what we call biologics, we're trying to grow things before you need them. We will likely be able to regrow a knee in the next 15 years. We can do so in a petri dish, so if we can build the right scaffold to transplant it with robotic assistance, we can make it happen."
—Dr. Martin Roche, orthopedic knee surgeon, Holy Cross Orthopedic Institute

While most high-end bionic limbs are still priced like high-end automobiles, 3D printing is changing the prosthetics market rapidly. Open Bionics's customizable 3D-printed Hero Arms (including a *Black Panther: Wakanda Forever* model) start around $10,000 and are covered by Medicare. Unlimited Tomorrow's 3D-printed TrueLimb, mentioned at left, costs less than $8,000 with capabilities that only a few years ago would have carried a price tag above $50,000.

The future looks even brighter for affordability and access to prosthetic technology. Bioengineer Hugh Herr—a double amputee and cohead of MIT's Yang Center for Bionics—and his former student David Moinina Sengeh, Sierra Leone's chief technology officer, lead Prosthetics for All—a mobile clinic providing affordable or even free 3D-printed prosthetics to Sierra Leoneans who have lost limbs. In India, Rise Bionics makes $300 legs whose wearers have outperformed competitors using $100,000 prosthetics in paralympic competition. The e-NABLE network—comprising thousands of volunteers in more than 100 countries—collaborates to produce free or low-cost 3D-printed prosthetics for anyone in need.

While millions of us have opted to replace worn-out knees and hips with artificial joints, Herr predicts that as limbs age and become compromised, people will move beyond joints to replace entire flesh-and-blood limbs with durable prosthetic versions connected to our brains by seamless, AI-augmented neural interfaces.

THE US HEALTHCARE SYSTEM COSTS TOO MUCH, FOCUSES ON PROFITS OVER PEOPLE, AND DELIVERS WORSE OUTCOMES THAN LESS EXPENSIVE SYSTEMS IN OTHER COUNTRIES. FORTUNATELY, NEW TECHNOLOGIES LIKE AI AND ROBOTICS COULD MAKE THE SYSTEM MORE EFFICIENT AND USER-FRIENDLY FOR PATIENTS AND CAREGIVERS OVER THE NEXT 10–20 YEARS—ALONGSIDE POTENTIALLY REVOLUTIONARY POLICY REFORM IDEAS TO DELIVER BETTER CARE FOR LESS MONEY. BUT ONLY IF WE HAVE THE WILL AS A SOCIETY TO CHANGE THE CURRENT SYSTEM.



06 REIMAGINING HEALTHCARE ECONOMICS AS A HUMAN-CENTERED SYSTEM

"I cannot say whether things will get better if we change; what I can say is they must change if they are to get better."

—Georg C. Lichtenberg, 18th-century German physicist

FROM PROFIT TO PEOPLE

The economics of healthcare is the elephant in the exam room. Money impacts everything in our medical system. Redesigning economic incentives can improve all aspects of healthcare, from patient experience to physician burnout. Will we see a future where the dazzling new ideas and technologies that we describe are deployed to optimally serve Americans?

Our current system is a paradox. On the one hand, science and technology in the past 100-plus years have vastly improved human health. Average lifespans have doubled, and the quality of life is dramatically better for millions of people. New discoveries and technologies continue to dazzle, and complex and costly interventions are on the rise. In 2022, there were 3,817 heart transplants in the US, up tenfold from a decade ago. But it's a system designed to treat the sick, and one rife with waste, exorbitant costs and soaring profits that too often benefit shareholders and special interests over people.

While medical providers and caregivers care deeply for their patients, the system makes it difficult to prioritize the long-term health of individuals. Our current fee-for-service system focuses on treating, not preventing, illness. Chronic conditions that require lifelong medications and expensive procedures are the profit centers for clinicians and hospitals.

In 2023, Medicaid will serve more than 100 million low-income people—fully one in three insured Americans. Unfortunately, recipients of the program often struggle to find primary care doctors and face long delays for surgery or specialty care. The result is that ERs are overused and fewer patients receive preventive screenings or consistent help managing chronic conditions. Medicare benefits in 2021 totaled $829 billion, rising from $541 billion in 2011.

At almost $5 trillion a year, healthcare costs in the US are unsustainable. That's $13,000 per person, an amount more than the annual income of people living in over 100 nations. The US ranks number one in per capita expenditures on healthcare, followed by Germany at $7,383 per person. Other wealthy countries spend around $6,000 per person a year—less than half the US expenditure. All totaled, healthcare costs account for nearly one-fifth of the country's gross domestic product.

A VAST MISMATCH OF OUTCOMES AND PROFITS

Despite the cost of our healthcare system, the US ranks 54th in infant mortality—behind Uruguay, Cuba and Russia and 34th in life expectancy. The US is still home to some of the best outcomes when it comes to highly technical procedures such as organ transplants and individualized cancer care. But for many other diseases we rank near the bottom of the 38 OECD (Organization of Economic Co-operation and Development) countries, which include many of the world's wealthiest nations. The US also ranks among the highest for obesity and diabetes. Fully six in ten Americans have one or more chronic conditions including high blood pressure, diabetes and mental illness. Four in ten are dealing with more than one disease.

At the same time, in 2020 the 35 largest pharmaceutical companies had double the net profit margin (nearly 14%) of non-pharma companies listed on the S&P 500 Index. For-profit hospitals have made nearly 11% in net profits since 2019, even during the pandemic. Employee-sponsored health insurance has soared 47% for the average family since 2011, with deductibles consuming almost 12% of their income. Recent polls have found that 46% of insured adults struggle to afford out-of-pocket costs and 29% don't take prescribed medicine because it costs too much. Medical costs are the number one cause of personal bankruptcies in the country.

$13 THOUSAND
Annual healthcare **cost per person**, US

14%
Pharmaceutical company **net profit margin**

$5 TRILLION
US **annual** healthcare spending

21%

National healthcare expenses **paid by Medicare, 2021**

26%

of all hospital care

26%

of all physician & clinical services

32%

of all retail prescription drug sales

MEDICAID

In 2023, Medicaid will serve more than 100 million people—fully one in three insured Americans. Unfortunately, recipients of the program often struggle to find primary care doctors and face long delays for surgery or specialty care. The result is that ERs are overused and fewer patients receive preventive screenings or consistent help managing chronic conditions.

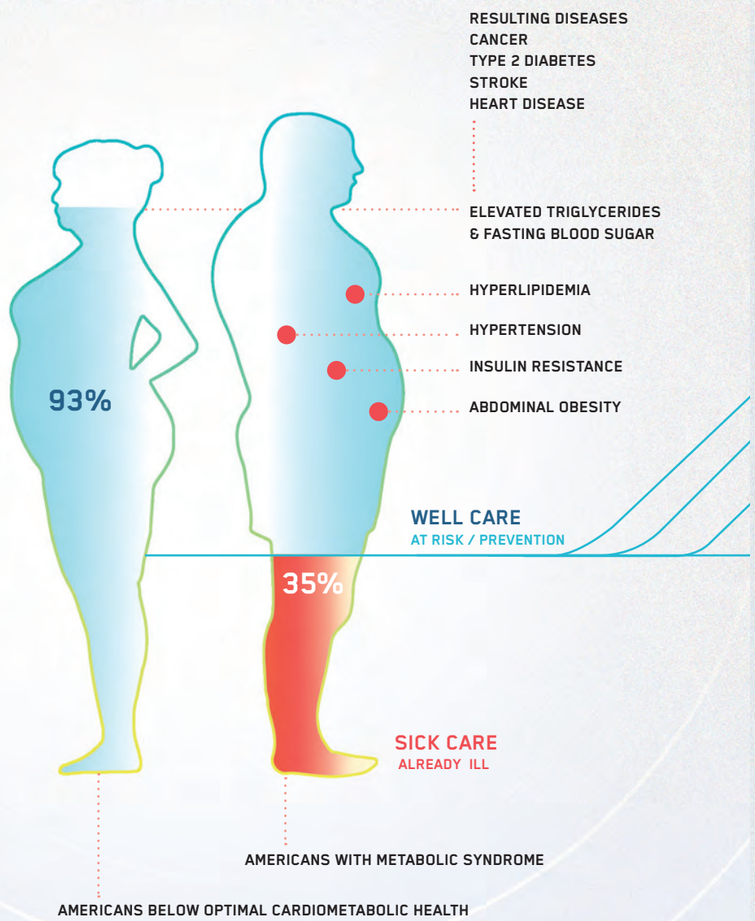
Medicare Advantage, created in 1997, is intended to incentivize doctors and health systems to keep patients healthy. Companies like Amazon, CVS and Walmart are experimenting with similar models in hopes of lowering costs and improving health outcomes.

6 IN 10

Americans have a chronic health condition

THE PATHWAY FROM FEE-BASED TO VALUE-BASED HEALTHCARE

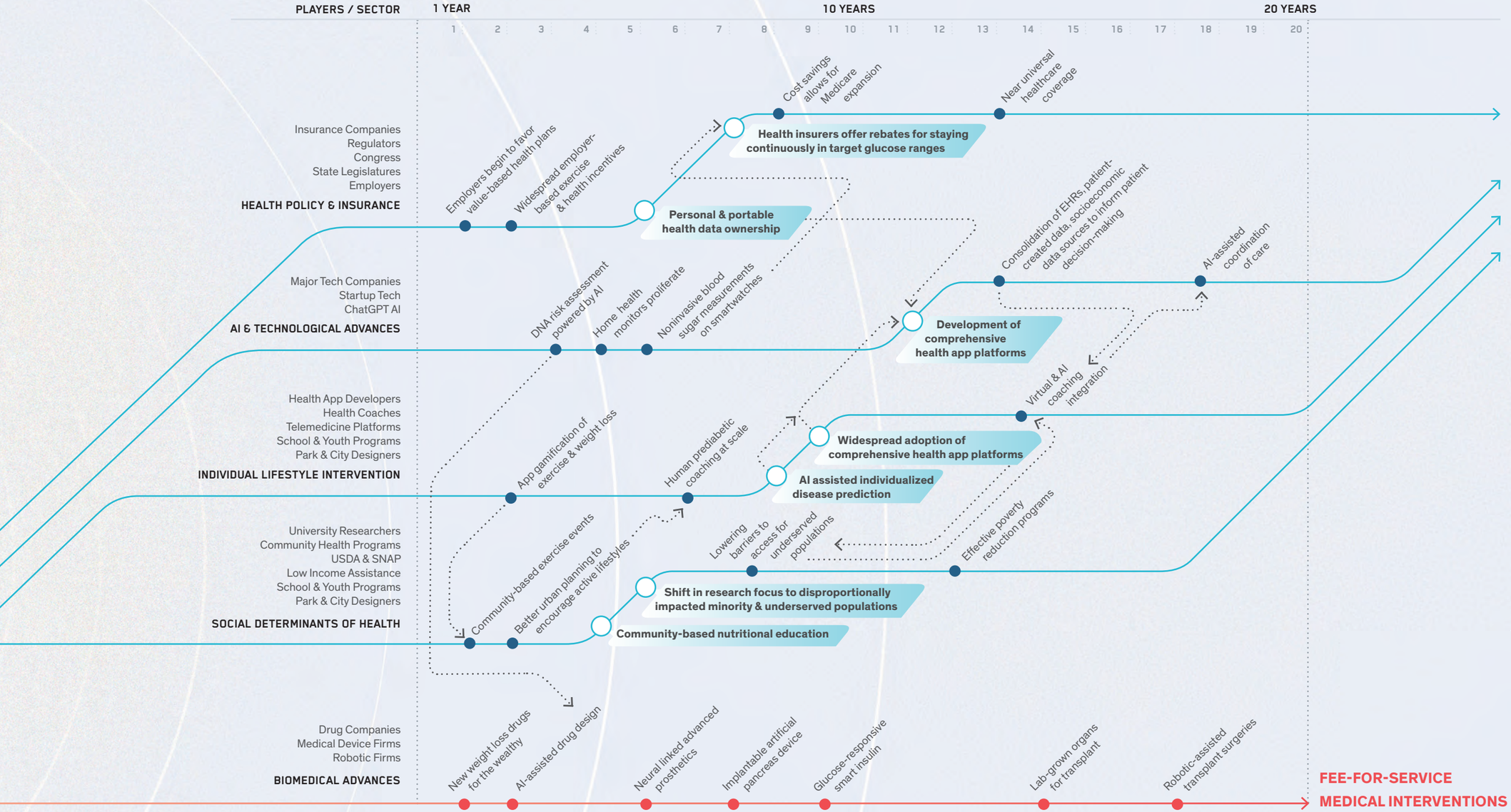
EXAMPLE: METABOLIC SYNDROME & TYPE 2 DIABETES



