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 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
CEO and Chief Medical Officer, Jacobs Institute
Professor and Vice Chairman of Neurosurgery, Jacobs School of Medicine and Biomedical Sciences

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 and Dean of the Jacobs School of Medicine and Biomedical Sciences
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.

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 aid to 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. Socking 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
Editor in Chief

David Ewing Duncan
Executive Editor

Ethan Walters
Senior Editor

EDITORS’ LETTER

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.
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 hypogravity 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.

DAVID EWING DUNCAN
EXECUTIVE EDITOR – JOURNALIST AND AUTHOR
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 commen-

tator 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 the Magazine Story of the Year from AAAS and three nominations for National Magazine awards, including Magazine Story of the Year from AAAS.

REBECCA FERRINI, MD, MPH, CMD
SECTION HEAD
Rebecca Ferrini is a full-time medical editor for Edgerton. In addition to her duties at Edgerton, the facility has achieved the highest possible ratings from the Centers for Medicare and Medicaid 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.

JONATHAN D. SONIS, MD, MHCMD
SECTION HEAD
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.

JOSHUA SPANOGLE, MD
SECTION HEAD
Joshua is a practicing dermatologic surgeon and author. His bestselling thrillers (Isolation Wound 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.

DANNY FORTSON
SECTION HEAD – JOURNALIST AND AUTHOR
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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SECTION HEAD – JOURNALIST AND AUTHOR
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, Electric.

TAMI LUCHOW
SECTION HEAD – DIVERSITY CONSULTANT, SPEAKER, WRITER
Tami is a DESAAB, Diversity, Equity, Inclusion, Accessibility and Belongingi consultant, leader and change-maker. She runs workshops on DESAAB, 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 seen not 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 QI, PHD
SECTION HEAD – WRITER AND SCIENTIST
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
SECTION HEAD – JOURNALIST AND RESEARCH EDITOR
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 Thalca 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.

NATALIE JONES
RESEARCH EDITOR
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 online. 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.

PATRICK HOUSE, PHD
RESEARCHER – SCIENTIST AND WRITER
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 Nature, among other outlets. His book, Nineteen Ways of Looking at Consciousness, was published in October 2022.
Andrew Hessel
**ADVISOR – CHAIRMAN, GENOME PROJECT-WRITER**

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 Human 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 as *The Genesis Machine: Our Sciences. His book, The Quest to Rewrite Life in the Age of Synthetic Biology*, coauthored with futurist Amy Webb, was released in 2018.

Alba Munoz Saiz
**MANAGING EDITOR AND SUSTAINABILITY EDITOR AT ATTENTION SPAN**

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.

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.

Larry Habegger
**MANAGING EDITOR**

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 Pros 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.

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
**CREATIVE DIRECTOR – CHIEF DESIGN AT ATTENTION SPAN**

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 Communications 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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**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.

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**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.

“*This is the biggest increase of emotional exhaustion that I’ve ever seen…*”


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**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

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**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 Scarica, Director of Periop and Procedural Business Ops, Kaleida Health

**GUTTER**

**Tomorrow’s Careforce**

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**NURSE SHORTAGE, US 1.3M**

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

"Medicare, but Congress has added and funding will be critical in turning no commensurate increase in residency education pipeline. In the past 20 years medical schools have increased enrollments by more than half, but there’s been a deficit of 200,000 doctors in the US in the mid-2000s.

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 double 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 NPs 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 independently 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

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**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.

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**Tomorrow’s Careforce**

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**AI AND THE MEDICAL CHART**

Remarkably, nurses and doctors spend a quarter and half of 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, automated documentation technology will chart 70% of patient encounters, alleviating one of the leading causes of provider burnout.

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**TELEMEDICINE**

Could drive 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.

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**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%.

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**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 (anatomy) and technical skill (acquisition, surgery and placement), along with empathy, communication skills and clinical decision-making. In certain cases, AR/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.

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**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 diversity of doctors will be matched by geographical and socioeconomic considerations.

As the medical students become more diverse, schools’ curricular 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 FAUGHT WITH LONG WAITS, OVERCROWDED CLINICS AND HOSPITALS, AND OUTMODED SYSTEMS FOR COMMUNICATION. BUT INNOVATORS ARE BUSY CREATING A NEW FUTURE FOR THE 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 technologically. 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%. Solis 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—inciting 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.

Beilinger, 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 ↘

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

“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

4 Days ↘

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

“Solving the value-based care puzzle begins by looking at how we can engage patients in the care process so that they understand their own health and can be advocates for themselves.” —Kaiser Permanente
“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.