WE KNOW WHAT'S WRONG AND HOW TO FIX IT BY 2040

The overriding philosophy for optimizing healthcare for 2040 will be to shift to a system that prioritizes patients and preventive care to keep people healthier longer—while streamlining management and reducing waste. According to a study in the *Journal of the American Medical Association*, waste in the US healthcare system equals about 25% of the total spent—or around $1.2 trillion. If this waste were eliminated starting next year, the US would save over $20 trillion by 2040.

NOW	OPTIMAL FIX FOR 2040
AN UNHEALTHY DEPENDENCY ON THE FEE-FOR-SERVICE MODEL This is Public Enemy No. 1—a system that incentivizes providers and caregivers to order as many tests and procedures as possible, and to charge often exorbitant rates for every Band-Aid, cholesterol test and surgery. Medicare and regulators have tried to tamp down costs and have made some reforms, but often they are thwarted by the lobbying of special interests. Private insurers often deny procedures and care, but frequently end up paying whatever providers charge and passing on the costs to policyholders and government.	Change the current fee-for-service system to a value-based system that bundles costs into single charges for procedures and services and financially rewards payers, caregivers and providers for delivering quality care and optimal outcomes based on keeping people well.
PHARMA HAS A LICENSE TO PRINT MONEY The incentives in the pharmaceutical industry are perhaps the most perverse. No doubt, the R&D for new drugs is expensive, which is why drug companies are allowed to hold exclusive long-term patents and generally charge whatever they want. Companies are incentivized to charge prices far in excess of costs, and to focus on meds that patients will take for years (for chronic conditions like diabetes or hypertension) rather than drugs like antibiotics and vaccines that are taken once or episodically.	Create price ceilings for drugs and limit drug company profits, keeping them in line with non-pharma industry norms.
PRIVATE VS. PUBLIC Those who defend the current system often claim that there is a stark choice between highly efficient private healthcare that is market-driven and bloated, and inefficient single-payer healthcare systems paid for with taxes and delivered by the government. This is a false choice. **With government-enforced virtual monopolies for drug companies, there is no true free market. Evidence also suggests that Medicare and the US Department of Veterans Affairs offer more patient-centric care than the private sector.**	Ideally, the system would be more efficient and less bloated if all Americans had basic healthcare paid for by the Centers for Medicare and Medicaid Services. People would still be free to supplement this with private insurance, as they do in Germany and most other Western European insurance systems.
US Healthcare Delivery Is Highly Decentralized—Change Will Not Come Easily Currently there are more than 400 health systems with 6,000 hospitals and nearly 35,000 ambulatory care centers, all regulated by a mishmash of federal, state and local policies. Over 900 health insurance companies operate in the US, employing 560,000 people to manage 224 million covered Americans—a 1-to-400 ratio. Medicare and Medicaid employ roughly 6,000 workers to manage 64 million Americans—a 1-to-10,000 ratio. Changing this system to emphasize health and preventive care will be a herculean task.	With a more centralized system styled after Medicare and Medicaid, all Americans would be insured by 2040 and much of the $260 billion in administrative waste (according to *JAMA*) would likely be reduced or eliminated.
DECENTRALIZED AND UNDERUTILIZED HEALTH DATA In an era where our data is being collected and used all the time by advertisers and companies trying to sell us things, **it's astonishing that the healthcare system can't collect and centralize health data that can follow us to wherever we need it to be.** Electronic Medical Records are too often used to track payments to providers rather than to improve people's health. Personal data collected on wearables and in tests, exams and checkups often isn't used to track patients' health or to inform treatments or for preventive care.	As the technology for analyzing health data becomes more effective, doctors will be able to better predict future diseases. This will incentivize healthcare systems to compete based on the level of preventive care they provide. With these vast troves of data, we'll also have a better understanding of which community-level interventions are most effective. A comprehensive system focused on keeping people well would save Americans trillions of dollars and bring costs more in line with other industrialized countries.
GEOGRAPHY AND INEQUALITY OF ACCESS Right now, hospitals often charge radically different prices for the same procedure or service even in the same city and from state to state. For instance, the same MRI scan can cost between $400 and $12,000 depending on a person's provider or payer or the state they live in. Medicare and Medicaid have tried to standardize pricing, but the efforts have largely failed. The Affordable Care Act, launched in 2009, proved change was possible. In 2022 uninsured rates reached an all-time low of 8% from 15% pre-Obamacare. This impressive change still left 26 million Americans without health insurance. Minorities, the economically disadvantaged and those with chronic health conditions have the greatest challenge in getting affordable health insurance and in accessing care.	Moves to standardize pricing for health services and procedures would remove a great deal of confusion and help alleviate the tens of billions of waste from overcharging each year. Making the 2009 Affordable Care Act (Obamacare) universal would ensure that all Americans are insured by 2040.



"The total cost of metabolic syndrome, including the cost of healthcare and loss of potential economic activity, is in the trillions. The present trend is not sustainable unless a magic cure is found (unlikely) or concerted global, governmental and societal efforts are made to change the lifestyle that is promoting it."

—Mohammad G. Saklayen, Professor of Medicine and Director of Nephrology Division at Wright State University

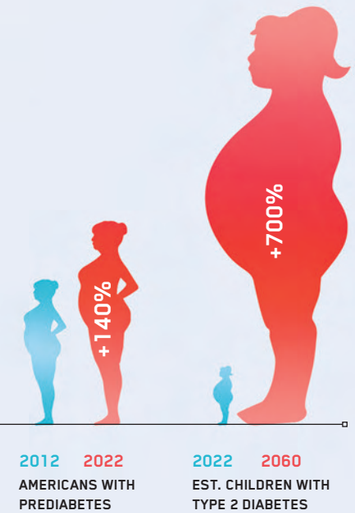
Metabolic Syndrome

In the US, we spend trillions of dollars treating the conditions resulting from metabolic syndrome. While it is important to have interventions for those already ill, there is much more we can do. Obesity and metabolic syndrome and all the attendant complications are not inevitable. However, prevention will require a fundamental rethinking of our shared approach to healthcare. We will need a renewed focus on the social and economic determinants of health. Prevention will also require changes in our food system, and the layout of our cities, along with a deeper understanding of the health impact of poverty and inequality.

Metabolic syndrome is characterized by abdominal obesity, insulin resistance, hypertension and hyperlipidemia. The syndrome causes or contributes to numerous devastating diseases, including cancer, type 2 diabetes, strokes and heart disease, among others. Although Western countries are the most affected, metabolic syndrome has become a global condition, particularly in urban centers in emerging economies. The rise of this noncommunicable disease has become the major health challenge of modernity.

Diabetes and Prediabetes

- More than 130 million US adults have diabetes or prediabetes.
- Rates of type 2 diabetes among children are expected to rise 700% by 2060.
- The number of Americans with prediabetes has risen 40% in the last decade.
- 26 million elderly (half the population) have prediabetes.
- Without changing our approach, 1 in 3 Americans could have diabetes by 2050.



07 CLIMATE CHANGE x HEALTH

5M Estimated deaths from climate-induced malnutrition, malaria, diarrhea and heat stress, 2030 to 2050

83M Estimated excess deaths caused by climate change by 2100

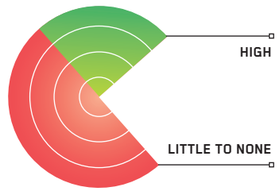
$800B Annual healthcare cost from air pollution and climate change

CLIMATE CHANGE POSES AN EXISTENTIAL CHALLENGE TO THE HEALTH OF THE PLANET AND ITS HUMAN POPULATION. THE HEALTHCARE INDUSTRY WILL HAVE TO MANAGE THE MEDICAL CONSEQUENCES WHILE DRAMATICALLY DECARBONIZING TO HEAD OFF A HOT AND DANGEROUS FUTURE.

There is no sugarcoating this. As temperatures soar and weather patterns shift as a result of burning fossil fuels, the human body will be bombarded by challenges caused by severe heat, pollution, pathogen spread and wildfires. The World Health Organization estimates that climate change will kill 5 million people between 2030 and 2050 from malnutrition, malaria, diarrhea and heat stress. By 2100, climate change will have caused 83 million excess deaths.

We have the knowledge and technology to limit the rise in temperature, but so far we have failed. At our current rate of warming, Earth's average temperature will exceed the 1.5° C threshold established in the 2015 Paris Agreement by 37% in 2030 and 103% in 2040.

This stark reality poses an urgent call to action for the healthcare sector to elevate its climate leadership over the next 10–20 years. **This means not only training medical residents on climate-related diseases, but also drastically reducing the carbon footprint of the medical field.**



RECOGNITION OF CLIMATE CHANGE HEALTH IMPACTS BY GLOBAL HEALTHCARE PROFESSIONALS

RICH AND POOR: WHO'S REALLY PAYING THE HEATING BILL?

A report by the Medical Society Consortium on Climate and Health concludes that the health costs of air pollution and climate change already exceed $800 billion per year, a price tag that is expected to rise. With 12% of the world's population already spending at least 10% of their household budgets on healthcare, the additional pressures of climate change will push more people into poverty each year.

Climate change will worsen existing disparities in healthcare resources and accessibility, and exacerbate psychological stress, racism and other forms of discrimination. Those who are most vulnerable—children, seniors, residents of developing countries, and people living below the poverty line—will suffer the most. These groups:

- bear the greatest burdens of air pollution and have the least access to healthcare
- are more likely to live in areas vulnerable to climate change
- have higher levels of existing health risks to begin with
- live in communities with limited access to healthcare services
- have a limited ability to relocate or rebuild after a disaster.

IGNORANCE AND EDUCATION: WHAT WE NEED TO TEACH IN MEDICAL SCHOOL

The healthcare sector is largely unaware of and unprepared to respond to climate-related impacts on patients and communities. A *New England Journal of Medicine* survey of healthcare professionals both in the US and the rest of the world showed that **less than a quarter of clinicians and clinical leaders had high recognition of the health impacts of climate change. Nearly 50% of global health executives had little or no recognition of these impacts.**

Medical and business schools are beginning to include the effects of climate change in their curricula.

- A 2020 paper published in *Academic Medicine*—and written by physicians across leading medical schools—proposed the first framework for educating residents about the implications of climate change for delivering healthcare.
- Harvard has launched Climate MD, a program that focuses on the healthcare effects of climate change.
- Emory School of Medicine has made climate change a formal part of its curriculum.

From the doctor's office to the boardroom to the chambers of Congress, healthcare leaders and policymakers will need to understand the impending impacts of climate change on our health and society. Look for a new subspecialty in climate change medicine, more healthcare companies advocating for strong climate policies and climate change discussions in investor calls.

"Climate change is one of the greatest threats to health America has ever faced–a true public health emergency."
—The American Medical Association and the American Academy of Nursing

CLIMATE CRUSH COMING FOR HOSPITALS AND CAREGIVERS

Hospitals and healthcare providers face a looming onslaught of illnesses and emergencies related to climate change. As temperatures rise, tropical pathogens previously unseen in temperate zones will present caregivers with unprecedented challenges. Asthma and other pollution-related diseases will increase, especially in children and marginalized groups, requiring more pediatric, primary care and mental health services. To understand their risks and mitigation opportunities, hospitals will have to conduct climate change assessments.

CLEANING UP THE HEALTHCARE SECTOR

"Climate change is bringing health equity issues to the forefront. For example, in the context of wildfires, the release of toxic carcinogens from smoke poses a significant health threat. People who lack proper filters in their air conditioning are at higher risk of inhaling these harmful pollutants which are going straight into their homes."
—Diana S. Aga, PhD, Director, RENEW Institute; Henry M. Woodburn Professor, Department of Chemistry, University at Buffalo

The healthcare sector itself is a major contributor to global warming, accounting for 5%–9% of total greenhouse gas (GHG) emissions in the US (4% globally). To remedy their climate impact, hospitals and research institutions will have to become transparent regarding their GHG emissions, switch operations and suppliers to renewable energy sources, and cut down on plastics and other toxic waste.

We are starting to see progress. Over 100 major US hospital and healthcare companies have committed to reducing GHG emissions 50% by 2030 and to net zero by 2050, under the Biden Administration's Health Sector Climate Pledge.

Nonprofit advocacy organization Health Care Without Harm has released a climate action playbook for hospitals—a guide for how to operationalize climate solutions by leaning in to clean energy and developing sustainable operations and procurement strategies.

As an example, 100% of Boston's Massachusetts General Hospital's electricity is derived from renewable sources. MGH has established a Center for the Environment and Health to integrate environmental sustainability into the clinical, research and educational activities of the hospital.

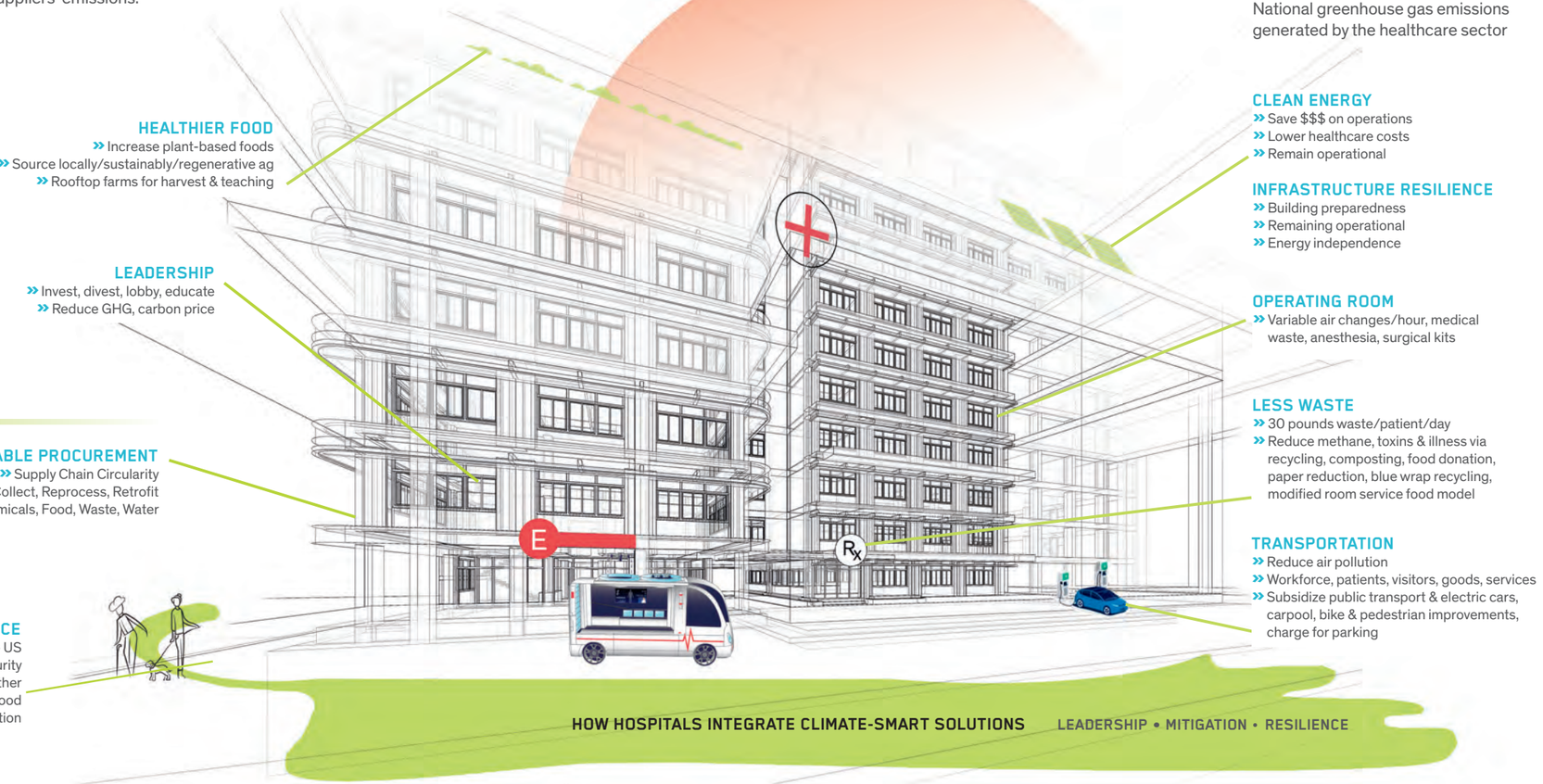
CommonSpirit Health, the second largest nonprofit hospital chain in the US, with over 700 care sites and 142 hospitals across 21 states, has committed to reaching net-zero greenhouse gas emissions by 2040. The organization recently released a detailed *Climate Action Plan*, which includes reducing emissions across buildings and operations, engaging with supply chain partners, advocating for stronger climate policies and building climate-resilient communities, among other strategies.

Expect to see more and more examples of hospitals and care facilities installing on-site solar plants, purchasing renewable energy and expanding their energy efficiency initiatives. But this is not enough—**the majority of the sector's emissions, nearly 80%, are being generated from the medical supply chain, outside a hospital's direct control. Efforts that don't take into account sustainable procurement strategies—including medical devices, food sourcing, pharmaceuticals, packaging—will fall flat.**

To incentivize those suppliers to take action, healthcare companies need to flex their collective purchasing power. In Britain, the National Health System requires its suppliers to report on their GHG emissions, and has set a net-zero carbon goal by 2045 for Scope 3 emissions, which includes their suppliers' suppliers' emissions.

Reducing resource consumption will present a pivotal task for the healthcare industry, and also bring a significant monetary return. Medical equipment maker Philips has committed to taking trade-ins on used professional medical equipment and refurbishing or locally recycling it. The UK's NHS has undergone a thorough analysis to better understand the types of waste generated and opportunities created. An NHS task force identified a way to divert 85,000 metric tons of plastic from the hospital system, cutting down CO2 emissions by 235,000 metric tons a year. Through recovery programs, the research team identified a potential to unlock nearly $50 million annually of new sources of revenue, from reintroducing valuable recycled materials back into the supply chain and avoiding costly waste disposal processes. The healthcare industry can make a significant difference by pursuing aggressive climate strategies to decarbonize day-to-day operations and supply chains.

"There may be an upfront investment with which to make your hospital resilient to climate change. But that investment is going to pay dividends when looking at the potential harms from an intensified weather event because of climate change."
—Dr. Renee N. Salas, Affiliated Faculty, Harvard Global Health Institute; Yerby Fellow, Center for Climate, Health and the Global Environment at Harvard T.H. Chan School of Public Health



HOW HOSPITALS INTEGRATE CLIMATE-SMART SOLUTIONS LEADERSHIP • MITIGATION • RESILIENCE

"Climate change significantly contributes to health inequities, affecting public health across our country, and we all have a stake in addressing it. We have pledged to work together to decarbonize healthcare and protect human health from climate change."
—David J. Skorton, MD, President and CEO of the Association of American Medical Colleges (AAMC)

"Collaboration is key. There is an opportunity for healthcare leaders to step up on climate and partner with peers across the value chain to enable systems-level change. Tackling the climate crisis is not something that any organization can easily do alone, yet the urgency calls on us all to take action."
—Mary Ann Ormond, Senior Director, Ceres Company Network

DIVISIVE POLITICS IN THE UNITED STATES WILL INCREASINGLY DISRUPT PATIENT OUTCOMES AND HEALTHCARE DELIVERY IN VARIOUS REGIONS OF THE COUNTRY, WITH POLITICS SUPERSEDING SCIENCE FOR MANY AMERICANS IN A FRACTIOUS ''RED VS. BLUE'' DIVIDE. BUT GEN Z'S GROWING VOTING POWER MAY FINALLY SET HEALTHCARE FREE.

08 POLITICS & HEALTHCARE

WHEN YOUR HEALTH BECOMES POLITICIZED

Healthcare will remain on the front lines of the culture wars for the foreseeable future. Issues including abortion, Covid-19 mitigation and transgender care have clearly shown a red state–blue state divide. Doctors in one state can now face jail time for practices that are the standard of care in the state next door.