**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 multipass 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.

**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, operational 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.

4,000

US hospitals offering home-based acute care programs in 2022
The consumer market for medical IT devices and apps has exploded in recent years, with over 435,000 health-related apps currently available. This 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 made by Apple, Fitbit, Garmin and others now include ECG by Uber-style delivery or by drone.

THE CONTINUOUS SMART DEVICE CHECKUP

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

“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. 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 microbiota.

» 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 3D-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 through 30-second selfies taken or by drone.

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.

THE FUTURE OF HEALTH

The numbers of people taking supplements and drugs outside traditional medicine will skyrocket; so will medical tourism.

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...
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. Uncannily profitable 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

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 Ribit data to DNA profiles to measurements of metabolites, proteins and other molecules, 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 systems will start taking their 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 recommendations 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

THE RISE OF PHENOMICS: BEYOND KNOWING YOUR DNA

A wave of phenomics-oriented start-ups will continue to make headline-worthy changes 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?

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.)

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 that indicate heart 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 for cancer and other diseases with a quick 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.

• Whippi – Amplifying Hidden Voices
  Mobile app converts whispering speech, vocal cord-impair speech and severe stuttering into a natural-sounding voice in real time.

• Opteeve Technologies’ ViralWarn – Portable Virus Detector
  This breath analyzer is intended to detect Covid-19, influenza and RSV in less than 60 seconds; under FDA review.
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.

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

50% of US healthcare costs occur in the last 3 years of life
25% of healthcare costs occur in the last 12 months of life
$37T amount contributed to the global economy by 1 extra year of healthy life
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**
- **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. Those 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 prosthesis, 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.)

- **The 9 Hallmarks of Aging**

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

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
“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 repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis. Another repurposed longevity drug to watch: rapamycin, an mTOR inhibitor that is repurposed longevity drug to watch: a trial to test this hypothesis.

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 build 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 state wide 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

85
83
80
66
63
60
Marin County, CA
Fort Worth, TX
2023
2050
The exposure of the exposome, the exposures one encounters from diet and lifestyle to environmental and occupational risks, has a huge impact on longevity. 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 state wide or metropolitan area figure, are considered food deserts.

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.

THE FUTURE OF HEALTH
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.

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 therapies.

**NEUROINTERVENTIONAL ELECTROPHYSIOLOGY**

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 TEND**

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.

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 morphogen 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. Brain–robotics’ 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 $4,800 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.

"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

**PROSTHETIC PRICE TAG**

<table>
<thead>
<tr>
<th>Prosthesis</th>
<th>Price</th>
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<tr>
<td>Microprocessor-controlled knee users vs. analog prosthetic knee users</td>
<td>$4,600</td>
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While most high-end bionic limbs are still priced like high-end automobiles, 3D printing is changing the prosthetics market rapidly. Open Bionics’s custom-izable 3D-printed Hero Arms (including a Black Panther Wakan’Dai forear model) start around $10,000 and are covered by Medicare. Unlimited Tomorrow’s 3D-printed TrueLimb, mentioned at left, costs less than $9,000 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 colead of MIT’s Yang Center for Bionics—and former student David Melena Sengah, 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 comparable users 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 prostheses 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.
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 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.

“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

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.
Reimagining Health Economics

THE PATHWAY FROM FEE-BASED TO VALUE-BASED HEALTHCARE

EXAMPLE: METABOLIC SYNDROME & TYPE 2 DIABETES

RESULTING DISEASES
\- CANCER
\- TYPE 2 DIABETES
\- STROKE
\- HEART DISEASE

ELEVATED TRIGLYCERIDES & FASTING BLOOD SUGAR

HYPERLIPIDEMIA

HYPERTENSION

INSULIN RESISTANCE

ABDOMINAL OBESITY

WELL CARE
AT RISK / PREVENTION

SICK CARE
ALREADY ILL

AMERICANS WITH METABOLIC SYNDROME

93%

35%

AMERICANS BELOW OPTIMAL CARDIOMETABOLIC HEALTH

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 those with chronic health conditions have the greatest challenge in getting affordable health insurance and in accessing care.

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.

PRIVATE VS. PUBLIC

Private insurers cover more than 260 million Americans and pay 80% of all hospital care, 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—1-to-10,000 ratio. Changing this 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 preventive care and optimal outcomes based on keeping people well.

Change the current fee-for-service system to a value-based system to lower costs, and reduce single charges for procedures and services and financially rewards payers, caregivers and providers for delivering preventive care and optimal outcomes based on keeping people well.

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.

PRIVATE VS. PUBLIC

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.

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.

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.