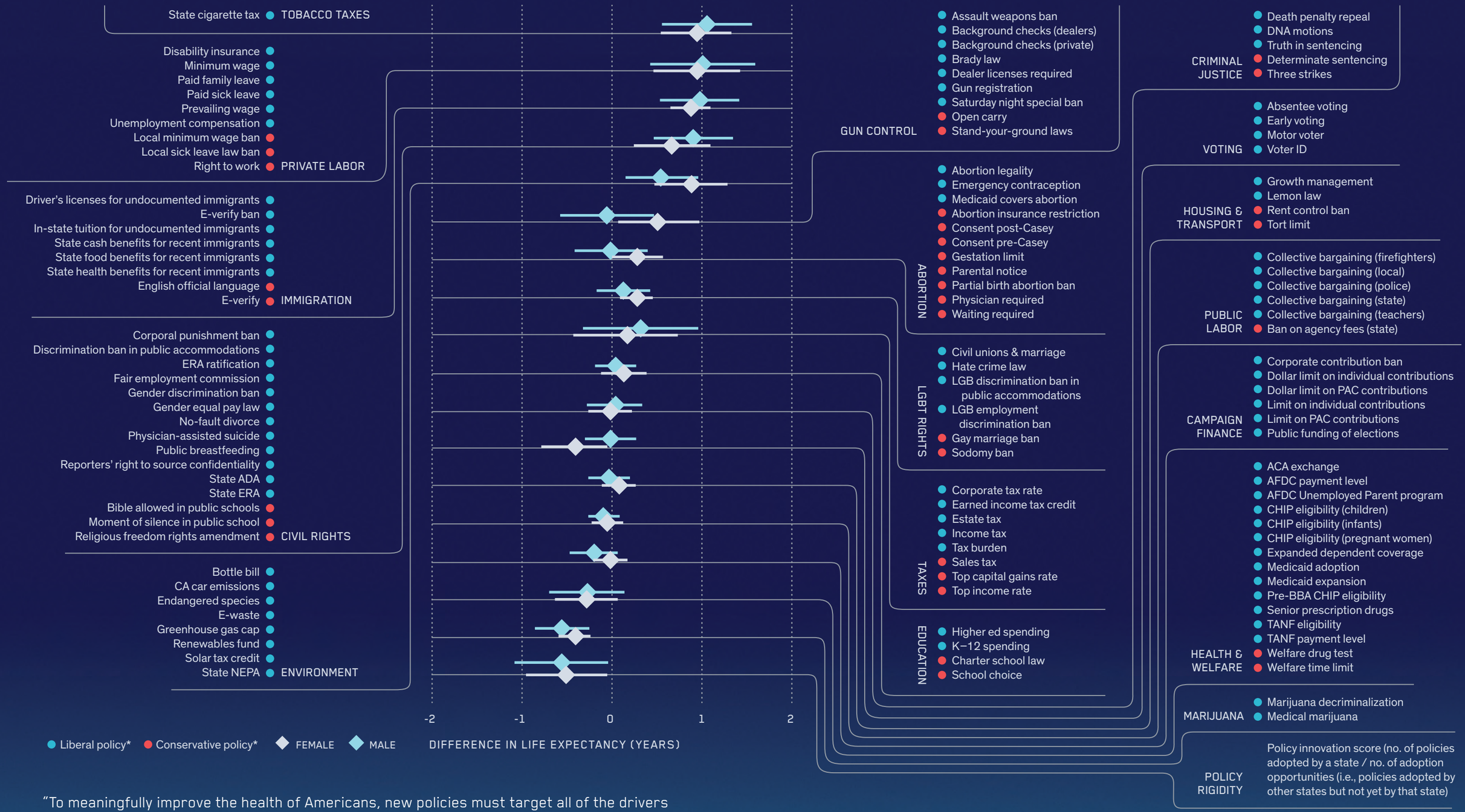
For millions of Americans, these fissures have engendered distrust of physicians, medical researchers and once-trusted institutions like the Centers for Disease Control and Prevention. While this trend is most noticeable on the far right, some groups—both liberal and libertarian—have also become increasingly skeptical of government health policies. In both red and blue states, political extremism degrades the quality of healthcare and medical research.

Congress has exacerbated the divide by shifting health policy decisions to state legislatures and distributing funding for Medicare and other programs to states through unrestricted block grants. Further complicating matters, health insurance is regulated separately in all 50 states, with insurance commissioners or commissions determining where the money goes. Commissioners are appointed in 39 states and elected in 11, so healthcare decisions tilt with the political orientation in each state. This fragmentation could be resolved if the federal government set a national policy and provided every citizen the same healthcare services currently enjoyed by members of Congress.

We can expect distrust and partisanship among millions of Americans to continue in the near future, although the 2022 midterm election offered some tentative evidence that the majority of voters are tiring of politicians with the most extreme anti-science positions. The biggest change in the electorate was Gen Z, which turned out in larger-than-expected numbers and overwhelmingly backed progressive candidates, thwarting a widely anticipated "red wave." But left-wing ideologues should take no comfort: **Gen Z regards both major political parties as misguided. They'll cross party lines to back policies and politicians they think will be most effective in addressing their major concerns: reproductive rights, climate change, racial and gender justice, and access to affordable, equitable healthcare.**

"Politics and polarization have life-and-death consequences."
—Jennifer Karas Montez, Professor of Sociology, Scholar in Aging Studies, Syracuse University

LEGISLATING LIFE: CORRELATION BETWEEN LIBERAL* STATE-LEVEL POLICY AND LIFE EXPECTANCY



"To meaningfully improve the health of Americans, new policies must target all of the drivers of health, including education, economic stability, neighborhoods and environments, social and community well-being, and historic inequities."

—Steven Woolf, MD, MPH, professor of family medicine and population health, Virginia Commonwealth University School of Medicine

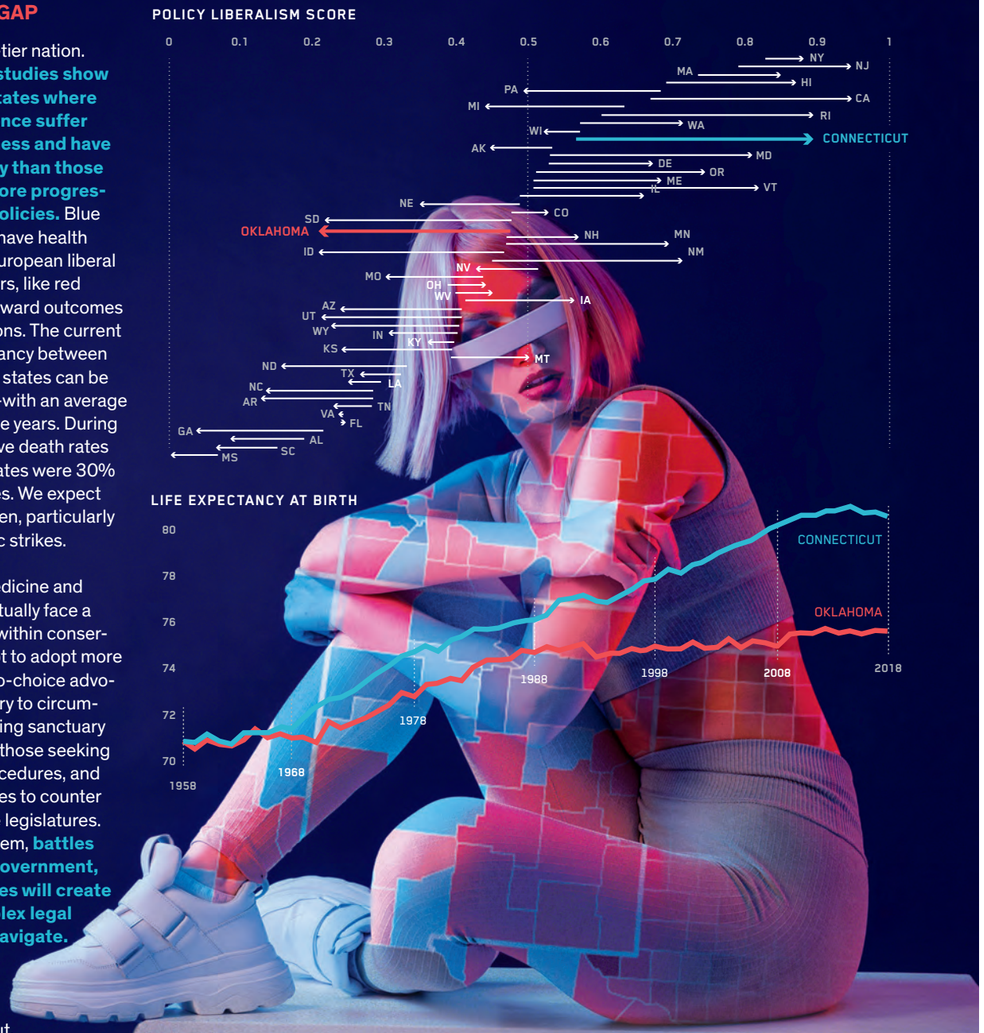
Data: Montez, J. et. al. 2020, 'US State Policies, Politics, and Life Expectancy,' *The Milbank Quarterly*, 04 August

* ***Liberal*** was defined as expanding state power for economic regulation and redistribution or for protecting marginalized groups, or restricting state power for punishing deviant social behavior; ***conservative*** was defined as the opposite.

OUTCOMES: A LIFE AND DEATH GAP

The US is already a two-tier nation. **Longevity and health studies show that people living in states where politics overrides science suffer from more chronic illness and have a lower life expectancy than those living in states with more progressive, science-driven policies.** Blue states like Connecticut have health outcomes on par with European liberal democracies while others, like red state Oklahoma, tend toward outcomes seen in developing nations. The current difference in life expectancy between liberal and conservative states can be as high as seven years—with an average difference of nearly three years. During the pandemic, cumulative death rates from Covid-19 in red states were 30% higher than in blue states. We expect the longevity gap to widen, particularly when the next pandemic strikes.

States that politicize medicine and health policies will eventually face a backlash. Liberal cities within conservative states will attempt to adopt more progressive policies. Pro-choice advocates, for example, will try to circumvent state bans by creating sanctuary cities, funding travel for those seeking abortions and other procedures, and launching ballot initiatives to counter the laws passed in state legislatures. Far from fixing the problem, **battles between the federal government, courts, states and cities will create an unstable and complex legal web for providers to navigate.** This will add new levels of regulatory burdens to provider workloads and will increase burnout. (For more on provider burnout, see *Tomorrow's Careforce*.)



A TWO-TIER NATION

CHANGES IN OVERALL POLICY ORIENTATION, 1958–2018, & LIFE EXPECTANCY BY US STATE, 1970–2014

Data: Montez, J. et. al. 2020, 'US State Policies, Politics, and Life Expectancy,' *The Milbank Quarterly*, 04 August

"When science becomes politicized and we don't believe medical research or data because they come from people with different politics, we are in a very bad place. Politics is going to continue to rear its ugly head and impact healthcare, but at some point the common good has to prevail and we have to hold our leaders responsible."

—Nancy Nielsen, MD, PhD, Senior Associate Dean for Health Policy, Jacobs School of Medicine and Biomedical Sciences

POLITICS IN THE CLINIC AND THE LAB—AND ON THE LEFT

Politically motivated regulation of medical procedures will limit the autonomy of doctors to make the best decisions for individual patients, and the practice of medicine will be increasingly controlled and shaped by the political leanings of state-level policymakers. Rural areas in conservative locales may face increasing physician shortages as doctors refuse to work where practicing particular specialties may subject them to criminal prosecution.

Medical schools in states with restrictive policies regarding procedures such as abortion may struggle to attract students, researchers and teachers in certain disciplines. Medical students hoping to be trained in specialties like reproductive medicine and transgender care will likely avoid training or practicing in states that limit those practices.

Professors and administrators may also abandon schools in states that don't share their values, whether conservative or progressive. People of diverse backgrounds will avoid places where access is difficult and a sense of belonging doesn't exist.

"Right now, in states that are poised to ban abortion, OB-GYN residents won't get proper training. It's going to be a big challenge."

—Allison Brashear, MD, MBA, Vice President for Health Sciences and Dean of the Jacobs School of Medicine and Biomedical Sciences

On the progressive left, a form of group censorship has been rising where researchers avoid controversial topics for fear of being shunned if they publish conclusions outside of accepted liberal orthodoxies. Academics who present controversial data or conclusions can face social media "cancellation," lose their jobs or funding and see their papers retracted.

Activists on the right, for their part, have hobbled health-related research by eliminating funding for studying gun violence and embryonic stem cells.

With research and free inquiry being inhibited or restricted by both the political right and left, **research in areas such as human DNA editing, artificial wombs, sex reassignment, human drug trials, live-donor organ transplantation, and human embryos may move to other countries with less restrictive regulations.** This could put us on the path to losing the 21st-century medical arms race, badly.

"In academia, we have created an environment where free expression is not really a thing anymore. If you happen to have a view that goes against the orthodoxy of academic medicine you risk losing your job or your reputation. … It's a dangerous trend."

—Dr. Haider Javed Warraich, Cardiologist, Writer and Clinical Researcher; Associate Director of Heart Failure at the VA Boston Healthcare System; Associate Physician at Brigham and Women's Hospital; Assistant Professor at Harvard Medical School

A TALE OF TWO FUTURES

WHAT IF POLITICAL POLARIZATION GETS WORSE

Rising polarization will lead to greater gaps in health outcomes and life expectancy. Politicians will likely expand the list of banned or restricted procedures and healthcare options to include types of contraception, surrogate decision-making and end-of-life care. **Imbalances in care will be accelerated as blue states become destinations for high-income patients seeking abortions, gender care and other procedures banned or limited in red states, and also for medical training in these fields. Lower-income patients who don't have the funds to travel will go without treatment or seek potentially dangerous alternatives.**

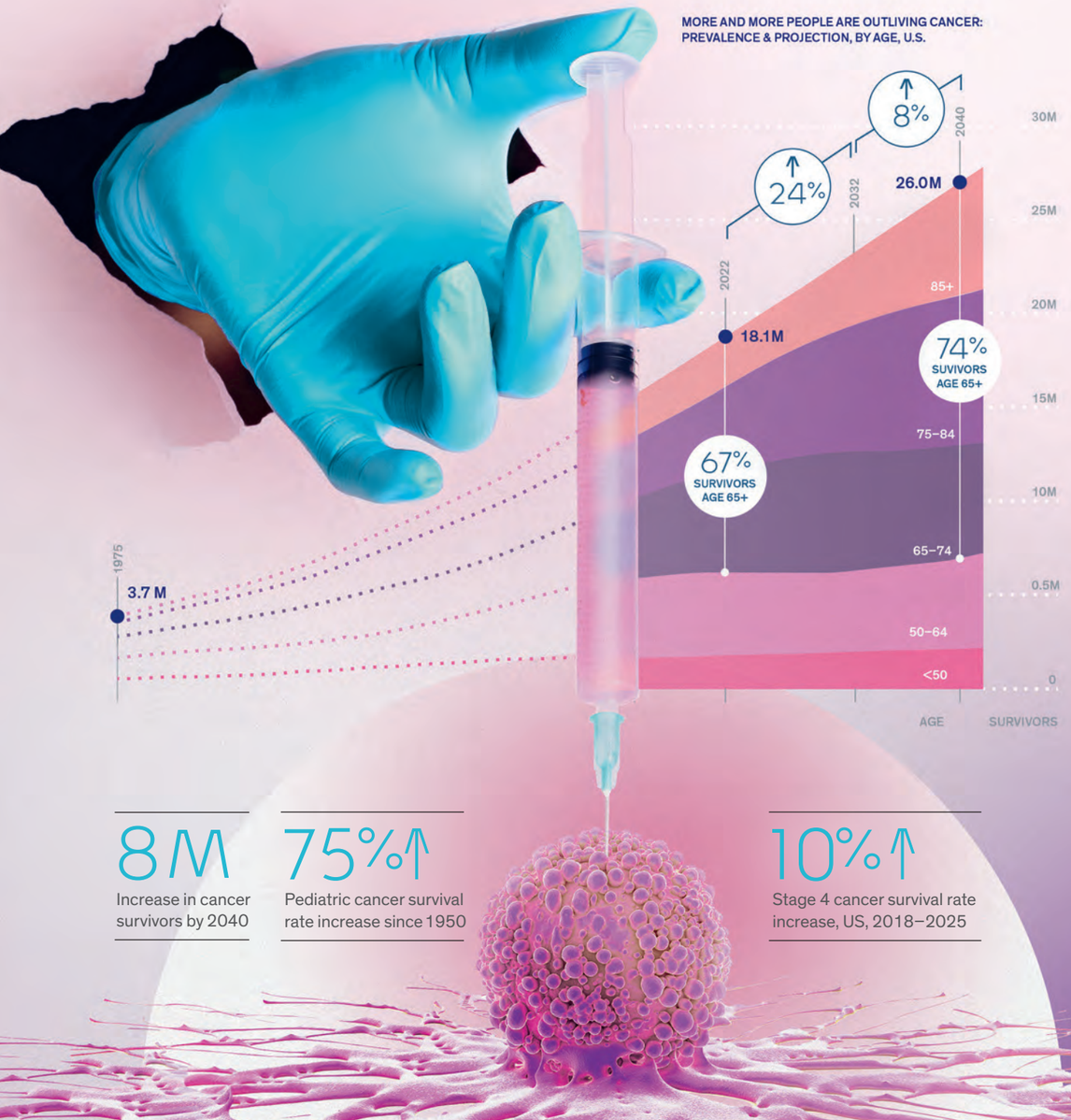
Some states will face boycotts by corporations, and by music and sports promoters. In addition, the most restrictive red states will see a brain drain of researchers and biomedical entrepreneurs.

IF WE BREAK THE IMPASSE

The political fever surrounding healthcare policies will break if voters reject politicians who sacrifice their constituents' health outcomes for political gain. Some likely scenarios:

- The voting-eligible Gen Z cohort that upended red-wave expectations of the 2022 elections represented less than half of their generation. Between now and 2030, eight more years' worth of Gen Z will reach voting age. Politicians who want to attain—and retain—power would do well to cater to their pragmatic aims.
- Companies that have locations across the country will flex their economic muscle and demand more uniformity across state policies that better reflect the needs and wishes of their employees and shareholders. This includes insurers who will be under pressure from corporate clients and customers to reject healthcare that isn't based on science. Hospitals and caregivers will use their considerable political and economic strength to actively advocate for pro-science and pro-patient policies.
- Citizens will realize that political polarization has delivered them poor health outcomes and shorter lives and will demand equity with other, healthier states. Less politicized and more civic-minded individuals will be motivated to run for office, participate in government committees and vote for policies that support science and improve medical outcomes.
- Lawmakers will find common ground on the issue that most impacts health: the economy. Studies suggest that a strong economy that lifts people from poverty overrides the impact of state policies in improving citizens' health. For instance, red states with oil revenue show improved life expectancy compared to those without the revenue. Politicians may continue to disagree on health policies but may find common cause promoting policies that stimulate economic growth.

MEDICINE IN THE 2020s IS POISED TO DEPLOY A BLIZZARD OF NEW INNOVATIONS THAT WILL TRANSFORM ''THE EMPEROR OF ALL MALADIES'' INTO A CHRONIC DISEASE RATHER THAN A DEATH SENTENCE.



8M
Increase in cancer survivors by 2040

75%↑
Pediatric cancer survival rate increase since 1950

10%↑
Stage 4 cancer survival rate increase, US, 2018–2025

"I've never seen the FDA approve so many drugs in such a short time, both for hematological malignancies and now for solid tumors that never had a treatment before."
—Giuseppe Giaccone, Associate Director for Clinical Research and Professor of Medicine, Weill Cornell Medical College

THE FUTURE VS. CANCER 09

MILLIONS OF LIVES WILL BE SAVED

In 1950, pediatric leukemia killed 90% of afflicted children. Back then, tobacco had yet to be causally connected with lung cancer, and the only breast cancer treatment available was a radical mastectomy. Chemotherapies were arriving, but were frequently as fatal as the cancers they were trying to treat.

Today cancer remains the second leading cause of death in the US after heart disease, but many cancers are in retreat as a raft of new treatments and discoveries come online. For instance, pediatric cancer survivability has increased from 10% in 1950 to 85% today. Targeted therapies pinpoint cancer-causing mutations and save more patients with fewer side effects. These include drugs that activate a person's own immune system to attack and neutralize tumors. By 2040, cancer survivors—patients who have been cancer-free for at least five years—will increase from 18 million to over 26 million people in the US.

Globally, nearly 20,000 clinical trials are underway, and spending on cancer drugs is slated to reach $269 billion by 2025. The US FDA is on track to approve an unprecedented number of new cancer treatments in the coming years, continuing a brisk pace that has seen over 80 new cancer drugs approved since 2015—one quarter of all pharmaceuticals approved.

PREDICTING AND PREVENTING MORE CANCERS

Detecting cancer in its earliest stages is a major focus of President Biden's 2022 Cancer Moonshot Initiative, which earmarked $200 million in grants issued by the Centers for Disease Control (CDC) for cancer prevention and screening. This includes a massive Multi-Cancer Early Detection (MCED) study backed by the National Cancer Institute (NCI). These **"liquid biopsies" hunt for multiple cancers in a single blood sample**. A test developed by Grail, a Menlo Park–based cancer detection company, became the first MCED test commercially available in the US in 2021.

Other programs that will help sniff out cancer include the Cancer Moonshot Biobank, which will collect tumor specimens and share samples with researchers to advance care. Also look for expanded use of nanotechnology in imaging, and for AI in biosensors and wearable technology to improve early detection.

Scaling and screening access will remain a challenge in remote and underserved regions of the US and in lower-income countries. The NCI has earmarked $23 million to create Telehealth Research Centers of Excellence to study how telehealth affects cancer care. Global events like pandemics, wars and natural disasters will also continue to disrupt early detection efforts. For instance, 10 million screenings were missed during the Covid-19 pandemic.

The rise of phenomics—the analysis of comprehensive personal biological data ranging from a person's DNA to metabolites—is also combining with other big data to provide sophisticated profiles of a person's risk for cancer and other diseases.