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.

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 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 2008, proved change was possible. In 2002 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.

Now

Change the current fee-for-service system to a value-based system to lower costs, and reduce single charges for procedures and services and financially rewards payers, caregivers and providers for delivering preventive care and optimal outcomes based on keeping people well.

PHARMA HAS A LICENSE TO PRINT MONEY

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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

Change the current fee-for-service system to a value-based system to lower costs, and reduce single charges for procedures and services and financially rewards payers, caregivers and providers for delivering preventive care and optimal outcomes based on keeping people well.

URGENT REFORMS TO TAKE PLACE NOW

We need to reduce single charges for procedures and services and financially reward providers for delivering preventive care and optimal outcomes. The incentives in the pharmaceutical industry are perhaps the most perverse. 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.

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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.

“Without changing our approach, 1 in 3 Americans could have diabetes by 2050. 26 million elderly (half the population) have prediabetes. The number of Americans with prediabetes has risen 40% in the last decade. Rates of type 2 diabetes among children are expected to rise 700% by 2060. More than 130 million US adults have diabetes or prediabetes. Over 20% of the US population have prediabetes.”

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

Diabetes and Prediabetes

- More than 30 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.
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.

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.

“My life in medicine has been defined by climate change discussions. It is one of the most important issues affecting our patients, our communities, our planet and our planet’s future.”

—Dr. Jonathan前方
Climate Change x Health

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. Agee, 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.

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—Mary Ann Omond, Senior Director, Ceres Company Network

**Climate CRUSH COMING FOR HOSPITALS AND CAREGIVERS**

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<td><strong>National greenhouse gas emissions generated by the healthcare sector</strong></td>
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<td><strong>HOW HOSPITALS INTEGRATE CLIMATE-SMART SOLUTIONS</strong></td>
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| **100% Healthcare sector GHG emissions generated by the medical supply chain** |
| **HEALTHIER FOOD** |
| **LEADERSHIP** |
| **SUSTAINABLE PROCUREMENT** |
| **COMMUNITY RESILIENCE** |

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“Climate change brings 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. Agee, PhD, Director, RENEW Institute; Henry M. Woodburn Professor, Department of Chemistry, University at Buffalo

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

Divisive politics in the United States will increasingly disrupt patient outcomes and healthcare delivery in various regions of the country, with politics supersed ing science for many Americans in a fractious “red vs. blue” divide. But Gen Z’s growing voting power may finally set healthcare free.

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
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
“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 background will avoid places where access is difficult and a sense of belonging doesn’t exist.

“My 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 Brashler, 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.

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 abortion, reproductions, 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.

POLITICIANS AND HEALTHCARE

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 from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect from Covid-19 in red states were 30% higher than in blue states. We expect
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 survival 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 Tele-health 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.

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

“T’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
“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

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 underfunded in low-income countries: distribution of vaccines for HPV, which causes cervical cancer.

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 significant increase in cancer survivors.

“Precision medicine is not the standard process for treating cancer yet, but I see that door opening.”
—Andrew Hessell, microbiologist, geneticist and entrepreneur

“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 blockbuster drugs. Developing individualized therapies will become the new holy grail. Healthcare systems will need to become more agile and retain oncology teams as more targeted therapies are approved, each one for smaller groups of patients.

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“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

“BIOHACKING CANCER: ACTIVATING YOUR OWN IMMUNE SYSTEM”

Immuno-oncology (IO) aims to rewire 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.

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“EQUITABLE CANCER SOLUTIONS: HOW CLOSE ARE WE?”

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.

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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.

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.
**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 rolling 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 those, 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 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. 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.

“One in five Americans experiencing mental illness.”

“Americans with a substance abuse disorder.”

“Teenagers who experienced a serious depressive episode, 2021.”

“Psychodedics 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*
Brain Health

**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 therapies 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 (“mushroom”), 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 psychotherapeutic 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 Aelt, 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 neuro-technological 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 (biotype). 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 best-selling 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 tech-nologies to repair damaged cells in the brain are in 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 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

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.

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 WELVILLE

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 2011 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.”

—Weihua Ying, MD, Professor and Associate Dean, Shanghai Jiao Tong University School of Biomedical Engineering

**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 mood, 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 microbes and other organisms 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 ES&G 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.

**STILL HUNGRY AFTER ALL THESE YEARS**

Americans spent $1.1 trillion on food every year, with the federal government spending almost $200 billion a year in food aid for the poor. Yet 13 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.

**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 Mymeet, are helping patients discover and avoid food triggers for autoimmune diseases.

**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. Diabates 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.
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.

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