One pandemic silver lining: the improvement of remote research processes due to researchers being forced to isolate. Companies like Benchling in San Francisco have developed cloud-based laboratory information management systems that streamline everything from protein modeling to collaborations. Clinical trials also went largely remote, as new treatments were monitored and administered more at home, setting the stage for a future where those formerly without access to hospitals and clinics can receive care. **This will benefit isolated and other historically underserved populations.**

25% of all pharmaceuticals approved since 2015 are new cancer drugs

20K Clinical cancer trials in progress, global

"Data science is disrupting each step of the drug development process."
—Yizhen Dong, healthcare venture investor

"Precision medicine is not the standard process for treating cancer yet, but I see that door opening."

—Andrew Hessel, microbiologist, geneticist and entrepreneur

BIOHACKING CANCER: ACTIVATING YOUR OWN IMMUNE SYSTEM

- **Immuno-oncology (IO)** aims to rev up a patient's immune system to recognize and kill cancer cells. IO strategies include monoclonal antibodies, checkpoint inhibitors, cytokines and CAR T–cell therapy. Early results have been extremely promising. **The checkpoint inhibitor dostarlimab produced 100% remission in patients with rectal cancer** in a small trial published in the *New England Journal of Medicine* in June 2022. In November, *Nature* published results from the first human trial in which **CRISPR-engineered immune T cells successfully blocked cancer progression**, paving the way for improved CAR T–cell therapies using CRISPR technology.
- **Cancer vaccines** are also a promising new cell therapy that can treat cancer by helping the immune system recognize and attack tumor cells. **Similar to vaccines for infectious diseases like Covid-19, these vaccines can be made from mRNA-encoding cancer peptides, effectively teaching immune cells what to go after.** If a current crop of early-stage trials proves successful, some will be approved within the next decade.
- **The gut microbiome** also plays a role in immune responses, cancer growth and treatment outcomes. Recent CAR T immunotherapy studies showed that use of antibiotics therapy disrupted the gut microbiome and was associated with worse outcomes. Future treatment strategies that enlist the microbiome include highly personalized probiotics, targeted antibiotics, fecal transplantation and targeted microbiota injection into a tumor.

Political leaders will increase their bets on immuno-oncology. The US Patent and Trademark Office is fast-tracking immunotherapy applications, and an immuno-oncology expert, Dr. Elizabeth Jaffee, was appointed as chair of the President's Cancer Panel.

LESS THAN 40%

Oncologists confident using genetic sequencing technologies, US

HITTING THE BULL'S EYE: PRECISION DRUGS THAT WORK

What we call cancer is actually a constellation of rare diseases. **In the next decade, pharmaceutical companies will be challenged to rethink their standard business model that looks for blockbusters. Developing individualized therapies will become the new holy grail. Healthcare systems will need to become more agile** and retrain oncology teams as more targeted therapies are approved, each one for smaller groups of patients.

Currently, only a fraction of cancers are treated with targeted agents. In 2020, nearly a quarter of lung cancer patients in the US did not get genomic testing before first-line treatment despite the availability of multiple targeted treatments based on a patient's DNA. Fewer than 40% of US oncologists in a survey felt confident using **new sequencing technologies**.

In addition to targeting cancer mutations, nanotechnology makes drug delivery more precise. **Nanoscale antibody-drug conjugates deliver a safer, more potent form of chemotherapy for solid and hematological cancers. Coupling nanotech with radiation and immunotherapy is on the horizon.** As physicians increasingly adopt genomic sequencing and targeted approaches in the coming decade, look for a significant increase in cancer survivors.

EQUITABLE CANCER SOLUTIONS: HOW CLOSE ARE WE?

"While many may think of technology solutions as objective and unbiased, recent clinical studies have demonstrated how these products often amplify the biases of their creators and can further exacerbate health inequities."

—Félix Chinea, MD, Head of Diversity, Equity, Inclusion and Belonging at Doximity

At first, accessibility will remain limited. Patients from historically underserved populations will experience delays and find it harder to get individualized treatments. But organizations from the AMA to the White House are making equity and access a key priority.

New companies are targeting overlooked communities, including Boston-based Folx Health, which addresses health concerns of LGBTQ+ patients, who are often stigmatized in traditional clinics. TrialJectory, in New York, matches cancer patients to clinical trials and boosts participation by underrepresented groups. Surveys show receptiveness to medical mobile apps like Survive and Thrive, which was created by Sacramento nonprofit Carrie's Touch to support black women with breast cancer, who have 40% higher mortality than white women.

Globally, over 90% of cancer research is conducted in high-income countries, and research lags in low-to-middle-income countries. Areas missed by research include cancers caused by occupational carcinogens, tobacco use and khat chewing. Also underfunded in low-income countries: distribution of vaccines for HPV, which causes cervical cancer.

In a first-of-its-kind deal, Novartis has agreed to license its leukemia drug Tasigna to generics manufacturers for distribution to lower-income nations. **If we want to ensure equitable access to care, a benefit to all society, more companies should follow suit.**

40% HIGHER

Mortality from breast cancer for black women vs. white women

"I see major advances in saving lives from cancer in the next 10 years by eliminating cancer health disparities … by ensuring equity in access to quality cancer care to all persons."

—Karen M. Freund, MD, MPH, Physician-in-Chief for the Tufts Medical Center Department of Medicine and Professor of Medicine at Tufts University

THE GROWING MENTAL ILLNESS PANDEMIC, PARTICULARLY AMONG ADOLESCENTS, IS A MASSIVE CHALLENGE FOR THE NEXT GENERATION OF HEALTHCARE PROVIDERS. IN ADDITION, AN AGING POPULATION NEEDS MORE WAYS TO SLOW AGE-RELATED COGNITIVE DECLINE. WE ARE REACHING A CRITICAL MASS OF EMERGING NEUROSCIENCE RESEARCH THAT WILL BOOST OUR KNOWLEDGE OF THE HUMAN BRAIN AND GENERATE EXCITING AND INNOVATIVE THERAPIES AT A FAST CLIP. WILL IT BE ENOUGH?

1/2
of new MDs can't find a psychiatric residency slot

$16 TRILLION
Estimated **annual global cost** from depression, 2030

10 BRAIN HEALTH

A MENTAL ILLNESS PANDEMIC IS UNDERWAY

Our early 21st-century brains are feeling fragile in the wake of the Covid pandemic, with information overload, politics and roiling economies driving an upswell of people looking for relief. Twenty percent of Americans are experiencing mental illness—anxiety, depression, eating disorders, post-traumatic stress disorder or compulsive behavior. Less than half of those are getting treatment—and the prevalence of mental pathologies is expected to keep rising. **One in six Americans has a substance use disorder. Of these, 93.5% get no treatment.** Brain fog that comes for many people suffering from long Covid will also continue to affect millions of people as the virus becomes endemic.

"Mental health challenges in children, adolescents and young adults are real and widespread. Even before the pandemic, an alarming number of young people struggled with feelings of helplessness, depression and thoughts of suicide. … The future well-being of our country depends on how we support and invest in the next generation."
—US Surgeon General Vivek Murthy

By 2030, the World Health Organization expects depression to cost the world $16 trillion a year, mostly from lost productivity, with an estimated 12 billion working days lost each year. More distressing is the toll on our kids. Over 16% of children ages 12–17 had a serious depressive episode in the past year. 58% of Americans think that the next generation will have a worse living standard than the current one, an 18% drop in optimism since 2019 and an almost 30% drop since 1999.

In the US, mental health care badly needs a system redesign. Doctors and nurses trained in mental health—and beds for psychiatric patients in hospitals and detox centers—are chronically strained. Right now, the US only has enough psychiatrists to meet 60% of the demand for their services. Three out of every five psychiatrists are over age 55, and yet almost half of newly minted MDs applying for psychiatric residencies can't find a slot.

The most visible manifestation of our broken mental health system: over half of those experiencing homelessness are severely mentally ill or addicted to hard drugs. **Major cities like New York are enacting involuntary commitment measures**—authorizing EMTs and other medical personnel to commit mentally ill patients to temporary incarceration. Disappointing early results in San Francisco's version of the program illustrate that **these efforts only have a future if we build more long-term mental health facilities and double the number of providers trained to treat mental illness.**

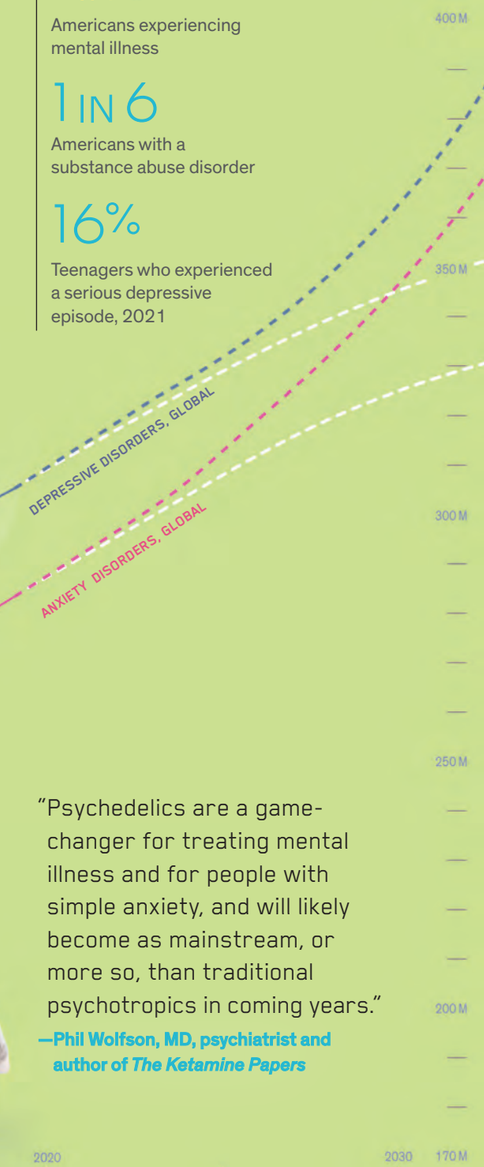
FLATTENING THE MENTAL ILLNESS CURVE

According to the United Nations, depression in 2010 was ranked third among causes of the global burden of disease and is projected to rank first in 2030. The challenge is to flatten this upward curve as much as possible. A host of solutions is emerging, some time-honored, others cutting-edge.

1 IN 5
Americans experiencing mental illness

1 IN 6
Americans with a substance abuse disorder

16%
Teenagers who experienced a serious depressive episode, 2021



"Psychedelics are a game-changer for treating mental illness and for people with simple anxiety, and will likely become as mainstream, or more so, than traditional psychotropics in coming years."
—Phil Wolfson, MD, psychiatrist and author of *The Ketamine Papers*

SOLUTIONS: TIME HONORED + CUTTING EDGE

OUT WITH CONVENTIONAL PSYCHOTROPICS, IN WITH PSYCHEDELICS

SSRIs like Prozac and Zoloft work for only about half the people who take them and have side effects that include an increased risk of suicidality in some patients. Other antidepressants also fail in too many patients. These therapeutics do work for some people, but we have been relying on and overprescribing them for decades while few alternatives were being developed.

But now, shelved or illegal—and in some cases, ancient—treatments are emerging and will likely provide relief for millions. These are psychoactive compounds derived from plants, including psilocybin ("magic mushrooms"), peyote, cannabis and mescaline as well as synthetic drugs like LSD, ketamine and MDMA.

Psychedelic molecules combined with behavioral therapy are showing efficacy as treatments for depression and other mental illnesses. **Clinical trials remain mostly small but are quickly expanding as medicine reevaluates substances that were mostly banned during the "war on drugs" from the 1970s to the 1990s. By 2030, these drugs are likely to be fully legalized in many states for medical use**—likely starting with the states that first legalized medical cannabis—and will be used alongside traditional psychotropics.

Psychedelic-assisted psychotherapy uses talk therapy along with psychedelics to treat patients, and encourages the use and interpretation of hallucinogenic effects. More traditional therapists administer the drugs looking for the physiological healing effects while considering the "journeys," or "trips," to be an undesirable side effect. Both approaches are likely to proliferate in the coming years. Venture money is piling in: Compass Pathways and other startups are attempting to patent everything from modified psychedelic molecules to hand-holding during therapy sessions.

"We have identified eight distinct ways that brain circuits can get disrupted or stuck, which I call 'biotypes.' We're identifying more than just the architecture of the brain, but also insights into how we reflect, how we control our thoughts, how we feel, how we regulate our emotions. We can now quantify those circuits."

—Leanne Williams, PhD, neuroscientist, Stanford University

NONCHEMICAL DIGITAL SOLUTIONS ("EXPERIENTIAL MEDICINE")

In 2020, for the first time ever, the FDA approved a video game to treat a mental health condition—in this case, ADHD in children. Invented in the lab of neurologist Adam Gazzaley at UCSF and developed by Akili, the game EndeavorRx is prescribed by physicians and played on an iPad, with results that match the effectiveness of Ritalin and other traditional chemical treatments, with none of the side effects. **Digital prescriptions will proliferate for other conditions including PTSD and phobias** as numerous companies work to develop new products, and Gazzaley and other researchers develop full-immersion games that use body sensors and technology to create virtual reality experiences—part of a new neuropsychiatric field that Gazzaley calls "experiential medicine."

LEARNING TO BE CALMER: MINDFULNESS

Even before Covid-19, millions of people were turning to meditation apps, yoga classes and lessons in intentional breathing to battle stress and anxiety. Thousands of companies now offer health coaching, massages and self-assessment questionnaires. (For more on mindfulness see the *Wellness and Nutrition* section.)

"Hopefully this big experiment in mindfulness will end up being a pandemic silver lining for the future, for business and for our kids."
—Camille Preston, PhD, founder and CEO, Aim Leadership

UNLOCKING THE BRAIN'S SECRETS WITH PRECISION NEUROSCIENCE

Basic neuroscience research is booming, unveiling how the brain is wired and how it functions, with projects like the Brain Atlas, which is setting out to map the approximately 200 billion brain cells in a human by type and function. Surgical techniques to repair damaged brains will get safer and more sophisticated, with an increase in the use of robotic systems for precision surgeries.

Nanobots—devices and machines thousands of times smaller than the width of a human hair—hold great promise in many healthcare applications. Most of the cellular processes in our bodies, after all, happen at nanoscale. For instance, **smart pills with nanoscale sensors that wirelessly send out data will be used to diagnose a variety of conditions. MIT researchers are creating drug-carrying nanoparticles that can cross the blood–brain barrier to target cancer cells and destroy them without damaging other tissue.**

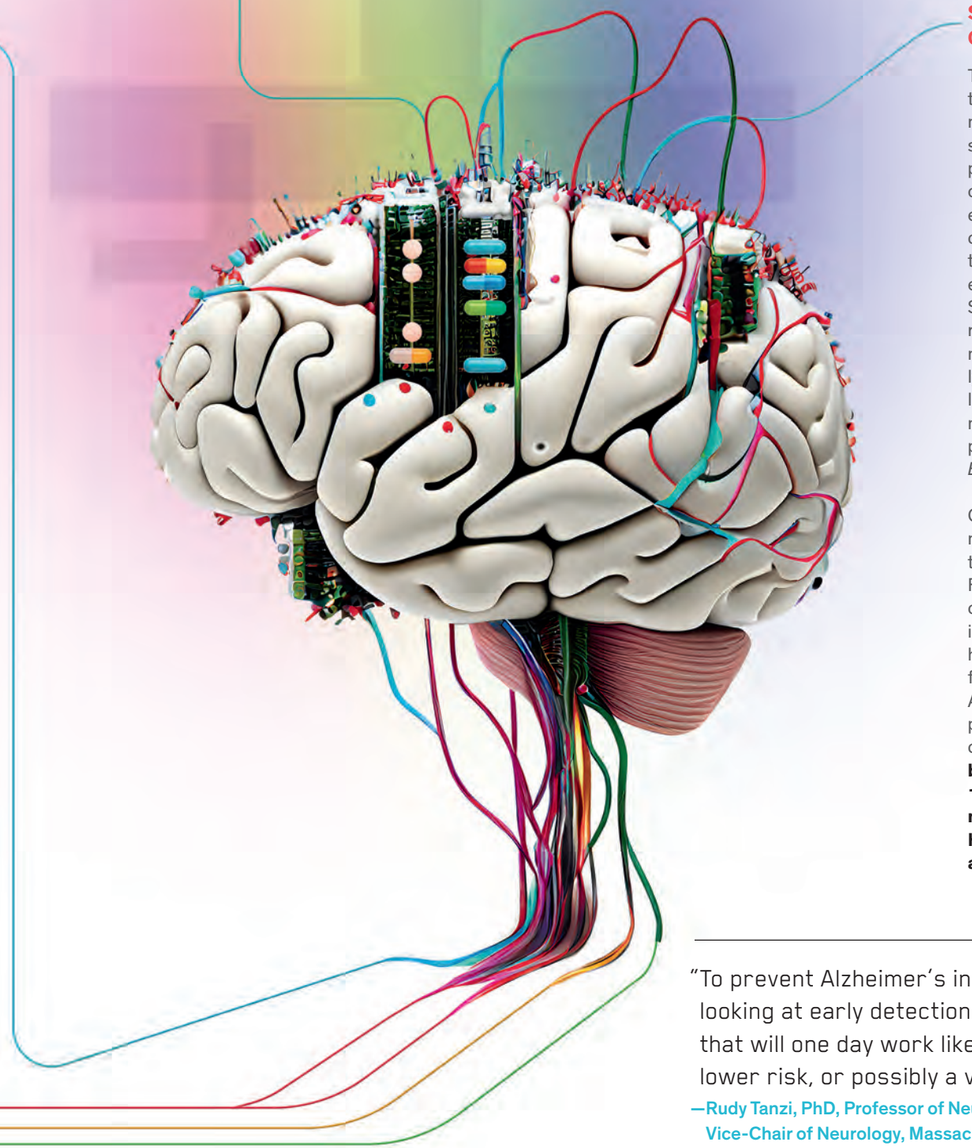
Precision neuroscience, aided by biodata and artificial intelligence, measures biomarkers that reveal personalized details of brain health and the structural differences in people's brains (biotypes). This will yield specific therapies targeted to each patient—including Alzheimer's and neurodegenerative diseases.

DE-AGING THE BRAIN

Alzheimer's remains irreversible even as patients are expected to double by 2050. Drugs with promise to stem this brain-health crisis are often being approved through the FDA's Accelerated Approval Program. Several drug candidates, most of which centered on removing protein tangles and plaque in the brain, have proven ineffective.

Recently approved Lequembi, however, has shown promise in slowing the progression of the illness. Rudy Tanzi and his team at Harvard and Massachusetts General are **investigating the role of pathogens in neurodegenerative disease and developing ways to combat Alzheimer's with antibiotics and antivirals.**

Protecting delicate young brains from injuries that can later lead to dementia is already a hot issue in football, soccer and other activities where heads are knocked around. This is driving innovation in rules and equipment—and may see the end of youth contact sports like football. Likewise, fun but dangerous playground structures like metal jungle gyms have mostly disappeared.



HARDWARE AND SOFTWARE: SYNTHETIC FIXES TO REPAIR OUR GRAY MATTER

The marriage of hardware and flesh in the brain will build on successes with neural prosthetics that help control seizures and tremors, to the point that patients start to ask for enhancement over baseline. Hearing prosthetics will evolve into one of the bestselling consumer devices ever. Optical implants that restore sight will also improve enough to become consumer-friendly. So will implanted electrodes that can reinvigorate neuronal synapses in the motor cortex in people who are paralyzed, allowing them to use prosthetic limbs and to operate computers and machines by thinking. (For more on prosthetic advances, see the *Make Me Bionic* section.)

Gene editing and regenerative technologies to repair damaged cells in the brain are in the early stages of FDA-sanctioned human trials. Hundreds of gene therapy products are currently in animal and in human testing, with a handful already approved by the FDA for diseases like macular degeneration. After some early gene therapy mishaps, physicians and regulators will remain cautious, but **gene therapies will become more common in the next 15-plus years to treat genetic-based neural and other diseases, including Huntington's, Alzheimer's, sickle cell anemia and AIDS.**

"To prevent Alzheimer's in my son's generation, we're looking at early detection and developing therapies that will one day work like statins for the heart to lower risk, or possibly a vaccine. This is coming."

—Rudy Tanzi, PhD, Professor of Neurology, Harvard University; Vice-Chair of Neurology, Massachusetts General Hospital

THE WELLNESS CRAZE WILL EXPLODE AS HUNDREDS OF MILLIONS OF HEALTH-CONSCIOUS PEOPLE SPEND MORE TIME AND MONEY ON EVERYTHING FROM GYMS, DIETS, SUPPLEMENTS AND WELLNESS TOURISM TO GENETIC AND OTHER METABOLIC TESTING. WELLNESS IS A $4.4 TRILLION GLOBAL MARKET AND WILL REACH $7 TRILLION BY 2025. IMPROVEMENTS IN THE SCIENCE OF NUTRITION WILL TURN THE TIDE IN THE BATTLE AGAINST THE EPIDEMICS OF OBESITY AND MALNUTRITION.

WELLNESS & NUTRITION 11

GOODBYE, REACTIVE SICK CARE—HELLO, PREVENTIVE WELL CARE

Until now, modern medicine has mostly waited until a person gets sick and symptoms are manifesting before intervening. In recent years, this dynamic has been changing as consumers have demonstrated an intense interest in staying well and avoiding illness. This shift toward prevention has spawned a massive global industry, and a bounty of products, technologies and experiences based on increasingly sophisticated wellness science. This holistic new approach to wellness combines fitness, nutrition, sleep, mindfulness and myriad lifestyle choices. Americans spend $1.5 trillion a year on well-care products and experiences, an amount that will double in the coming decade.

THREE EMERGING STEPS ON THE ROAD TO WELLVILLE

Cleaner Living Ahead

Smoking and Drinking

Smoking still costs the US economy $600 billion a year. Significant numbers of young adults are beginning to turn away from alcohol in the same way their parents' generation reduced smoking. The market for low-alcohol or non-alcoholic spirits, wine and beer has grown over 20% in the US in the last year as more people choose mocktails, kombuchas and botanical tinctures to replace traditional cocktails. In 2022, global sales of the no- and low-alcohol category surpassed $11 billion, and are expected to reach over $20 billion by 2030. More apps are being developed that help assist progress in smoking cessation and alcohol reduction. We are now seeing a fresh wave of bars, dance parties and events geared toward the "sober curious."

Opioid Hangover

While there are many hopeful and healthy lifestyle trends, opioid use continues to be a major health crisis. Drug use took more than 100,000 American lives in 2022. In New York state, opioid mortality increased by 14% from 2021 to 2022 to a staggering total of 4,766 deaths. Over the next decade, pharmaceutical companies, insurers, pharmacies and the medical profession at large must have a full accounting of the mistakes and policies that sparked the crisis. However, there is wide agreement that opioid overuse represents a systemic societal problem that will require changes outside the medical system to fully address. Comprehensive and multifaceted services like the MATTERS Network, founded at the University at Buffalo, connect patients with treatments and services for opioid users while also establishing prescribing guidelines for healthcare providers in Western New York.

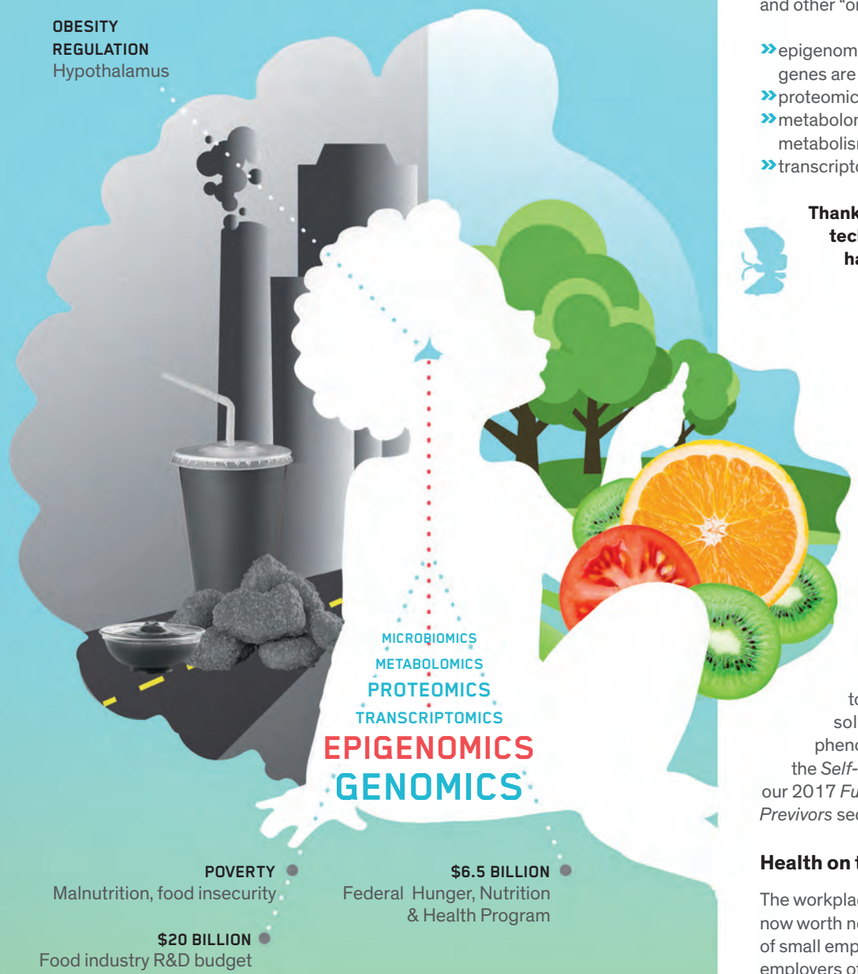
"The notion that prevention is better than cure is hundreds of years old. However, we still get paid when the patient gets sick. We need to be incentivized to keep people well. When we change what gets reimbursed, we will change the system."

—Dr. Vijay Iyer, MD, PhD, Chief of Cardiovascular Medicine, Associate Professor of Medicine, Jacobs School of Medicine and Biomedical Sciences

"Phenomic studies on diseases will profoundly and comprehensively enhance our capacity in prevention, diagnosis and treatment of diseases. … It is reasonable to expect that the 'Golden Age of Phenomics' is arriving."

—Weihai Ying, Med-X Professor and Associate Dean, Shanghai Jiao Tong University School of Biomedical Engineering

SOLVING OBESITY IN CHILDREN



12M
American children **are malnourished**

Now on the Menu: Biodata and AI

The Dawn of Phenomics: Auguring Your Future Health

Through the power of artificial intelligence we are building our understanding of the interplay between our individual genomics and other "omics" such as:

- epigenomics (analysis of the way genes are switched on and off)
- proteomics (analysis of cell proteins)
- metabolomics (analysis of cell metabolism)
- transcriptomics (analysis of cell RNA)

Thanks to these "multi-omic" technologies, we will soon have a more holistic view of an individual's biological system and a deep understanding of the complex interactions between what we eat and other lifestyle and environmental factors. Doctors will develop ever better risk profiles for diseases before a person gets sick. A host of apps, wearables and monitoring devices will trigger health alerts allowing for early interventions. This will encourage patients to advocate for preventive solutions. (For more on phenomics and previvors, see the *Self-Health Rising* section and our 2017 *Future of Medicine* report's *Previvors* section.)

Health on the Job

The workplace wellness industry is now worth nearly $55 billion, with 53% of small employers and 81% of large employers offering some sort of wellness program. These perks are quickly becoming a core benefit for most workers in the US, with companies offering everything from gym memberships to bike-share programs, fitness classes, massages and nutritional and mental health counseling.

FOOD IS MEDICINE

TRUST YOUR GUT

Average human lifespan has doubled over the past 150 years primarily because of improvements in nutrition and hygiene, with technology and modern medicine coming in as less important factors. Our understanding of the interplay of food and the human body is becoming more sophisticated—even as millions of people in the US remain food insecure and many millions more struggle with obesity. Eating badly can impact our moods, make us sick and even kill us.

In the coming decade, primary care doctors and health apps will prescribe diets designed by AI to optimize the interaction between our individual microbiome (the collection of microorganisms living in and on our bodies) and our epigenome, metabolome and proteome. We are already far along in understanding how diet can spur epigenetic changes in children's developing brains, and how these changes can impact obesity later in life. Carefully designed individual diets may be key to curing or postponing many diseases.

Watch for a growing number of big businesses to add population health to their ESG goals. Pharmaceutical giant Novo Nordisk is jumping into the food-as-medicine fray, investing $20 million over the next three years in locally led initiatives from the Mississippi Delta to Arizona that improve access to healthy foods and recreation space for underserved communities. These projects range from building greater demand for locally sourced, healthy produce to improving nutrition literacy.

SMART TECH FOR HEALTHY EATING

Apps will keep proliferating to help people track their diet, with more sophisticated AI algorithms helping to link diet data with the latest research. These algorithms will also link diet data with data on a person's genetic and other risk factors for diet-linked diseases. Apps and other food-tracking systems will be developed that help patients with Alzheimer's, cancer and other diseases to eat targeted foods that could slow down the progression of their disease. Other apps, like one created by New York City startup Mymee, are helping patients discover and avoid food triggers for autoimmune diseases.

STILL HUNGRY AFTER ALL THESE YEARS

Americans spend $1.1 trillion on food every year, with the federal government spending almost $200 billion a year in food aid for the poor. Yet 12 million children in America remain malnourished. The link between poverty and malnutrition—and deficits in cognition and overall health—is indisputable. One dollar spent on providing children with good nutrition saves four dollars in services later in life, although current partisan deadlocks in state and federal legislatures will make increased investment in child nutrition a challenge in the near future. (See the *Politics and Healthcare* section for more on this.)

The Biden Administration's new Hunger, Nutrition and Health initiative pledged to spend $2.5 billion on startup companies that are "pioneering solutions to hunger and food insecurity," and over $4 billion on philanthropies that improve "access to nutritious food, promote healthy choices, and increase physical activity." Much more will be needed in the coming years.

EVERY $1 = $4

spent on childood nutrition

saved on adulthood healthcare

FUNCTIONAL FOOD REPLACES JUNK FOOD

Even as scientists learn more about the interplay between food as chemistry and what is good and bad for us, policymakers don't always agree on best practices. This results in shifting nutritional standards that often don't keep up with the latest research. Policymakers struggle to stay abreast of the latest data and to find the will to combat powerful interest groups and muster the resources to optimize good nutrition for kids and others.

The food industry has a long history of producing processed and high-sugar food that human taste buds adore rather than food that's good for us. For instance, it's long been known that high-sugar cereals like Raisin Bran, Special K and Life are not healthy by any reasonable standard. But it took until October 2022 for the FDA to remove them from a list of "healthy" breakfast foods. **Diabetes and cardiovascular disease caused by unhealthy eating racked up a $1 trillion healthcare bill in 2021 alone.**

A significant percentage of consumers are now demanding more from what they eat and drink. They are shopping for functional foods that increase performance, relaxation and overall wellness. Consumer packaged goods companies of all sizes are realigning to launch products that provide additional health benefits. Many new food and beverage products promise to reduce inflammation and increase the health of your gut microbiome. As the lines between food and medicine continue to blur, companies will compete to win over customers who increasingly want nutrient-packed food that is regeneratively produced and delivered via a transparent supply chain.

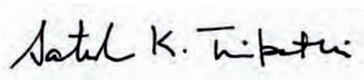
THE FINAL WORD

THIS REPORT LOOKS TO THE FUTURE, BUT IS NOT INTENDED PRIMARILY TO PREDICT SPECIFIC OUTCOMES. THE HOPE IS THAT THIS DOCUMENT KICKS OFF A VIBRANT AND ONGOING CONVERSATION ABOUT THE CHALLENGES AND OPPORTUNITIES OF THE DECADES AHEAD. THIS IS NOT JUST A CONVERSATION FOR FACULTY, STAFF AND STUDENTS AT THE UNIVERSITY AT BUFFALO AND THE JACOBS INSTITUTE, BUT FOR ALL THE STAKEHOLDERS IN OUR NATIONAL HEALTH SYSTEM.

Throughout this report, our team of researchers, doctors and futurists have explored both utopian and dystopian scenarios for the future of healthcare. Ultimately, we are confident that the future is bright. Our certainty isn't just wishful thinking. We've watched with pride and admiration as the curious and ambitious students, faculty and research staff in our Buffalo-area institutions continually embrace and advance new ideas and technologies. By creating new partnerships and collaborations with stakeholders both within and outside the medical field, they are becoming leaders at this critical moment in the history of healthcare.

We hope this report will help the next generation of healthcare providers, administrators, innovators and policy-makers envision and embrace a hopeful vision for the future of healthcare—one that is inclusive and accessible and extends not just lifespan but healthspan for all.

Jeremy M. Jacobs
Chairman
Delaware North
The Jacobs Institute
University at Buffalo Council



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